Corporate Innovation

Global Perspectives

Hugo Hodges

Corporate Innovation: Global Perspectives

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‘We are connected, but constrained’: internet inequality and the challenges of millennials in Africa as actors in innovation

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Abstract

One of the biggest news stories in the past decade has been the increasing impact of the internet and information technology on young people, from first-generation mission countries in North America and Western Europe to the global south—particularly in Africa. This advancement has fueled the growth of a “connected” and “plugged in” cohort of young people known as millennials, who are utilizing this medium to improve their social status and create potential for economic and professional growth. However, while the Internet has created opportunities for growth and development on the continent, many online platforms and services continue to restrict full access to certain parts of the global south. Hence, in some African countries, for example, opportunities for scaling innovation and development can be very difficult to access. Consequently, as our daily activities sync with technology, concerns over access to the Internet economy and the undue restrictions over internet services persist. Using the storytelling research methodology, this paper seeks to highlight why geo-restrictions and regional lockouts over internet-related services seem to be a major challenge for millennials in Africa, who are actors in innovation by virtue of their contribution to the growth of the internet technology. We argue that this enforced regional lockout not only deflates the productivity and creativity of African millennials, but also points to a functionalist view of internet inequality constituted through the "divides" of accessibility, censored participation, and acceptability in the internet economy. Understanding the staggering nature of this problem would require telling the stories of young internet entrepreneurs and innovators in Africa, who continue to be marginalized while investing and contributing to the internet economy.

Keywords: African millennials, Usage access, Narrative inquiry, Storytelling, Internet inequality, Digital development, Internet usage policy

Background

In February 2010, the Pew Research Forum came out with a comprehensive survey conducted in association with the PBS documentary series on millennials. In their research findings, millennials, a demographic cohort following Generation X (Horovitz 2012), were summarized as being confident, connected, and open to change (Pew Research 2010). Periodic events and trends, in this case, their technological exceptionalism, have left a particularly deep impression on this social generation, which then shapes their emerging identities. Thus these imprints stay with them as they move

through their life cycle (cf. Howe and Strauss 1991, 1997). Ultimately, technological exceptionalism is not just about the gadgets—it is the way millennials have fused their social lives into them. For example, three-quarter of millennials have created a profile on a social networking site, compared with half of Xers, 30 % of Boomers, and 6 % of Silents (cf. Pew Research 2010). There are big generation gaps, as well, in using wireless technology, playing video games, and posting self-created videos online.

To a large extent, African teens and twenty-somethings, even those in their early thirties, who are making the passage into adulthood at the start of the third millennium, have begun to fuse their social lives into technology. Besides, if technological exceptionalism truly differentiates the millennial generation from other generations—as we assume that Africa's teens and twenty-somethings are the millennials of Africa—what effect can technology and its associated systems have on Africa's millennial generation? And to what extent can millennials contribute to development in Africa? We take the risk of using the Americanized constructed term "millennial" to equally refer to young Africans within the millennial age-group. Arguably, Africa's young social generation may not have the same identity "parallels" as their American counterparts; which, of course, requires further investment in research. Hence, when we refer to African millennials in this article, we only mean young Africans who are between the millennial age bracket and born between 1982 and 2001 (cf. Howe and Strauss, 1991; Counted 2016b).

We now turn to our primary research question which is constructed as follows: Why are geo-restrictions and regional lockouts on internet-related services a major challenge for millennials in Africa and how do these enforced restrictions hinder Internet-fueled developments in Africa?

According to the Global Information Technology Report released in 2015, nearly half of the world's population now has access to high-speed broadband connection, totalling 3.4 billion in 2014 (Pepper and Garrity 2015). This access has contributed to innovation and economic growth in various regions of sub-Saharan Africa including Mauritius, Seychelles, South Africa, Nigeria, Rwanda, Kenya, and Cape Verde—scaling past that of the Middle East and North Africa. Furthermore, providing evidence of increased opportunities for investments to leverage new business models and services for continued growth and development (cf. Pepper and Garrity 2015).

Tremendous opportunities exist for tech-savvy millennials, with a positive outlook for the future. Although internet connectivity is rapidly growing, and penetration within many regions is still lacking, young Africans are claiming their spots in the internet economy (Kalan 2013). To date, there are vast number of internet hubs and business incubators that exist for young people to connect and innovate, as they develop tech-driven start-ups (Everett 2014), create online forums, networks, and blogs (Kalan 2013) — proving that the African youth and millennials in general are hungry for content, connectivity and change (cf. Kalan, 2013). However, while being connected has significantly impacted the continent, imposed restrictions and limited access to varied online platforms and services that come with usage access in many instances, continue to be restricted.

Therefore, since African millennials not only access and engage the internet technology through fading internet cafés, incubators, and increasing mobile access, concerns over the kind of opportunities such platforms provide become increasingly domineering

as research further points that mobile internet usage in Africa is among the highest, with an estimate of one billion phones by 2016, with smartphone sales surpassing that of computers four to one (cf. Kalan, 2013). As it seems, innovation and the penetrated use of wireless technology on a daily basis in Africa has inspired a new breed of innovators who are developing life-saving applications, content, and platforms used to improve the standard of living (Jung et al. 2001: 512). The surge behind these inventions is determined by the opportunities available to create new ideas. And to a point, technological change and generational change often go hand in hand. This is exemplified in the story of African millennials and their embrace of all things digital (Heaven and Turriby 2003), as they try to put themselves at the frontlines of internet-fuelled development, even through unfair restrictions in the internet ecosystem.

Internet diffusion and internet inequality in Africa

The Internet is the fastest diffusing innovation to date (Dholakia et al. 2003: 7–12). To illustrate, it took just 10 years for it to reach 50 % of American homes, compared to 52 years with electricity and 71 years with the telephone (Thierer 2000:83). Fifty million users were counted just within 2 years, compared to 38 years for radio and 13 years for television (Bell and Tang 1998: 8). As of 1999, the number of Internet users increased by one million every single month (McLaren 1999). While there are predictable challenges which center around having more affordable and widespread access and usage of the internet on the continent, connectivity is definitely in motion in many African countries, according to Nicholas Seidler (2013). Hence, debates have shifted to other more pressing issues gravitating around the all-important question: once you are connected, what are you able to do with it? Seidler (2013) expresses that,

> The mere fact of being connected doesn't guarantee one will be able to innovate or able to freely share information and ideas: These abilities require an enabling Internet environment, one that is based on openness and without excessive restrictions on online activities (Seidler 2013:3)

According to the *State of the Internet Report* in 2000 by the US Internet Council, "Internet diffusion in Africa has been hampered by factors such as poverty, low computer penetration, illiteracy, lack of trained personnel, disinterest, corruption, identity theft, and a failure to understand the benefits of Internet access" (Dholakia et al. 2003: 43). Worldwide, there is a modest correlation between economic atmosphere, information access, and the democratic political environment (Howard et al. 2010:110). It has been difficult to relate policy interventions with improvement in the diffusion or distribution of information technology within or between countries (Howard et al. 2009:208–219; Howard et al. 2009:1159–1169). And while some researchers have worked on the global Internet inequality by developing quantitative measures, much less work has been done on developing benchmarks for measuring the internet divide within countries. However, since the 9/11 attack on the United States, banks and online payment processors have changed their policies and terms of use (Onodu 2013:2). Some countries are not "supported online" as part of the ongoing but never ending reforms in the financial sector, while others are able to engage actively in its use. This shows a breach of fairness. Why would populations of a particular region have full

access to information and communication technologies (ICTs) while others are denied access?

Although, the number of millennials who report positive impacts about the internet have grown, equally, the sheer size of millennials in Africa who are dissatisfied with policy-related issues having to do with internet usage and access also continue to increase. Even with the numerous opportunities available in the internet economy (offering narrow social and economic inequalities, supporting individual's wealth creation, and achieving the broader development goals of the community, cf. DOTForce 2001: 3), there still appears to be geographical limitations with communication technologies that people from poor societies have access to (Norris 2001). Frankly, there seem to be no straightforward connection between new-internet policy reforms in the ICT industry and closing the digital divide (Howard et al. 2009: 1159–1169).

Recall, in the mid-1990s, most of the Internet's computer nodes were physically based in the USA where a handful of other wealthy nations, and most Internet users were at universities, in government and military agencies, or living in urban areas and paying for dial-up services (Davison and Sheila 2003). By the late 1990s, new ICTs were diffusing rapidly, but unevenly, around the world (Howard et al. 2010: 110). According to Howard (2006) and Kling (1996), at this time in history, new Internet users in most countries belonged to specific categories of race and class and were more often creative, well educated, and younger, which had implications for the kinds of civic engagement, social interaction and resources found online (Howard 2006; Kling 1996:297–314). The point is that the benefits of the fast, multimedia networks in today's Internet-driven world economy are accruing disproportionately to those who can afford access or live in countries where usage/access is allowed (Badshah et al. 2005; Mossberger et al. 2003).

Drawing from Emile Durkheim's (1984) functionalist view on inequality, every society operates in a particular order that requires individuals to play certain roles in society. This targeted division of labor provides a greater return for the society and individuals involved, in such a way that this kind of institutional framework is often vulnerable to inequality. In other words, individuals specializing in certain tasks often are rewarded more than the others for their role in the society—on the grounds of a system of incentives constructed by that very society which supposedly should justify inequality (cf. Durkheim 1984, Witte and Mannon 2010).

Drawing from the functionalist view of inequality, it does not matter that many African regions do not use some internet applications, content and services, if, at the end of the day, certain societies and (western) regions, or population benefit from the information and resources provided by those internet vendors. Functionalist theorists would argue in this case that what matters is not whether everyone can access those internet services, but whether the world (although polarised to the West) benefits in general, while ignoring the countless number of others in the global population system (especially from the developing regions) not using those internet services. Therefore, the argument that the inequality attached to this particular division of benefits becomes justified and thus becomes the byproduct of a social order that constitutes the internet economy. Taking from the functionalist position on social order, the overwhelming evidence of internet inequality in this article focuses on how internet applications, contents, and services are accessible from certain locations but restricted for certain

African regions. In this article, we argue that these kind of restrictions are perhaps a demonstration of a functionalist social structure in the internet ecosystem (cf. Witte and Mannon 2010). Although on a peripheral level, Witte and Mannon (2010) discuss how internet conglomerate Yahoo! focuses on sharing targeted contents that are aligned with the interests and needs of a privileged group of Internet users. This perhaps might also be an example of internet inequality: though open for the public, but targeted towards a particular group of people.

On a more serious note, the internet is designed in a way that guides certain web users to specified channels of resources and network links, in order to function in the order of its functional skeleton. So then, why bother about web inequality since a stream of online users benefit from the set up—hence, inequality is justified! Again, we see this pattern of inequality repeating itself across different web platforms and services. Before its extension of operation, PayPal for example, locked-out users from certain regions in Africa from using their services and focused on providing services to the Western population. Even with PayPal recent penetration in some African countries such as Nigeria, still, some services (e.g., the payment receiving feature) are not yet fully functional for their clients in countries like Nigeria (cf. Nairaland.com 2015). Most of the global South (especially African countries) were not beneficiaries of the PayPal operation even though PayPal was the major source of e-payment at that time. Again, based on the functionalist ideology, they met the needs of certain selected regions and groups, which served their interest (cf. Caprio 2014; Nsehe 2014). Today, there are still countries in the global south that do not have access to the PayPal application.

However, internet inequality is more than a mere functionalist propaganda. It is the lack of sensibility. Van Dijk and Hacker (2003) proposed four different forms of internet inequality, which they contend is a question of "access". In other words, the extent of internet inequality depends on the kind of access defined or denied. The first is the lack of "psychological access", which simply refers to a lack of elementary digital experience caused by a lack of interest, computer fear, and unattractiveness of the new technology. The second is the lack of "material access". This simply indicates a lack of possessing a computer and network connection. The third dimension is the lack of "skill access", which is a lack of digital and professional skills caused by insufficient user-friendliness and inadequate education and social support. The lack of "usage access" signifies the lack of meaningful usage opportunities for the online user, who perhaps has relative experience in the first three categories. (Van Dijk and Hacker 2003:315–326). The fourth type of access is associated with the functionalist view of internet inequality in this article, which implies that access to internet opportunities is given to privileged users and restricted to unprivileged users for the greater good of the internet economy.

Van Dijk and Hacker (2003) further argued that "in terms of material or psychological access to computers and the internet, internet inequality is closing in developed countries, whereas in developing societies it is still growing" (p. 315–326). However, Africa's relationship with the Internet and its governance seem to be improving in the first three categories of internet access, with the exception of *usage access*. Lack of usage access is therefore argued to be a major challenge for the millennial generation in Africa as they converge online and struggle to use the limited Internet-related resources and services available to them to solve urban and rural challenges within their communities.

Particularly, the kind of enforced geo-restrictions experienced when there is an interest to access certain websites, web applications (like PayPal, Wordpress, Google checkout), online contents, or host a website but cannot access the online resources or fully utilize its applications because of your geographic location.

The emphasis in this article is to stress why geo-restrictions and regional lockouts over certain internet-related opportunities are problematic for millennials in Africa who are actors in innovation and internet-fuelled development.

Methods

We have made an attempt to write this article within the confines of a scientific inquiry. As a result, we adhered to some general scientific rules in order to accurately describe the ideas, procedures, and outcomes of our study (cf. Hoogenboom and Manske 2012). However, we may have skipped some formalities and instead, focus more intently on our argument and position to highlight the experiences of Africa's millennial population, who are actively connected to the internet and using it as part of their daily activities, as well as to solve rural and urban challenges in their communities and equally disturbed over their shared marginalization over internet-related services.

It might interest the reader to remember that our approach is the narrative inquiry methodology, also known as the storytelling methodology. This is a method of qualitative research in which the storyteller uses field texts in the form of stories, journal reports, online forum discussions and comments, notes, interviews, photos, conversations, and experiences in general, as the units of analysis to report and interpret the way people create meaning in their life's experiences through narratives (Riessman 1993). Narrative inquiry is a qualitative methodology where the narrative inquirer tries to understand human experiences through recursive, reflexive means—"moving from field (with starting points in telling or living of stories) to field texts (data) to interim and final research texts" (Clandinin and Huber 2010: 124). Hence, the commonality in place scenarios, experiences and situations create a conceptual framework within which the themes emerge and analyses done. At the core of its practice, the narrative inquiry or storytelling methodology is most appropriate for researching ethical matters that have to do with human dignity (cf. Clandinin and Huber 2010; Musimbi 2002). This is why we employed this methodological approach in telling the stories of a marginalised social generation in order to construct a theoretical understanding around the experiences of Africa's millennial generation in the internet ecosystem.

We took the storytelling approach and gathered reports, comments, forum discussions, and notes from various known and unknown young entrepreneurs and innovators within Africa who are a larger part of the Third Millennium Africa Project (TMAFRICA) ecosystem; most of whom are based in Africa and innovators in their own right, and equally between the millennial age brackets (1982–2001). Some of the stories were gathered during the "Spotlight Talks" interviews (a monthly initiative of TMAFRICA) with promising African millennial leaders who are solving rural and urban challenges using the Internet technology. Most of them were asked the challenges they were facing in their work. Their answers have helped us to put together this narrative. Others were taken from random online comments, forums, and notes recovered from African millennials who were frustrated with online platforms that were making them victims of their functionalist internet social structure, which seems to

satisfy the online "usage access" needs of certain "privileged" regions, and thus leaving out the collective "usage access" needs of other regions who, as a policy, are not allowed to have full usage access to opportunities and resources in some online platforms. Equally, relevant literatures and evidences were used to support and backup these claims as well.

Results: Internet geo-restrictions and regional lockouts as constructed forms of internet inequality–telling the stories of African millennials

The "connected" and "innovative" African millennial generation

According to Ball-Rokeach (2001), the term "connected" reflects a multi-level and contextual way of envisioning the relationship between individuals and technology (cf. Ball-Rokeach 2001:485–510). Being technologically connected in a general sense suggests an increased internet penetration and demand. Of late, Africa's internet penetration has been at an all-time high—with an estimated growth of 27.0 % with 313,257,074 users as of June 30, 2015 (Internet World Stats 2015). Consultants at the McKinsey Global Institute have equally estimated a double penetration of 50 % by 2025 with an influx of over 360 million smartphones on the continent (cf. Manyika et al. 2013). With the increased connectivity to the internet among millions of unemployed and innovative tech-savvy millennials across the African continent, it seems that internet connectivity is bringing tremendous opportunities and revolutionizing home-grown solutions in Africa, as Africa's millennial generation boost their own prospects using the internet technology to transform businesses, and drive entrepreneurship and economic growth (cf. World Bank 2012; Kalan 2013; Dutta et al. 2015).

Today, over 313 million people living in Africa regularly use the Internet (cf. Internet World Stats 2015). The World Bank funded report, *eTransform Africa*, provides data on the ICT revolution that is taking place in Africa and its transformational prospects on the continent's development as of 2012.

> At the start of 2012, there were some 650 million mobile subscriptions, making the African mobile telephone market bigger than either the EU or the United States. Some 68,000 km of submarine cable and over 615,000 km of national backbone networks have been laid, greatly increasing connectivity across Africa. The Internet bandwidth available to Africa's one billion citizens has grown 20-fold since 2008 (World Bank 2012).

In a more recent 2015 *United Nations Economic and Social Council* report on "Digital Development" by the Commission on Science and Technology for Development, it was estimated that mobile broadband and smartphones will be the key driving force of future technology trends in ICTs. With over 200 million millennials between 15 and 24 in Africa, the majority of future technology pioneers would come from Africa's millennial generation, given that they are the largest population of young people in the world (cf. Ighobor 2013).

Today, a growing number of millennials in Africa are actors in innovation due to internet connectivity. With the growth of internet penetration and connectivity, there are positive stories of Africa's millennials contributing to internet development through their internet-inspired innovation. Looking across the web, there are hundreds of inspiring success stories from Africa, as we will share just a few.

The story of Chike Maduegbunam, a businessman from Nigeria, and the creator of the popular Afrinolly mobile app, which has almost a million downloads is a good example. With the passion to bring Nigeria's entertainment industry to the world, Chike's team developed Afrinolly for this purpose; therefore making it easy for anybody from any part of the world to have access to Nollywood movies through their smartphones.

Another inspiring example is the Funda e-learning platform, a South African-based online learning solution. Funda is argued to have one of the best e-learning platforms created specifically for developing countries. The funda platform has made it possible to *"integrate already existing solutions at Universities to take courses online",* says Kola Olajide, the Co-founder and lead engineer at funda during his *Spotlight Talks* interview with TMAFRICA. Funda is an exceptional e-learning platform because of its user experience that takes account the delivery mechanism, data analysis, and assessments for learners. They currently provide e-learning solutions to Universities in Southern Africa, and gradually dominating the rest of Africa. According to Kola Olajide (2014), *"funda works with educators to make sure the content is digitally ready and prides itself in providing a complete solution to the education ecosystem."* The funda technology is so innovative that companies in Europe and America are interested in partnering with their platform, according to Olajide.

Amr Sobhy is another African millennial success story from Egypt, whose technological exceptionalism has propelled change and civic engagement within and across Egypt. After the Arab Spring crisis that led to the removal of the then Egyptian President Mubarak, Amr designed an internet application known as *MorsiMeter* to monitor the progress and promise of the then new Egyptian President Morsi within his first 100 days in office. For Amr, his connectivity to the internet has allowed him to use the Internet technology to empower people and bring about some sort of civic engagement (cf. Sobhy 2014). Amr hopes to use technology *"to practice democracy in a way that is beyond the ballot box"*.

Seeing himself as an information activist, Amr had equally used technology to solve other problems that really interest him. In his *Spotlight Talks* interview with TMAFRICA, Amr admits that he had started other innovative internet projects which according to him are like the different hats that he wears. With his undergraduate background in Pharmaceutical Science, Amr equally developed *Dawaa*—an online drug index that makes it easy to answer questions related to drug names, doses, brands, and prices. Amr notes,

> "I was actually surprised that…in 2014 that the only way to navigate that [drugs names] is through a book and some list of apps that are really out-dated. And that's because lately it's a niche problem and no one is interested in solving it. It's a lot of money, and there aren't really that many pharmacists out here. It was a really interesting problem for me and I created Dawaa as a weekend project. I created the first digital drug index with a very simple to use interface and it also adds a lot of enhancements to the functionality: like if you want to search by the name and the brand and figure out some information about them, and which is the cheapest and the most expensive. This is something that was not even possible using books."

Amr is also the creator of PushBots and Zabatek, online tools he developed for not just the Egyptian population but for the world at large.

Other inspiring examples include the Egyptian Nihal Fares who is the co-founder of *Eventtus*, a social networking app that enables its users to find social events and networking opportunities matching their interests; Tebogo Mogale and Sammy Rabolele's *Beyond The Eyes online TV*, which is the first black-owned online TV to come out of South Africa; and Alan Knott-Craig, CEO and founder of *Project Isizwe*, a start-up bringing free Wi-Fi to South Africans—connecting people for online education opportunities, economic development and social inclusion (cf. TMAFRICA Spotlight Talks, 2014–2015).

Without doubt, access to the Internet and mobile phones are transforming the development landscape in Africa, injecting new innovative opportunities and information in key sectors (Saghir 2013). And more so, creating new actors and change makers of transformative and innovative developments from Africa. Indeed, internet-related developments have empowered millennials in Africa to drive entrepreneurship, innovation and income growth in Africa (Yonazi et al. 2013).

The "constrained" but "innovative" African millennial generation

As we move further, it is important to reiterate the type of internet inequality we are looking at: the lack of usage access/opportunities (Van Dijk and Hacker 2003). The lack of significant usage access to opportunities is the kind of internet inequality, watered by a functionalist worldview, where certain internet services, resources, and intellectual property are restricted to benefit certain privileged online users in the internet ecosystem. Such kind of internet inequality, according to Van Dijk and Hacker (2003), demonstrate that "'free' internet access or computer hardware is not really free, of course. There are nominal monthly fees, long-term service agreements, privacy selling and low-quality service, for instance." (p. 11). Van Dijk and Hacker (2003) further described the reason for this inequality: "It is simply a question of some having the technology now and others having it later. They first pay for the innovation and make later adoption cheaper for the last." (p.11). The idea of usage access generally points to the various uses of internet applications, which include both the active and creative use of the internet technology. Ghobadi and Ghobadi (2015): 332 list examples of this kind of usage opportunities to include but are not limited to publishing a personal website, creating a weblog, posting a contribution on an online bulletin board, newsgroup or community, and website payment integration. The authors further explained that usage access is "largely linked to demographic characteristics of users and connections (e.g., social class, education, age, gender, and ethnicity, effectiveness of the connection)" (Ghobadi and Ghobadi 2015: 332).

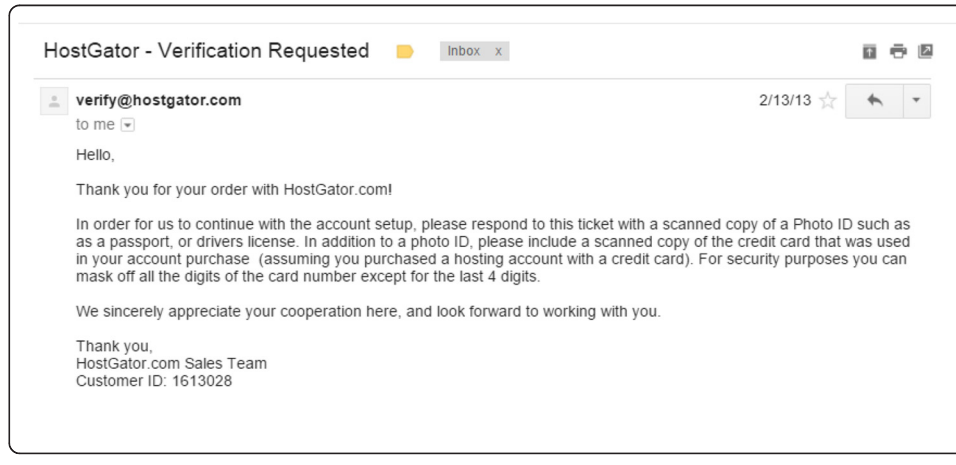
We argue that even though Africa's millennial generation are connected to the Internet through other means (e.g., psychological access, material access, and skill access, cf. Van Dijk and Hacker 2003), they are yet to realise the full potential of the Internet technology due to the lack of significant usage access to online opportunities.

As we interviewed certain individuals and observed the trends of internet inequality across the continent, two main recursive experiences (acceptability or identity problem and accessibility or participation problem) are salient among millennials in Africa as they engage the online community to participate as actors in innovation. "Acceptability or identity problem" is an undeniably increasing psychological challenge in internet usage access where certain individuals are not accepted in some online communities

on the basis of their social or regional identity. On the other hand, "accessibility or participation problem" highlights the salient culture of denying certain individuals the basic human right to participate in some online communities due to certain stereotypical thoughts or beliefs about their identity. We saw these two instances of internet inequality often overlapping with each other, and at some point giving rise to each other. To note, we do not wish to discuss these two forms of internet inequality trends separately, since often times they go hand-in-hand with each other.

Before we continue with the stories, let us first begin with a personal experience one of the authors had in 2013 while living in Nigeria, which actually inspired this paper. Victor is a trained web designer, even though he does not design websites professionally as his main source of income. A friend had asked Victor to assist in providing a web presence for their 5 Star Hotelas they plan on upgrading their services. Victor agreed to help the friend design the website. Victor paid for the web hosting at HostGastor.com using his Guaranty Trust Bank debit card, which he also often use to make online payments from Nigeria. The payment went through successfully. However, the domain was not registered by HostGastor. A complaint was sent to HostGator by Victor using his twitter account on February 14, 2013 (see image below), and HostGastor responded saying, "The domain appears to be currently available as it wasn't registered due to the lack of follow through on the verification". The "follow through on the verification" (see screenshot of email below) they were referring to was to send a photo picture of the debit card Victor used for the payment, with a photo of him holding the bank card, and a copy of his International passport or ID—which he did. After waiting for almost a week to approve the domain hosting, HostGastor still delayed on verifying the transaction. The truth was, as one of the HostGator staff told Victor in an honest disclosure, that the company does not accept users from his geographical location on their platform due to fears of Internet fraud since there was a general notion that everyone using the Internet from West Africa was either a fraudster or involved in some kind of identity theft online. On knowing the truth, Victor had to cancel the transaction since it was almost about 2 weeks since the initial payment. It took Victor another 2 weeks to receive a refund.

While trying to bring about innovation in the hospitality business by giving it a web presence, Victor was denied access to host a website on a hosting platform that only serves a specific geographical region. Once again, we see how the functionalist position


HostGator - Verification Requested

Inbox x

verify@hostgator.com 2/13/13

to me

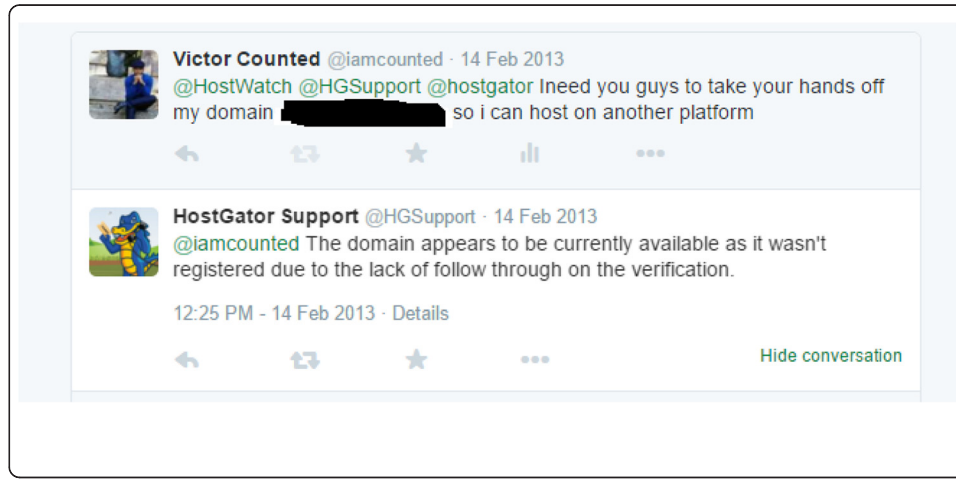
Hello,

Thank you for your order with HostGator.com!

In order for us to continue with the account setup, please respond to this ticket with a scanned copy of a Photo ID such as as a passport, or drivers license. In addition to a photo ID, please include a scanned copy of the credit card that was used in your account purchase (assuming you purchased a hosting account with a credit card). For security purposes you can mask off all the digits of the card number except for the last 4 digits.

We sincerely appreciate your cooperation here, and look forward to working with you.

Thank you,
HostGator.com Sales Team
Customer ID: 1613028



of internet inequality is structurally formalized in the internet ecosystem, serving only a specific group of users.

Although there are other hosting platforms that are willing to accept payments from Victor's geographical location, a major challenge for innovation among millennials in Africa, as we observed, is having a universally recognized e-payment integration system.

Following an ordeal with PayPal.com, user "Normaljenny" in an online forum discussion on nairaland.com (2012) was seeking advice on how to advance his online business which would require an e-payment processor to complete his new online project. His fears was that while he might be able to create e-payment processors using *payza* and *checkout* (which are e-payment systems designed for users from developing countries) the problem was that it would be preferable to use *PayPal,* since, according to him, *"is just too trusted and accepted worldwide".* User Normaljenny has a fiancée in the USA and contemplated asking her to use her Social Security Number to open a new bank account for him so that he could use the details to verify his PayPal account in order to integrate PayPal's e-payment processor into his new business website. Normaljenny equally considered going to a neighboring country like Benin Republic since PayPal was not operating in Nigeria at this time, but available in Benin. Normaljenny is now receiving feedback and recommendations on what to do by fellow forum users. Most of the responders also shared their own PayPal experiences—most of which had very similar storylines. Not to mention *Google Checkout*, which Normaljenny claimed to have tried, but was locked out and unable to access. In her/his words, *"I tried Google checkout and they have only USA and UK as allies and you must verify with credit card "made" in USA or UK, or your tax this and that."*

User Normaljenny complaints on nairaland.com are here captured on the screenshot below.

In particular, while other forum responders shared their own experiences and recommended change of VPN/IP to USA dedicated IP, user "Marvid" in particular does not subscribe to the idea of changing an IP address. Marvid clarifies the situation on the

Re: How To Use Paypal In Nigeria by **normaljenny**(m): 2:15am On Dec 16, 2012

Fellow nairalanders, I have really given this paypal stuff a big long thought. I wanted to run a site selling biz that requires a payment processor, and I wanted to use the yahoo small biz and then intergrate my (yet to get) paypal acct into it. I do not really trust all those adverts of marketers selling ideas of possibilities of verifying paypal in "whatsoever way" in naija. I have seen and heard how peeps gets frozen and lost huge sums, and I think I like learning from other peoples experience.

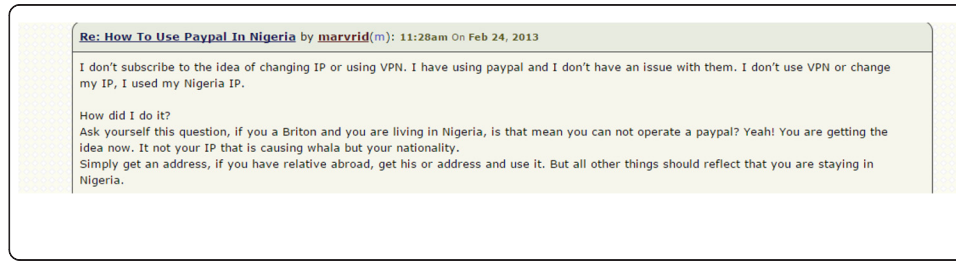
I have been refered to payza.com and I found out that u have to submit ur website for them to approve first and other conditions too. I tried checkout google and they hav only usa and uk as allies and u must verify with credit card "made" in usa or uk, or ur tax dis and dat. And for 2checkout, I don't understand them at all and their payoneer is not reliable for naijas. Now the koko is paypal is just too trusted and accepted worldwide.

So my question is dis, I hav a fiance in the states that has a SSN, can I tell her to open a fresh checking bank account there in usa, so that I can use her bank account number to verify the USA paypal account?

Secondly, since benin republic is paypal friendly, can I get into Cotonou and use their IP address to create and verify the USA paypal account. Since I don't have a cotonou bank account and does not want to verify with cotonou bank acct. Hope they won't close me up if I use cotonou IP address (which I believe to be paypal friendl) to verify a USA premier account?

forum challenging other forum users with a question: "If you a Briton and you are living in Nigeria, does that mean you cannot operate your paypal?" Marvid insists that it is not about their IP address but their nationality. See Marvid comments in the screenshot below.

Paypal's e-payment integration in Marvid's website seems not to work properly, as seen in the screenshot captured below, showing PayPal's default checkout response ("This recipient is currently unable to receive money"), which means it is impossible to



Re: How To Use Paypal In Nigeria by **marvrid**(m): 11:28am On Feb 24, 2013

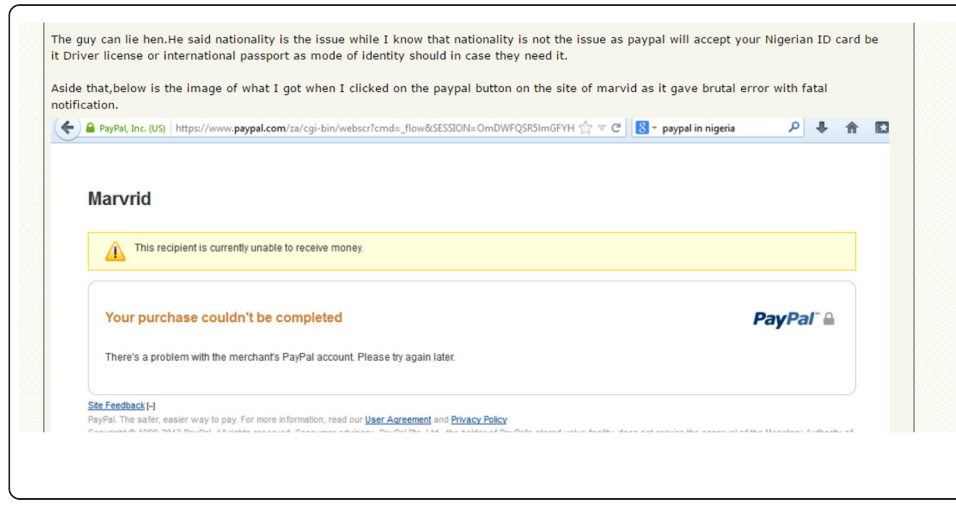
I don't subscribe to the idea of changing IP or using VPN. I have using paypal and I don't have an issue with them. I don't use VPN or change my IP, I used my Nigeria IP.

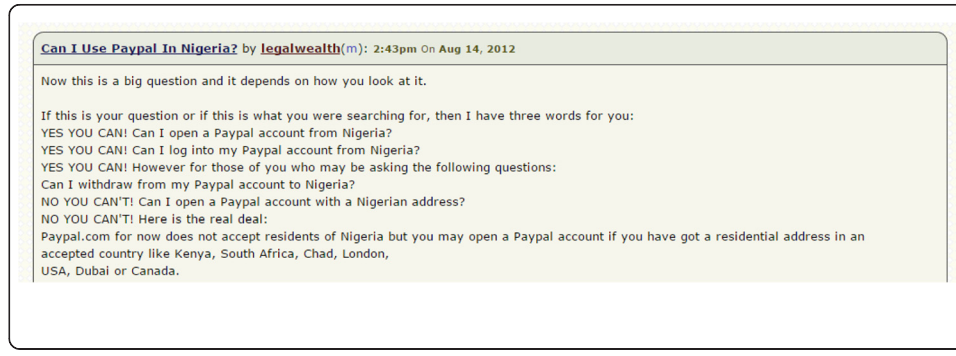
How did I do it?
Ask yourself this question, if you a Briton and you are living in Nigeria, is that mean you can not operate a paypal? Yeah! You are getting the idea now. It not your IP that is causing whala but your nationality.
Simply get an address, if you have relative abroad, get his or address and use it. But all other things should reflect that you are staying in Nigeria.

make a purchase on Marvid's website. An attempt to open Marvid's business website (www.marvrid.com) shows that the site is no longer in service; perhaps due to the restriction not to receive payment due to his location. Of what benefit is it to sustain and maintain an online service or business you cannot even receive payment for? PayPal's refusal to allow Marvid to integrate their e-payment system into his website and thus receive online payments for his business is captured in the screenshot below, as attempt was made to test-run his PayPal payment system by one of the forum users prior to the final shutdown of his online business on marvrid.com.

On the other hand, user "legalwealth" captured the situation of "usage access" in Nigeria with emphasis to PayPal as of 2013 in the screenshot below.

However, PayPal has recently extended their service to Nigeria in 2014 (cf. Nsehe 2014). And within the space of 1 year, the Nigerian PayPal market became the second largest market for PayPal in Africa (cf. Chima 2015; Ventures Africa 2015). Sadly, even with the acclaimed extension, there are still restrictions as to how Nigerian users should use the PayPal payment system.



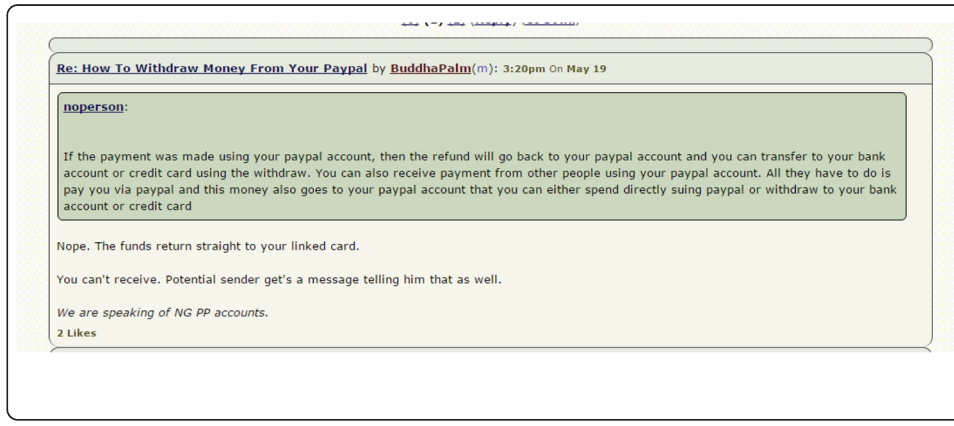


One of the Nigerian users claimed to have sold some of his products online through the new PayPal system introduced in the country but unfortunately could not receive his money because PayPal is of the position that Nigerian users should not be allowed to receive online payments, even though they can use their PayPal accounts to make payments to other PayPal users. Miskoblog.com notes this in their article as below:

> A Nigerian PayPal account can only be used to shop online on merchant sites that accept Nigerians and also to send money to accounts eligible to receive PayPal payments. For example you cannot send money to another Nigerian PayPal account but you can send to a USA PayPal account which is eligible for receiving payments on PayPal (Miskoblog 2014: para. 5).

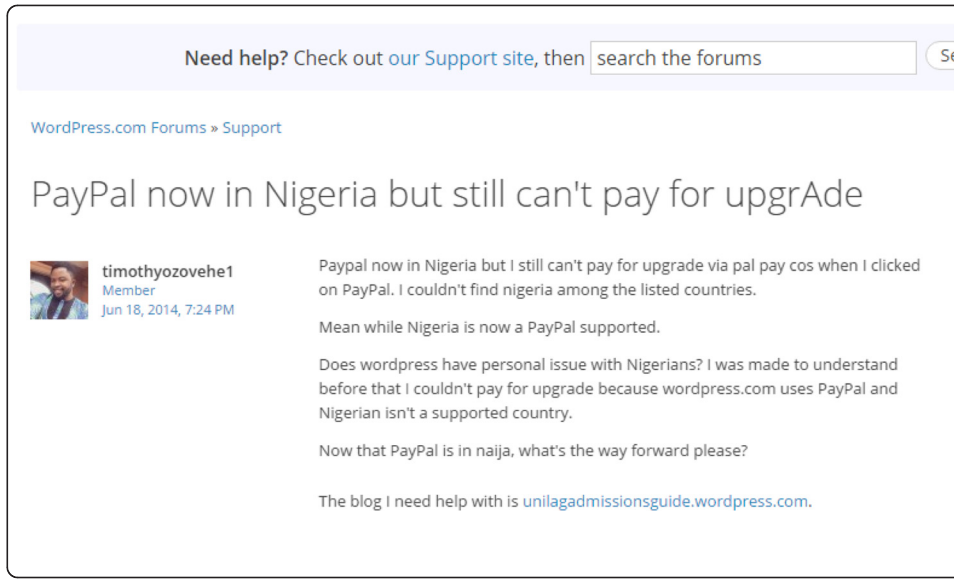
Compare this claim with the screenshot below (cf. Nairaland.com 2015), as one of the forum users asks how he/she could withdraw money from his/her PayPal account and user “BuddahaPalm” clarifies saying, *“Nope….You can’t receive. Potential sender gets a message telling him that as well”*.

To put forward, some of the millennials in Nigeria are aware that PayPal has extended their services to the region but other third party PayPal accredited web vendors like



Wordpress seem not to have upgraded their system to include "Nigeria" in their checkout database. Timothy Ozovehe (2014) complains in his comment on a Wordpress forum, frustrated trying to pay for a wordpress service but unable to do so since Wordpress, according to him, seems to have a *"personal issue with Nigerians"*. This is captured in the screenshot below:

Overall, one of the common trend in the discussion forums is seeing many of the online forum users, who at some point serve as advisors, rationalizing that their experiences with PayPal were the springboard that inspired them to create and support new African-initiated e-payment alternatives (e.g., GTBank GTPay, Interswitch InternetPay, eTransact, Simplepay,



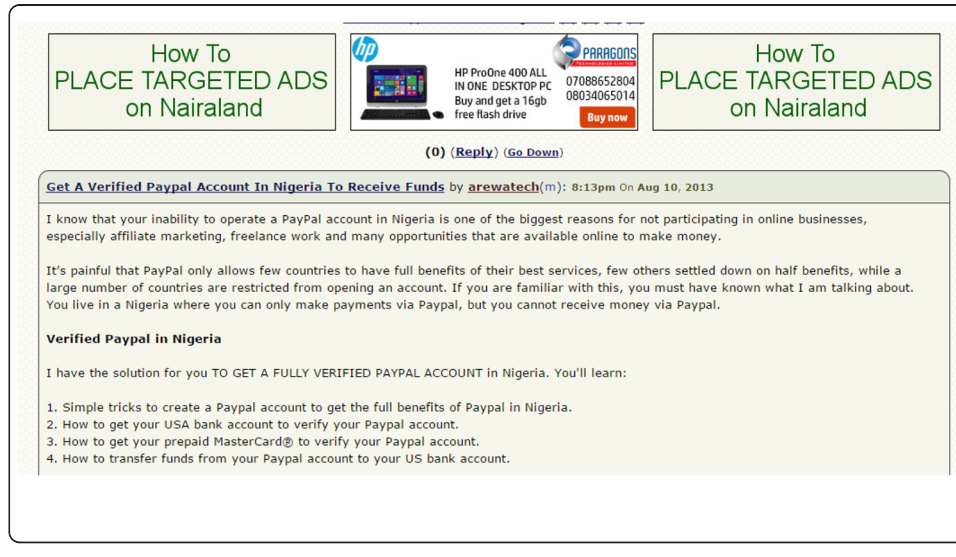
Cashenvoy, UBA UCollect, Zenith Bank GlobalPay, 2Checkout (2CO), Payza, and Paga) designed specifically for the African market (cf. King 2015). Many of the founders of these new e-payment systems draw their inspiration for starting their own e-paymentcompanies based on the difficulties surrounding online payments in some parts of Africa. African millennial, Simeon Ononubi, founded *Simplepay* in 2013 after his frustration with Western-based online payment systems like PayPal that do not understand the African market and often think of African e-payment users from the lens of negatives stereotypes. According to Ononubi, in his interview with Muyiwa Matuluko of *Techpoint Nigeria*, he has this to say,

"I don't believe that you can just borrow something from America and use it in this environment." (cf. Matuluko 2015: para. 1). With Ononubi's Simplepay, African users can securely and conveniently make online payments simply by using their email address and bank account as a "sort of reminiscent of PayPal", Matuluko (2015) claims. Today, *Simplepay* has over 10,000 registered users monthly (cf. Matuluko 2015) and the company continues to grow as it hopes to reach one million users by the end of 2015 through a grand partnership with the African banking giant, Zenith Bank PLC (cf. Matuluko 2015).

Simplepay seems to excel in a difficult African e-payment market terrain. However, PayPal still wields the upper hand since the PayPal system is universally recognised and respected as a more secure and reliable e-payment system due to its popularity. For millennials who are in desperate need of the PayPal payment system, using the Simplepay e-payment system is just not an option, especially when their client base is in Europe and North America.

Occasionally, we noticed some of the desperate forum users in need of the PayPal system, resort to manipulating their identities in order to gain access to PayPal and sell their products to the Western market, where PayPal is the most trusted means for online payments. We see this in the screenshot below, as forum user "Arewatch" on nairaland.com now beckons on "wanna-be" PayPal users, who are willing to take any risk to get verified PayPal accounts for their online businesses (cf. Nairaland.com 2013).

As we move our attention away from the narratives that support the subtle existence of internet inequality in the internet economy, we now focus our attention back on the stories of millennials who are part of the Third Millennium Africa Project ecosystem and their comments on internet inequality from a broader spectrum. These comments and observations were gathered during the recent *Spotlight Talks* interviews they had



with TMAFRICA, when they were asked to talk about their start-up projects and the challenges they were facing in their different fields.

Kola Olajida, the lead engineer at Funda (an emerging e-learning system) who is originally from Nigeria, in his *Spotlight Talks* interview (cf. Olajide cited in TMAFRICA

2014), notes how difficult it was for him to start his niche in Nigeria due to the negative stereotype associated with that particular region. He believes that South Africa was a better playing ground for his e-learning project launch, which has recorded some incredible success over the years. But what if Kola could not afford the means to relocate to Cape Town; what could have been of his Funda dream?

Kola is not the only one of our ambassadors who seems to have been a victim to internet inequality. Internet information activist, Amr Sobhy (2014: para.7), equally shares the same concern as he intellectually captures the trend of internet inequality in his Spotlight Talks interview with TMAFRICA:

> "When it comes to the entrepreneurial scene in Africa, there are a lot of challenges… the basic challenge is the ecosystem is not as well or as mature as in other continents and in other countries. And sometimes there is actually a huge gap between what we have here as a reality and what exists in other places. It is ok because we need to start somewhere."

Indeed, the problem with internet inequality is in the internet ecosystem, which is configured to benefit certain regions whereas giving "internet milk" to "internet babies" in other regions. The internet usage access gap between what is obtainable in the internet economy from African countries is far below what is the standard in other places. Amr believes that the internet stakeholders do not see the value in investing in the African market but *"They are willing to spend the same amount of money but in more experienced places as investors. Like they don't want to invest locally, but they are willing to invest 2 to 4 times that money, but in other more mature ecosystems which will not help African entrepreneurs and startups to really grow."* However, we don't have much of a choice, and like Amr states, Africa *"need to start somewhere"* (Sobhy cited in TMAFRICA 2014: para.7).

We believe there is an awareness "out there" about what internet inequality is all about, which often points to the deep-seated understanding (or misunderstanding) of internet-generated inequality and online interaction. In fact, building engaging interfaces online can be a daunting task that does not go without encountering some form of inequality or stereotype, especially when surfing from the breadth of Africa.

To put it more clearly, Piragoff (2005) reasons that the way in which virtual communities are organized into predictable relationships, patterns of social interaction (the way in which people respond to each other) are to some extent a precursor to cybercrime (Piragoff 2005:133), and for us, an evidence of the injustice of inequality roaming the internet ecosystem. When access is denied based on one's identity or a perceived stereotype, a more acceptable but vague identity is often forged to gain access and acceptance as we have seen in the narratives. At the end of the day, nobody actually wins. And this, for us, is the more reason why identity theft is more rampant in the internet economy. Unfortunately, usage access to opportunities and resources on the internet still remains an unbelievable reality and a major challenge facing the future of Africa's millennial generation.

Discussions: A case for internet equality and full usage access to internet opportunities

Throughout the developing world, creating access to sophisticated services for the most marginalized populations is a huge challenge (cf. Dalberg 2013). Those who are

connected online can testify that the Internet is a tool with great potential. Yet, the expansion of the internet is a contradictory phenomenon. There is significant evidence of inequality in Internet usage access, especially in terms of "proprietary production models and intellectual property rights" (United Nations Economic and Social Council, 2015: 11). While there are forms of online activities and policies that encourage Internet penetration in Africa, there are some Internet models, protocols, and intellectual properties that are restricted or locked out for some African countries. As a result, millennials within these regions miss out on a great deal of online resources and opportunities on these platforms.

The internet introduces huge social inequalities due to its functionalist downside. The distribution of users is polarised due to economic and social status and inadequate economic structures in many parts of the world (Conachy 1999). The 2015 *United Nations Economic and Social Council* report links this inequality to the lack of open source models like the open source software production which are based on a commitment to share and open participation to online community users without any enforced geographical restriction that serves a particular region. Looker and Thiessen (2003) are of the opinion that geographical location has an impact on patterns of use and attitudes to new technologies. The authors argue that internet inequality will be a persistent phenomenon that is likely to "affect the ways and the extent to which members of different subgroups involve themselves in the information society" (Looker and Thiessen 2003:487).

Though an incredible, undisputed force for unleashing new forms of connectivity and opportunities, the Internet ecosystem needs some critical reforms. Breaking the barriers that are necessary for achieving a competitive advantage in the internet economy is essential for Africa's growth in order to connect Africa's millennial generation to opportunities on the internet that will enable them to create innovative solutions for rural and urban challenges in Africa. Not only will an improved reform on usage access impact Africa's millennial generation, it equally would provide an outlet for new forms of innovation, entrepreneurship, and social good. As a result of an improved access to Internet opportunities in developing countries as of 2009, according to the World Bank report, there has been a 10 % increase in broadband which correlates to a 1.38 % increase in GDP growth (Qiang 2009). Imagine what would happen if the negative stereotypes about Africa were laid to rest?

As for us, we envision Africa where innovation and development are commonplace through access to the right information and resources. It would be a daunting vision if Africa's future generation are denied the human right to access opportunities and resources in the Internet economy like their western counterparts.

In Dalberg's research, survey results of over 1300 firms in Africa cited access to information as one of the Internet's most significant benefits for their businesses—but agricultural firms voiced the strongest emphasis with over 70 % of respondents ranking access to information as "essential" (Dalberg 2013). Access to solutions in agriculture are demonstrating impact on operations, leading to direct impact on household incomes. SMEs within the agricultural sector have used a range of new tools, such as Nokia Life Agriculture Services and Ghana's Esoko, to obtain information that was once difficult to find over long distances, such as market prices and weather information (Dalberg 2013).

Yet, PayPal, Google Checkout, wordpress, HostGator, and the likes still have not fully recognised several African countries in their e-payment network. And not to forget, several cases of IP address restrictions to many websites have been of great concern to internet inequality as well. While all these seem to be the consequence of an ongoing battle to mitigate cybercrime, this approach seems to overall be self-defeating and limits access to information and opportunities that may as well help young people in Africa, within these restricted confines, to succeed and live above the poverty line. What a shame!

Apparently, one of the important lessons of the past two decades has been the central role of innovation especially in the area of the Internet technology in economic development (Organization for Economic Co-orporation and Development OECD 2005). A challenge, however, is to ensure that innovation and channels through which innovation can take place are inclusive; that is, to ensure that the benefits are shared more evenly across all groups and regions in order to improve the overall social well-being of mankind, because we are all human beings!

Good governance of the Internet economy and its related technologies is necessary for progress on economic, social, and environmental levels as we progress into the future. Creating a fair atmosphere that allows millennials in Africa to freely and fully connect to the rest of the world online is important. With unlimited access to the Internet economy, millennials in Africa not only have access to online information and opportunities, but can become actors in innovation as they transform from morally decentralized to digitally transformed role models in their communities. By granting them full usage access online and deconstructing the functionalist structures of internet inequality, the hope of rebranding the African image can come alive and strong as young people share stories of Africa's growth, strength, and transformation. Fighting internet inequality is a great way to create social inclusion and access to opportunities on the Internet economy. Opportunities, we believe, that will enhance development and build the capacity to promote ongoing sustainability that will elevate Africa from the abyss of under-development to the playing field of global competitiveness.

Despite Africa's history of bad reputation (Howard et al. 2010:110), concrete efforts must be put in place by policy makers and government organizations as we design ICT-related policies that will promote a smooth transition to the Internet age for the sake of the future emerging generation of Africans. This cohort of young people are arguably the largest in the world (cf. Ighobor 2013), and are unique from the previous generation because of their technological exceptionalism (cf. Howe and Strauss 1991, 1997). Such internet policies must include but not remain limited to providing full Internet usage access to our promising future African leaders. Other areas of access should be explored as well.

In order to accomplish this, however, there must be grassroot reform that links the relationship between economic corruption and the freedom to access meaningful information and spread ideas online. Regardless, adapting the internet into our society to fit and wrestle our morally challenging borders requires not just an overflow of cultural and contextual relevant opportunities but an inclusive internationalization of Internet governance—inclusive of all nations, and not regulated on geographical, racial, sexual, or individual basis—to assure a complete internet breakthrough in Africa.

On humanitarian ground, internet vendors need to operate an open internet policy for the sake of human dignity, in order to empower the edges (where Africans seem to

settle) of the Internet economy rather than the center. With such kind of user-centric template, voices are given to even the end-users and everyone benefit at the end of the day (Seidler 2013).

Conclusions

While we took note that access to the Internet in general has largely contributed to Africa's advancement, we equally contested that the challenge for a huge percentage of Africa's millennials is the lack of meaningful usage access to opportunities and resources on the Internet, specifically created for users in the global North and countries in the West. We argued that this kind of internet structure represents the functionalist view of internet inequality, which fundamentally is created to benefit a particular social group in a social system. Using the narrative inquiry, we narrated stories of how millennials in Africa are sidelined on the margins of the Internet ecosystem as part of the functionalist agenda to apportion a large portion of opportunities available online to users from Western countries. Hence, citing how PayPal, Wordpress, Google check, HostGator, and other internet vendors are agents of internet inequality, carrying out this functionalist agenda within the Internet ecosystem.

Drawing from these stories, we contend for a full usage access to meaningful internet opportunities, which is the primary area of internet inequality experienced by millennials in Africa who are skilled with the knowledge of the internet technology. The human right to access information or resources or utilize an application online should not be determined by an "insensitive few" who enforce geographical restrictions on the most useful Internet products on the basis of a functionalist propaganda and stereotype.

Needless to say, Africa's ongoing internet-fuelled developments lie in the creative hands of Africa's millennials as they exchange ideas and engage the rest of the world online without undue restrictions to participate in online communities, contribute to the internet technology, add to the positive stories about Africa, and benefit from the bottomless opportunities that abound in the internet ecosystem.

Competing interests
All authors declare that they have no competing interests.

Authors' contributions
All authors read and approved the final manuscript.

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Evolution of strategic interactions from the triple to quad helix innovation models for sustainable development in the era of globalization

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Abstract

The innovative and sustainable economic development of a country depends not only on the presence of a strong government, universities and industries but more so on how they mutually interact for strategic objectives. The evolution of these interactions has given rise to science parks, technopolis, and at more advanced stages to innopolis. Further, common economic- and market-driven innovative demands and goals of the trio have caused the emergence of clustering and concentration of experts in various fields. However, the development and growth of the service sector, Internet and globalization have created the need for informed watchdogs for the sustainable interactions in the triple helix. Studies have revealed that the evolution of the interactions of the innovation models has increasingly raised the necessity of a strong civil society in the triple helix. This development has now transformed the triple helix into the quad helix as it is discussed in this paper. There is an urgent need for developing and middle-income countries to learn and implement the discussed global best practices of science park creation in the triple helix settings. This shall revitalize their technological innovation and gradually advance by building the infrastructure needed for competitive economic growth.

Keywords: Triple helix, Government, University, Industry, Globalization, Science park

Introduction

It has been proven through many studies that local sustainable economic development is promoted through various initiatives that link universities, government and industries (UGI) (Etzkowitz and Leydesdorff, 1995; 2000) leading to the creation of science parks (Afonso et al., 2010). Countries which have not advanced in linking the three (UGI) have yet to realize that although scientific research can be powerful, it is not the only organized human activity that produces sustainable innovation ecosystems relevant to the development of viable economic policies that meets societal needs (Gibbons et al., 1994; Carayannis and Campbell 2006). It is an almost common consensus that development arises as a result of cooperating and strategically consulting specialized productive units that are complementary. Since the 2000s, a series of new ways regarding models for sustaining innovation systems has taken place in order to accommodate global networking. This has been enhanced by the need for food

safety, green energy and other international agreements caused by technological advances and the speeding up of access to resources (Powell and Grodal, 2005).

The triple helix innovation model based on strategic interactions of UGI has played both integrated and overlapping roles for the benefit and sustainability of economic development in many countries. Analysis showed that economies where the triple helix has been operational had knowledge-based development and have created industries that are innovation-driven. Moreover, the universities in these countries have spurred technology-intensive research (Etzkowitz and Klofsten, 2005). There have been several advances in the triple helix model due to the need to maximize the benefits realized by the mutual interaction of the integrated innovation ecosystem.

There has been a problem in advancing and sustaining technological development in developing countries especially in Africa. This has made them lag behind in stimulating innovations needed to either compete in global markets or to make their higher education relevant to market demands. This paper examines critically some of the perceived knowledge gaps which most developing countries have not cracked in understanding the drivers of the technological edge. The paper goes back in the primordial stages and systematically outlines the evolution of these changes and discusses the crucial role of each stage of interaction. We suggest that the growth of each stage in the triple helix as it advances to quad helix is very important for establishing a sustainable developmental ecosystem. Furthermore, each stage should advisedly be implemented. There are factors that have contributed to these interaction changes, for example, Leydesdorff and Sun (2009) reported that in Japan the government, university and industry relations had actually started to decline, because of differences in strategic intentions. This was much more conspicuous in the university-industry collaborations. However, there have been explicit policies to stimulate these relations and some have succeeded. Furthermore, analysis of the quadruple helix concept showed that it is not yet a very well-established concept in innovation research and policy in some countries (Arnkil et al., 2010), but its adoption and implementation seem that it is becoming increasingly paramount in a globalized society. The objective of this work is to highlight and explain the past developments of the GUI interactions and how they are imperative in sustainable development of a country.

Review

The interactions of the triple helix innovative model in Third World Countries

The governments, universities and industries in the third world countries, especially in Africa, have not been creating new business opportunities and have passively been watching as former famous industries head to oblivion. They are also not fostering entrepreneurship, and hence, hardly are they having a mechanism of generating knowledge-based jobs. Much money has been spent in trying to discover what could be the cause of this situation. But, it is now becoming increasingly clear that this has been caused by lack or little interaction between the government, universities and industries. They in fact practically work in independent silos as shown in Fig. 1.

How the triple helix works is operating in the middle-income nations

In the middle-income countries, the governments are making demands for universities to participate and contribute to long-term strategic plans for the countries. This

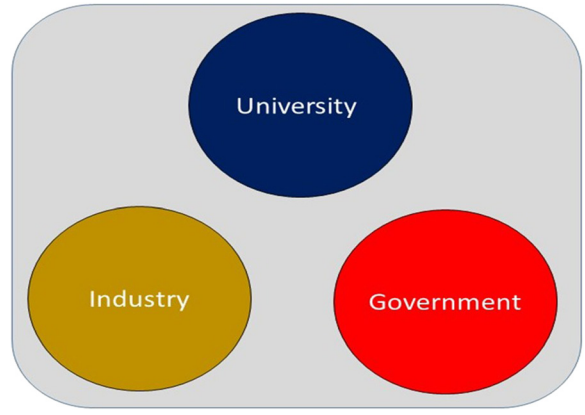

Fig. 1 The operation of the government, university and industry interaction in the Third World is almost with no meaningful interactions. It seems to be a kind of silo confinement for each institution

has made governments and universities sign annual performance contracts, and reciprocally, the universities have demanded the government to provide the necessary technological infrastructure. It seems that at this stage the governments are at crossroads to either be competitive in international markets or lose the support of former donors. Hence, the governments in a bid to keep afloat are pushing the industries to brand their economies with innovative products and create employment for the growing populations. This has made them start negotiations with local industries and at the same time attract investments in order to create jobs and competitive products. On the other hand, the industries have also demanded for a better innovative environment with friendly taxes and better marketing infrastructure. This kind of economic push and technological pull has made interactions between government, universities and industries begin to be established (see Fig. 2). It is not an easy process to initiate, but logic has shown that it is the only way for a sustainable competitive economic growth which is mutually beneficial.

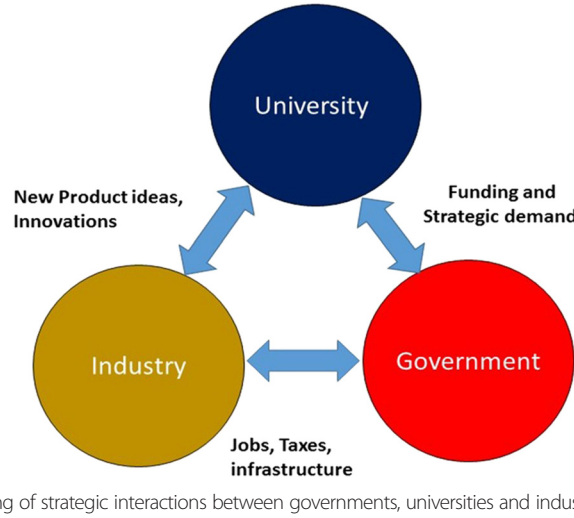

Fig. 2 The beginning of strategic interactions between governments, universities and industries in middle-income countries. This is usually triggered by the push for economic growth and the pull for a competitive market-driven technological advancement

The triple helix in the developed nations

The operation of the triple helix in the developed countries has actually matured in bringing the governments, universities and industries closer over the years. This has made them identify cross-cutting issues which none of them can adequately deal with individually. These common issues include energy, information technology and communication (ICT) and transport. The commonality of the challenge has brought them together so as to find sustainable innovative ways of tackling them. In many cases, they ended up identifying a physical place close to the universities to meet regularly for innovative discussions. This venue for representative experts was in many places globally called a science park. The concept has matured over decades in many countries and has been the source of great innovations. For example, the Bluetooth technology innovation, and its marketing which is common in computers and mobile phones, was developed by the Lund University, Sweden, based on this interactive background. This is basically the technological secret of developed countries. The innovations in these countries have greatly increased because of these interactions and have made big technological cities called technopolis and later innopolis.

The governments in these countries fund strategic research in universities as demanded by the need for new products in industries and the need to create jobs. The outcome usually makes them more globally competitive. Although the science park is mainly the main outcome or focus of such interactions, we also have other dual peripheral interactions in the triple helix components (see Fig. 3).

The evolution of triple helix at the globalization scale

The triple helix has benefited industries by enabling them to obtain informed labour from universities by linking market demands to experts in the field and obtaining sustainable licensing agreements. The governments have been able to initiate new industries and new products leading to more jobs for citizens. They also have gotten more taxes and duties leading to a higher status of living and economic development. The universities have benefited from the science parks by getting reliable sources of funding from industry and government and better training in industry-related research good for

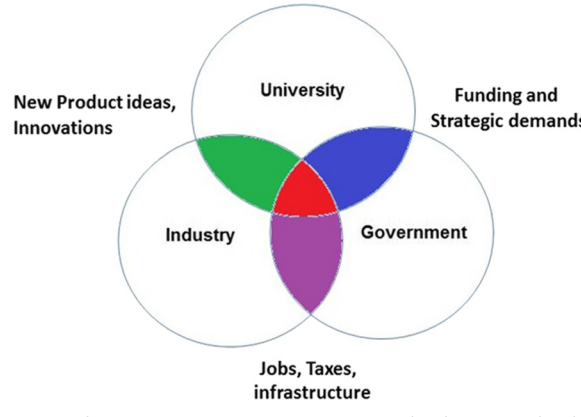

Fig. 3 The closer interaction between government, universities and industries in developed countries based on cross-cutting issues from the science park (indicated as *red*). This kind of interaction is the basis and sustainable strategy for technological innovation necessary for creating local jobs and maintaining international product competitiveness in markets

quicker job placements. They also have been able to do research which is based on national and global needs.

The inclusion of the Internet has made the world become so small especially after the increase and the impact of the service sector in economic development. This has led to globalization. There are clear benefits of globalization like the provision of a platform for advocacy of human rights and safety which have to be addressed in the economic interactions of the triple helix. But, the citizens or users cannot directly always voice their informed concerns to the government, universities or industries, but a strengthened civil society has been suggested to be much better placed to play the watchdog in the now well-established link between government, universities and industries.

The number of industries and subsectors in a science park always increase, and they end up in the formation of clusters for effective and efficient innovation of products. Therefore, there is need for a specialized body of personnel or think tank to evaluate the sustainability of some of the advances in technology based on economic, social and environmental impacts in various settings. This inclusion of the civil society has made us to suggest the inclusion of the civil society as a fourth component in the triple helix, making a quad helix (see Fig. 4).

The development of technological incubators

Normally, universities have a local system of producing their own commercial products. Their system is linear, and it includes the doing of research, publishing of findings, patenting of innovations, making of prototypes and then finally making products for industries. This process is normally abbreviated as RPPP, to represent the following: Research, Publish, Patents, Prototype and Product. These products are then expected to be incubated. The role of incubators is to provide an environment for the cross-fertilization of technology, marketing and innovation. The incubators provide insights into modalities of management, scalability and marketability logistics for the product in

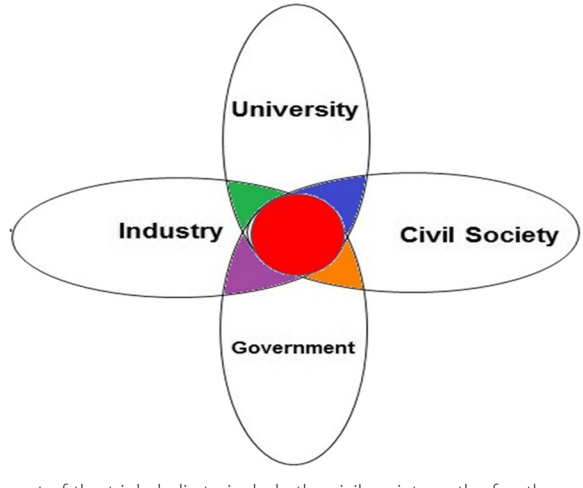

Fig. 4 The advancement of the triple helix to include the civil society as the fourth component makes a quad helix. This inclusion aids in raising the voice of the user of the innovations so as to cater for mainly the social and environmental needs on a global scale. This is because, although for the sake of the global market and product competitions, we are bound to think globally but should always act locally

the society. A researcher who has undergone incubation process with his or her product is capable of creating jobs and marketing new technologies and is able to build national and international economies. However, although this is absolutely possible, it is not sustainable and it cannot create jobs and products which are globally competitive. Hence, there is need for universities in developing countries and middle-income countries to make a paradigm shift and begin to invest in science park-based innovation models as it is taking place in developed countries.

Discussions and conclusions

In a knowledge-based system, it is possible to transform products analytically and innovatively so as to make them seem as new products. For example, although the Netherlands does not produce tomatoes, it has become a major exporter of tomatoes due to its strategic innovativeness. Most of the developing countries and those which are even referred to as poor nations also have great entrepreneurs; by this, we mean people who can think and come up with ideas to solve community problems. Therefore, we should encourage them to be ready to launch their ideas and be absolutely responsible for the inherent risks and outcomes. The provision of the necessary infrastructure can provide proactive guidance to deal with the risks involved therein. Someone may ask, so if developing countries have had entrepreneurs, why has economic development been very slow? What has been the problem? We suggest that the problem has been how to put the operational institutions in strategic venues for a sustainable innovation ecosystem. The above analysis makes an outline how the innovative models have evolved since their inception in the 1930s, when the idea of "science park" was coined in the USA.

The introduction of the civil society in the triple helix

Later studies suggested the insufficiency of the triple helix in long-term sustainable innovative growth and then suggested an addition of a fourth helix, called the civil society (Lijemark, 2004; Khan and Al-Ansari, 2005). Studies suggested that the fourth helix could include faith-based organizations (FBO), non-governmental organizations (NGO), etc. which could combine funding from governmental with the community and private donors (Delman and Madsen, 2007). The civil society serves as the voice of the citizen and could make development to be more human-sensitive and in the cultural context of the communities. Some researchers had chosen the user as the fourth helix of the quad helix. But they confessed that the "user-driven" is problematic as it suggests a bigger role to the user than what there actually often exists. Another recent suggestion was to include a model called "the citizen-centered". It focused on the development of innovations that are relevant and safe for citizens (Arnkil et al., 2010). However, the citizens are hardly able to know the procedures for getting the government and citizen to legally listen to their voices; hence, a strong civil society becomes a very important component for the triple helix. The interactions between the four helices could be varied (Etzkowitz and Leydesdor, 2000). Studies show that the four helices form what is referred to as ecosystems of innovation (Afonso et al., 2010). This shows innovative ideas passing from one source and perfected on a different platform can be supported by another source. New processes or products could start from national innovation demands or by creative citizens.

The Internet and globalized economies

The international outlook of products and processes shall give an edge in global economic competition. Globalization shall make the international-national dimension of operation become increasingly relevant (Wagner, 2008). The Internet has caused the service sector to play a major role in economic development in many countries. We are not suggesting that the quad helix is the ultimate, but we are open to new ideas which can make the interaction among government, universities and industries become profitability closer. We have complex issues to deal with in the different sectors in the science parks. Hence, the creation and simulation of better synergies among economy, society, environment, and democracy in the digital era might take its use to other levels.

Competing interests
The author declares that he has no competing interests.

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Innovation and service outsourcing: an empirical analysis based on data from Tunisian firms

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Abstract

Recently, outsourcing services has been an important component of the organizational strategy of service firms. However, most research studies mainly focus on analyzing the determining factors of outsourcing at the expense of its structural effects. The aim of this paper is to examine the extent to which outsourcing relationships can be a source of service innovation by using a sample of 108 Tunisian service firms. Specifically, we are interested in the domestic outsourcing of auxiliary activities. Our results support the evidence of positive effects of outsourcing service activities on the capacity of innovation. This suggests that outsourcing allows Tunisian service firms to create value, increase flexibility and improve the quality of their services.

Keywords: Innovation, Outsourcing, Services sector

JEL Classification: D23, L21, L80, O31, O32

Background

In a competitive context and in an uncertain economic environment, the access to the best available technologies and the creation of value -among others- are two objectives that a service firm cannot always reach in-house by its own means. It is for this reason that many firms have resorted to new ways of managing the relationships with their environment. Indeed, the most frequently used organizational strategies are establishing new forms of collaboration with research centers or clients, using new methods of integration with suppliers and outsourcing an organization's own services (OCDE 2005). Among these forms, the present paper focuses mainly on outsourcing as it represents an important potential source for innovation. Outsourcing allows the access to the specialized technological competences of the external organizations as well as sustaining the research and development (R&D) activities more effectively in order to develop new products/services (i.e., by reducing costs, shrinking the time to market, increasing flexibility and enhancing quality) (Quinn 2000; Espino-Rodríguez and Padrón-Robaina 2004 and Carson 2007).

Therefore, after affecting the industrial activities, the outsourcing approach has now an impact on the service sector. Indeed, this approach has incremented with the development of technology-intensive sectors. Outsourcing is no longer new as its forms have been well developed in the European countries. According to the Outsourcing

Barometer published by Young (2010), 70 % of European firms resort to outsourcing. In the Tunisian context, for instance, outsourcing services has recently witnessed an outstanding expansion with 77 % of Tunisian firms resorting to outsourcing (Outsourcing Barometer 2006). Engardio and Arndt (2006) indicate that 18.4 billion dollars of trade in the information technologies and 11.4 billion dollars of company services were outsourced, representing 10 % of the potential market. In addition, the OECD 2005 report shows that the total number of positions that can be affected by outsourcing accounts for about 20 % of the employment in certain countries.

Rare are the empirical studies that analyze the relationship between outsourcing and performance, and these are restricted to the motivations that incentivize firms to outsource. Girma and Görg (2004) have shown that outsourcing is positively linked to labor productivity and total factor productivity. Also, Maskell et al. (2007) have concluded that outsourcing can offer firms not only lower costs but also better quality and access to innovation. Yet, this kind of analysis has never included emerging countries, Tunisia in particular. The present paper aims at analyzing then the effect of the domestic outsourcing of the auxiliary activities on the development of innovations. This work is an attempt at proving the extent to which the domestic outsourcing of service activities leads to lower costs, higher production flexibility and better service quality for Tunisian service firms.

The remainder of the paper is organized as follows. 'Outsourcing service activities: related literature' section outlines a brief literature review. The 'Methods' section deals with the data, the variables measure and the models' economic specification. 'Results and discussion'. section analyzes the main econometric results. The last section is the 'Conclusions' section.

Outsourcing service activities: related literature

Context and definitions

Outsourcing implies the transfer of goods and services that were previously carried in-house to an external and more specialized provider (Domberger 1998). Nowadays, reinforcing the outsourcing of industrial production arouses growing concerns. This tendency has long existed, but it seems to become more marked and to expand beyond the manufacturing sector to encompass that of services. In the same context, Lankford and Parsa (1999) define outsourcing as the fact of providing services to sources that are external to the firm. Thus, outsourcing means the allocation or reallocation of service activities of an internal source to an external one (Schniederjans et al. 2005).

The topic of outsourcing is a key concept for services and their innovation (Gallouj and Windrum 2009). In this setting, many authors have closely examined the determining factors of taking the decision to outsource. Bartel et al. (2008) have shown that outsourcing activities are more advantageous for a service firm when the technological changes are evolving rapidly. Windrum et al. (2009) have focused on the paradox of outsourcing productivity by examining the links between total outsourcing and operational innovation. They have shown that, on the short term, the 'outsourcing' firms are willing to decrease their marginal production costs. However, Espino-Rodríguez and Padrón-Robaina (2004) have revealed that outsourcing has a great potential not only through reducing costs but also in terms of other operational objectives such as enhancing quality and ensuring

production flexibility. Miozzo and Soete (2001) show that the services suppliers, which are historically internalized in large corporations (accounting, advertising, distribution, etc), were outsourced during the last decades mainly in the developed economies.

Outsourcing motivations

Outsourcing is integrated to the essential elements of firms' strategy. Firms are constantly searching an organization which provides high service at lower cost. Therefore, diminishing costs represent the main factor urging firms to outsource (Pierre-Paul 2006). Indeed, outsourcing offers the advantage of transparency and allows better expenditure management. It is considered as a means of re-centring the company activity on its primary competence while allocating its secondary tasks to more specialized providers in order to generate higher added value. As they focus on their primary task, firms provide better solutions through constant technological watch and upgrading of labor methods. The multiplicity and diversity of customers continually enrich firms' know-how and improve the efficiency of their operating methods. Furthermore, competition puts pressure on firms in a bid to seek a standing efficiency. Indeed, the globalization of economy, the shortening of the products life cycle as well as the increase of uncertainties oblige companies to delegate the operations that are doomed to have lower added value for their activities to external providers. In other words, outsourcing enables companies to optimize their operational competitiveness and to adapt to the frequent changes and the constant evolution of their environment.

Methods

Data and variables measure

Data

In this paper, the data used are from a survey conducted on Tunisian service firms.[1] This survey belongs to the modified version of the third Community Innovation Survey (CIS) 3 and to the second European innovation survey 1997. However, to account for the role of integrating information technologies on the firms' performance, the 2002 survey on information and communication technologies (henceforth ICTs) and electronic trade has also been referred to.

The questionnaire[2] used for the survey offers a wide range of data. Apart from the general information about the firm, the questionnaire is built on three major sections: outsourcing, innovation and the use of the ICT. First of all, the surveyed firms were asked about their firm's operational structure. More precisely, they were interviewed about outsourcing activities which were previously realized in-house. Secondly, the survey also questions whether the firm has introduced any innovations during the 2005–2007 period. Finally, a section is devoted to exploring the impact of integrating ICTs within firms. The respondents were asked to specify whether the firm has resorted to any new technologies during 2005–2007 and the extent to which these technologies contributed to sales growth.

Among the 200 questionnaires directly delivered to the firms, only 108 workable responses were obtained, that is to say a 54.5 % response rate. Yet, these observations are not adequately weighted. Nonetheless, to ensure the representativeness of the sample, this latter was stratified by workforce bracket using the NTA[3] code of the National Institute of the Statistics (seven classes by number of employees: 1–6, 7–9, 10–19, 20–49, 50–90, 100–199, 200

and more). To each class, a weight was attributed, representing this bracket's weight at the national level, so as to obtain a more representative sample of the service firms in Tunisia.

Table 1 summarizes the determining factors of this operation. It shows that 85.18 % of the surveyed firms declared having resorted to outsourcing during 2005–2007. If the size of firms, in terms of the number of employees, is taken into account, it is noticed that the small firms outsource more than the large ones (22.82 %). Thus, this table shows that 22.22 % of the innovating firms declare having outsourced a part of their functions during the survey period.

The survey provides information about the sector where a firm operates. We have classified the firms according to three main activities.[4] First, ACT1 incarnates the enterprises that belong to sections H (transportation and storage), N (administrative and support service activities) and S (other service activities). Second, ACT2 incorporates the enterprises that are affiliated to sections M (professional, scientific and technical activities) and K (financial and insurance activities). Finally, ACT 3 consists of the enterprises that are in section J (Information and communication). Using the data collected from this survey, we also present the distribution of firms by business sector. We show that the largest number of companies is located in ACT3 (52.78 %), followed by companies operating in ACT2 (32.41 %) and 14.81 % are in ACT1 (see Appendix 1).

Variables measure

Innovation

The literature includes many indicators to measure the output of innovation. Some use the patent portfolio (Mairesse and Mohnen 2003) while others use the R&D expenses as innovation indicators. This paper uses variables showing the main advantages urging firms to outsource. The choice is justified by the fact that outsourcing represents an important potential source of innovation, according to Quinn (2000) and Espino-Rodríguez and Padrón-Robaina (2004). To measure these advantages, an ordinal 5-point scale is used, showing the degree of importance that firms attribute to the following objectives: reducing costs (*red_cout*), enhancing services quality (*qua_ser*) and increasing flexibility (*flex_pro*).

The innovation output (*inserv*) is also measured by a binary variable taking the value 1 if the firm has innovated during the last 3 years and the value 0 otherwise. More precisely, the focus is on information stipulating whether a firm has already implemented any product or any new procedure or has even considerably improved any new

Table 1 Distribution and weighting of the sample firms

Size	Total				Outsourcing		Innovation	
	Number of respondents	INS' firms	Corrected weight	(%)	Number	(%)	Number	(%)
1–6	23	12,649	549.95	21.30	21	22.82	16	22.22
7–9	17	785	46.17	15.74	14	15.21	9	12.5
10–19	18	713	39.61	16.67	13	14.13	11	15.27
20–49	13	509	93.15	12.04	11	11.95	10	13.88
50–90	10	230	23	9.26	8	8.69	6	8.33
100–199	10	167	16.7	9.26	9	9.78	6	8.33
≥ 200	17	215	12.64	15.74	16	17.39	14	19.44
Total	108	15268	781.24	100	92	100	72	100

marketing or operating method in its practices. In fact, we have enclosed with the questionnaire a supplementary explanatory guide where we have defined all the technical terms including service innovation. This latter has been taken from the third Community Innovation Survey (CIS3).[5]

Outsourcing

Prior empirical studies have used different indicators in order to measure outsourcing. Gilley and Rasheed (2000) have measured outsourcing by the share of the total value of the firm's outsourced activities. Following Cusmano et al. (2009), we define outsourcing (*exter*) by a binary variable showing whether a firm has delegated a given task to a specialist outside the firm between 2005 and 2007. We have essentially focused on the outsourcing of the auxiliary activities that are not at the core of the main activity of the enterprise. We have asked the following question: 'During the three years 2005 to 2007, did your enterprise outsource auxiliary tasks?'

Use of ICTs

These are considered as sources of innovation in services. To measure this variable, some authors use the investments in ICT as an appropriate indicator (Gago and Rubalcaba 2007). In this paper, however, as there are nominal variables in the survey, the factorial analysis is the most suitable method in order to process data and analyze the correlations existing between the different items. This method aims at summarizing the huge amount of data. Therefore, a first multiple correspondence analysis is conducted (MCA) on the items relative to the use of ICTs: 'local Internet network,' 'Internet,' 'Intranet,' 'Exchange of computerized data on Internet,' and 'Web site'. This MCA allows the retaining of only one factor, called 'tic'. The MCA results on these items (Table 2) show that, according to the precision of the Kaiser-Meyer-Olkin measure of sampling adequacy (0.753) as well as the significance of the Bartlett Sphericity test, the items are so correlated that they are factorized ($\chi^2 = 113.45$). Thus, the retained dimension presents a good reliability given by the Crombach α value (0.721).

Relationship with clients

Studies dealing with the innovation in services have focused on the services-specific characteristics that directly affect the development of innovations, such as the interaction between the service provider and the client. In this paper, the interaction with clients is measured by a constructed variable generated from the principal components analysis (PCA) so as to

Table 2 Matrix of components (use of ICTs)

Items	Dimension
Local internet network	0.729
Internet	0.499
Intranet	0.756
Exchange of computerized data Internet	0.736
Web site (their own or shared)	0.756
Cronbach's alpha	0.721
Kaiser-Meyer-Olkin (KMO)	0.753
Eigenvalue	2.466
% variance	49.313
Bartlett sphericity test chi square	113.45
df	10
sig	0.000

summarize the huge amount of data from the study of items that show the advantages of online business. These items are 'reducing costs', 'increasing the number of clients', 'better coordination with clients and suppliers', and 'shrinking the time to market'. The PCA results on these items and according to the statistic criterion of eigenvalues associated to the axis ($\lambda > 1/4$) show that only one dimension called 'intclt' can be retained (Table 3). The reliability of this measure is confirmed by the Bartlett sphericity test ($\chi^2 = 435.416$) and by the Kaiser-Meyer-Olkin (KMO) test (0.846).

Another variable is also used to show the impact of using Internet on the growth of firms' sales (*inter*). For this reason, one possibility is to ask firms to indicate whether their sales have changed after using the internet. More precisely, an ordered dichotomic variable is used to show whether sales have increased, decreased or stabilized after using Internet as a marketing tool.

Organizing R&D activities

Although the internal R&D activities are necessary to attract the external competences (Cohen and Levinthal 1990), the extramural R&D, if correctly planned and implemented, can help companies further innovate and hence improve their performances (Caudy 2001). Similar to Huang et al. (2009), a binary variable is used showing whether the company has acquired any external R&D services between 2005 and 2007 as a measure of organizing R&D activities (*rd_ex*).

Concentration

Many studies have analyzed the role of the innovating corporate spatial concentration in particular territories (Cusmano et al. 2009 and Uzunidis 2010). These territories can be high-tech park that include companies, research centers or universities. In this paper, to account for the impact of concentration on firms, a binary variable is used showing whether the respondent firm is located or not in the ICT high-tech park (*concen*). If a firm is located there, it generates synergy effects by developing interaction relationships, and it then benefits from the experiences and the competences of the neighboring firms.

National cooperation

It is widely known that cooperation is an important factor favoring innovation in services (Sdiri and Ayadi 2014). The national cooperation variable (*cooperNat*) is introduced as a binary variable showing whether a firm has signed, during the 2005–2007 period, any cooperation contracts with other companies in the same field, with

Table 3 Matrix of components (interaction with clients)

Items	Dimension
Reducing costs	0.919
Increasing the number of clients	0.94
Better coordination with clients and suppliers	0.938
Shrinking the time to market	0.936
Cronbach's alpha	0.951
Kaiser-Meyer-Olkin (KMO)	0.846
Eigenvalue	3.485
% variance	87.143
Bartlett Sphericity Test chi square	435.416
df	6
sig	0.000

consumers, with equipment and software suppliers, with competitors, with research and counseling firms and with universities situated in Tunisia. This variable is introduced in the models to show the extent to which the external relationships enable the development of innovations.

Qualification and age of the firm

In this paper, the level of qualification (*Qual*) is measured by the number of qualified[6] employees divided by the total number of the firm's employees. The age of the firm (*age*) is determined by the date of its foundation. More precisely, this measure represents the experiences as well as the competences accumulated during the firm's history. Thus, the age is a source for creating innovations and provides more and more absorptive capacities.

Models' economic specification

Ordered probit model

The answers to the different motivations that allow the Tunisian service firms to outsource a part of their activities are classified according to a 6-point scale. The value zero indicates that the firm gives 'no importance' to the different listed motivations while the value 5 means that it accords a 'very large importance' to them. The discrete and ordered structure of this dependent variable allows the use of ordered response models. The values taken by the multinomial variable ($y_i = 0, 1, 2, 3, 4, 5$) are grouped into intervals where we find only one continuous unobservable latent variable y_i^*. This kind of model assumes that the values are identical for all observations. Indeed, the level of y^* is parameterized by the threshold parameters c_j, and a constant is therefore not introduced in the linear model. This model is written as follows[7]

$$y_i = \begin{cases} 0 & \text{if } y_i^* < c_1 \\ 1 & \text{if } c_1 \leq y_i^* < c_2 \quad \forall i = 1, \ldots 108 \\ \ldots & \\ 5 & \text{if } y_i^* > c_5 \end{cases} \tag{1}$$

The threshold parameters c_j are in ascending order ($c_{j+1} \geq c_j$) where the variable y_i^* is defined by:

$$y_i^* = x_i\beta' + \varepsilon_i \quad \varepsilon_i \tilde{} N[0, 1] \tag{2}$$

where x_i represents the vector of the explanatory variables and ε_i is an random error term assumed to have a normal distribution. The parameters β and $c_j, j = 1,\ldots5$ are estimated using the ordered probit model by maximizing the log-likelihood function. The implied probabilities are obtained by

$$P_{ij} = \Pr(y_i = j) \forall j = 0, \ldots, 5$$

$$\begin{aligned} \text{where ;} \quad \Pr(y_i = j) &= \Pr\left(\alpha_j < x_i\beta' + \varepsilon_i \leq \alpha_{j+1}\right) \\ &= \Pr\left(\alpha_j < x_i\beta' + \varepsilon_i \leq \alpha_{j+1}\right) \\ &= \Pr\left(\alpha_j - x_i\beta' < \varepsilon_i \leq \alpha_{j+1} - x_i\beta'\right) \\ &= F\left(\alpha_{j+1} - x_i\beta'\right) - F\left(\alpha_j - x_i\beta'\right) \end{aligned}$$

where $F(.)$ denotes the standard normal cumulative distribution function.

Ordered probit model with selection

In the previous section, the contribution of outsourcing to the development of service innovation has been analyzed. This analysis was achieved on the total sample of firms. Nonetheless, it could not be reasonable to admit that the innovating and non-innovating firms are randomly selected from a total population of firms. If that were the case, we would fall into a selection bias problem. Consequently, the maximum likelihood estimator can be irrelevant since it does not account for the selection effects operating by the non-observables in the model.

Many methods can be used to control this bias, namely Heckman (1979)'s two-stage method. Yet, this procedure cannot be applied in the present case. Indeed, Heckman's selection models apply to continuous dependant variables in the interest equation. In this paper, we hold a multinomial ordered data. For that reason, a De Luca and Perotti (2010)[8] ordered probit model is used, taking into account the selection bias problem. This model includes two equations, one for the binary indicator of the sample selection (the selection equation) and another for the ordered variable. Accordingly, the observed variable y is determined by another variable which in turn determines whether the innovating effect exists or not (called z^*). The variable z^* can have the null value if the firm does not innovate and 1 if the firm innovates. Therefore, the variable y is observed only if the selection condition ($z = 1$) is met. The model is given as follows:

$$\begin{aligned} y* &= \beta' x + \varepsilon, \\ z* &= \alpha' v + u, \qquad o\grave{u}\, \varepsilon, u \approx N\left(0, 0, \sigma_\varepsilon^2, \rho\right) \end{aligned} \tag{3}$$

The variables z^* and y^* are not observed. On the other hand, the variable z is observed and given by:

$$z = \begin{cases} 1 & if \;\; z* > 0 \\ 0 & if \;\; z* \leq 0 \end{cases} \tag{4}$$

Results and discussion

Empirical validation

Table 4 presents the means, the standard deviations of each variable as well as the correlation matrix between variables used in the models. The table also provides the test

Table 4 The correlation matrix between variables

Variables	Mean	SD	VIF	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) exter	0.85	0.35	1.12	1								
(2) intclt	−4.35e−09	1	1.57	0.10	1							
(3) tic	1.90e−08	1	1.47	-0.06	0.11	1						
(4) inter	1.49	0.50	1.76	0.04	−0.51*	−0.37*	1					
(5) cooperNat	0.5	0.5	1.12	0.10	0.10	−0.01	−0.20*	1				
(6) age	12.93	19.25	1.36	0.15	−0.20*	0.14	0.04	0.01	1			
(7) concen	0.24	0.42	1.16	−0.07	0.12	0.20*	−0.16	0.12	−0.17	1		
(8) rd_ex	0.36	0.48	1.17	0.09	0.15	0.27*	−0.15	0.21*	−0.03	0.07	1	
(9) Qual	0.74	0.24	1.47	−0.24*	0.11	0.27*	−0.20*	−0.08	−0.39*	0.31*	0.04	1

*Significance at the level of 5 %

based on each coefficient's variance inflation factor (VIF). More precisely, it is noticed that the mean VIF is about 1.36 inferior to 6 and that VIF of each variable is inferior to 10. According to this result, it is proved that there is no multicollinearity problem between the explanatory variables used in these models. Consequently, the heteroscedasticity problem was solved using White's correction. Hence, to check that some variables seem endogenous, Hausman's specification test was used as it allows the detection of any endogeneity bias. Indeed, the test confirms the absence of the endogeneity problem. This means that the residuals obtained from the equations of the first step are not correlated to the measure of innovation, which refutes the endogeneity hypothesis.

The estimations relative to the models with or without selection lead to a quality of adjustment, given by the Wald test χ^2 and the likelihood ratio test LR, that is acceptable at 1 %. On the other hand, to choose the suitable model, the Akaike information criterion is used (Akaike 1974) AIC = – 2LL + 2*k* as well as the Bayesien information criterion (Schwarz 1978) BIC = – 2LL + *k* log(*n*), where *k* is the number of parameters, LL is the maximum log-likelihood and *n* the number of observations. As indicated in Table 5 below, the ordered probit model with selection is the most relevant except for the case the 'qua_ser' dimension.

Impact of outsourcing and other innovation explaining variables

Based on the results of Table 6, it is noticed that the interest variable (*exter*) of the model without selection has a positive coefficient and is statistically significant at 1 %, confirming the hypothesis that outsourcing services is positively correlated to innovation. This result suggests that resorting to outsourcing permits the Tunisian service firms to create value (by reducing costs). Outsourcing abates the marginal production costs and increases profits by producing higher stimuli for innovation (Glass and Saggi 2001). Moreover, it allows increasing flexibility and enhancing the quality of the firms' services. Likewise, the results obtained from the second model (with selection) confirm that outsourcing remains significant also at the level of 1 %. The results of the ordered probit model with selection justify, in some way, the conclusions drawn from the first model. This means that the outsourcing strategy is beneficial for the Tunisian service firms in terms of innovation. A similar effect was noticed by Cantone and Testa (2009). This result unveils that the outsourcing relationships contribute to the development of the firms'organizational capacities. In fact, the motivations impelling firms to outsource are not limited to diminishing costs, but have rather changed to include other exploitation-related objectives such as quality and flexibility (Ehie 2001; Kremic et al. 2006).

Table 5 Comparison of models

	Standard ordered probit			Ordered probit with selection		
	(1) red_cout	(2) qua_ser	(3) flex_pro	(1) red_cout	(2) qua_ser	(3) flex_pro
LR test	7118.654	9766.78	5960.21	4529.506	1581.3	3691.124
Prob > χ^2	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Wald χ^2_7	35.385	41.49	30.82	35.26	44.821	27.773
Prob > χ^2	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AIC	42,663.3	31,940.35[a]	45,414.32	37,893.89[a]	35,921.03	41,897.73[a]
BIC	42,695.03	31,972.08[a]	45,446.05	37,946[a]	35,973.14	41,949.83[a]

[a]Shows the relevant model

Table 6 Standard ordered probit versus ordered probit with selection

Variables	Standard ordered probit (M1)						Ordered probit with selection (M2)					
	red_cout		qua_ser		flex_pro		red_cout		qua_ser		flex_pro	
	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE	Coef.	RSE
Outsourcing (*exter*)	2.884***	(0.609)	2.306***	(0.495)	1.943***	(0.494)	2.936***	(0.693)	1.998***	(0.466)	1.469***	(0.519)
Interaction with clients (*intclt*)	−0.037	(0.294)	0.618**	(0.313)	0.226	(0.252)	0.527 **	(0.245)	0.968 ***	(0.308)	0.643 **	(0.258)
Use of ICTs (*tic*)	−0.138	(0.178)	−0.868***	(0.313)	−0.218	(0.171)	−0.548	(0.358)	−0.555	(0.390)	−0.677 **	(0.296)
Internet business (*inter*)	−0.011	(0.580)	0.407	(0.535)	−0.204	(0.606)	0.217	(0.541)	0.641	(0.541)	0.119	(0.564)
National cooperation (*cooperNat*)	0.078	(0.355)	0.186	(0.353)	−0.406	(0.381)	−0.390	(0.274)	−0.011	(0.326)	−0.749 **	(0.356)
Age of the firm (age)	0.018	(0.022)	0.004	(0.013)	0.011	(0.013)	0.035 *	(0.019)	0.012	(0.010)	0.015	(0.012)
Concentration (*concen*)	0.834**	(0.399)	0.769*	(0.435)	1.594***	(0.479)	0.969 **	(0.447)	0.593	(0.430)	1.510 ***	(0.508)
Outsourcing (*exter*)							1.370 **	(0.625)	1.390 **	(0.673)	1.322 **	(0.627)
Interaction with clients (*intclt*)							0.221	(0.309)	0.318	(0.300)	0.174	(0.280)
Use of ICTs (*tic*)							0.657 **	(0.264)	0.842 ***	(0.312)	0.615**	(0.259)
Internet business (*inter*)							0.321	(0.607)	0.597	(0.570)	0.058	(0.484)
Extramural R&D (*rd_ex*)							1.575 ***	(0.572)	1.123 *	(0.640)	1.117 **	(0.544)
Qualification (*Qual*)							1.667 **	(0.777)	1.890 **	(0.741)	2.238 ***	(0.823)
$_{c1}$	1.347	(0.969)	1.243	(0.928)	0.322	(1.029)	1.627 *	(0.900)	1.426	(0.906)	0.268	(0.998)
$_{c2}$	2.176***	(0.770)	1.912**	(0.829)	0.658	(1.019)	2.775 ***	(0.746)	2.256 ***	(0.810)	0.688	(0.997)
$_{c3}$	2.540***	(0.789)	1.988**	(0.827)	1.413	(1.014)	3.258 ***	(0.781)	2.340 ***	(0.810)	1.460	(1.020)
$_{c4}$	2.963***	(0.805)	2.493***	(0.861)	1.918**	(0.976)	3.656 ***	(0.782)	2.894 ***	(0.835)	1.962 **	(0.954)
$_{c5}$	3.441***	(0.805)	3.073***	(0.915)	2.654***	(0.975)	3.966 ***	(0.807)	3.513 ***	(0.899)	2.595 ***	(0.995)
Athrho							1.853 **	(0.824)	1.284 ***	(0.362)	1.085 ***	(0.374)
Number of observations	104		104		104		100		100		100	
Log-likelihood	−21,319.648		−15,958.174		−22,695.161		−18,926.947		−17,940.517		−20,928.864	
Pseudo R^2	0.1431		0.2343		0.1161		0.107		0.042		0.081	

The values between parentheses are the robust standard error corrected by the White method
Significance level: *10 %; **5 %; ***1 %

Table 6 equally shows that the (*tic*) variable has no considerable impact on innovation while concentration (*concen*) plainly affects the innovation activity. Indeed, the findings of this paper attest that introducing information technologies in a firm has no impact on reducing costs and production flexibility. On the other hand, it has a significant, but negative, impact on enhancing the quality of service. This result invalidates that of Gago and Rubalcaba (2007) who notice that introducing ICTs is propitious to innovation in services. Nevertheless, it can be said that service firms can introduce ICTs but that does not mean they can manage and valorize these ICTs to develop innovations (Omrane and Bouillon 2004).

As previously mentioned, it is shown that the concentration of firms (*concen*) positively affects the development of innovations. Actually, establishing a firm in a technology-intensive area (for instance the science parks) contributes to enhancing its new product/service development policy. Due to such favorable technological infrastructure, parks favor the creation and marketing of new products/services. According to this ascertainment, it would be better for service firms to get as close as possible to each other in order to take advantage from productivity and innovation returns. This proximity permits also to firms to reap extra employment opportunity. Consequently, firms become capable of adapting to frequent changes and to the evolution of their environment. Again, the coefficient linked to "the interaction with clients" variable (*intclt*) bears a positive sign. This implies that the variable *intclt* has a positive and statistically significant impact on the three dimensions of innovation. The result implies that using the online marketing strategy to meet clients' needs allows firms to reduce costs, improve the quality of their services and increase the flexibility of their productions.

Conclusions

This paper endeavored to analyze how the domestic outsourcing of service activities contributes to the development of innovations. To do so, a standard ordered probit model is, first, used to explain the relationship between outsourcing and innovation. Second, to account for the selection effect, an ordered probit model with selection is adopted. The findings of the two estimating models show that, in accordance with those of Glass and Saggi (2001) and Görg and Hanley (2011), outsourcing positively affects innovation by reducing costs, increasing flexibility and enhancing the quality of services. On the other hand, it is found that corporate concentration positively affects innovation. If a firm is situated in a competence-intensive environment that includes activities such as IT, R&D, data management, architecture and engineering services, it is more likely to adapt to frequent changes and to the evolution of its environment. This advantageous technological infrastructure enables firms to access to the neighboring firms' experiences and competences. Therefore, service firms would better be established close by other ones to take advantage from productivity and innovation profits. Thus, if a firm is established in a given area, it can have a fairly good idea about the surrounding firms. It can, therefore, make a selection among the providers it will accommodate. Accordingly, it can manage all or part of their information system in order to concentrate on its own core task while benefitting from adaptation, flexibility and competitiveness vis-à-vis the market demands and needs.

Endnotes

[1]As there is emphasis on analyzing the impact of innovation in the services sector, the choice of the population was restricted to the firms that mainly provide value-

added services: companies linked to ICT-based services according to the nomenclature published in 'The directory of ICT in Tunisia' that is edited by Symbols Media (2005), The Banks listed in the 'Tunisia's Professional Association of Banks and Financial Institutions (APTBEF)' and Insurance Companies that are listed in the 'Tunisian Federation of Insurance Companies (FTUSA)'.

[2]A French version of the questionnaire and a data collection are available upon request.

[3]National Institute of the Statistics (INS): distribution of companies by number of employees in 2007.

[4]For more details, see National Institute of the Statistics (INS): distribution of companies by activities.

[5]According to the CIS3, product (good or service) innovation is 'the market introduction of a new good or service or a significantly improved good or service with respect to its capabilities, such as improved software, user friendliness, components or subsystems. The innovation (new or improved) must be new to your enterprise, but it does not need to be new to your sector or market. It does not matter if the innovation was originally developed by your enterprise or by other enterprises'.

[6]Are considered qualified the percentage of the number of employees in the firm holding a high academic level (baccalaureate or more).

[7]For further details, see Greene (2003).

[8]De Luca and Perotti (2010) have developed a new *opsel* command on the STATA software. The opsel command uses a standard maximum likelihood (ML) approach to fit a parametric specification of the model where errors are assumed to follow a bivariate Gaussian distribution.

Appendix 1

Table 7 Distribution of firms by main activity

Industry	Total of firms		Innovative firms		Outsourcing firms	
	Number	%	Number	%	Number	%
ACT1	16	14.81	9	10.71	15	16.30
ACT2	35	32.41	24	28.57	32	34.78
ACT3	57	52.78	51	60.71	45	48.91
Total	108	100	84	100	92	100

Abbreviations

CIS: Community Innovation Survey; ICT: information and communication technologies; KMO: Kaiser-Meyer-Olkin; MCA: multiple correspondence analysis is conducted; PCA: principal components analysis; R&D: research and development; VIF: variance inflation factor.

Authors' contribution

The authors contributed equally to this work. All authors read and approved the final manuscript.

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Competing interests
The authors declare that they have no competing interests.

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Can formal innovation training improve group- and organizational-level innovativeness in a healthcare setting?

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Abstract

Purpose: Does formalization really destroy creative or innovative thinking? What if formal innovation training actually improved firm-level innovativeness? What if a manager could predict the likelihood of success or failure of such a program, prior to any resources being used? This is the aim of the study, to determine whether formalization has a positive impact on group- and organizational-level innovativeness. Additionally, this study will explore the extent to which success or failure of such a program can be predetermined, prior to the start of training.

Method: An intervention study was conducted in a healthcare setting. Quantitative and qualitative measurements were used in determining the effect of the formal innovation training. There were two groups: a participant group and a nonparticipant group. The intervention's express aim was to improve both group- and organizational-level innovativeness.

Findings: After the innovation intervention was completed, the participant group had a significant improvement in their understanding of innovation strategy and idea initiations, while the nonparticipant group had a significant improvement in innovation strategy. Additionally, eight innovative ideas emerged as a result of the training; three of those ideas were implemented and diffused within the organization.

Conclusion: First, this study showed that formalization could improve both group- and organizational-level innovativeness, which was contrary to theory. Second, this study indicated that the level of excitement and engagement in a group is essential to the success of this initiative. In this study, the participating group's level of excitement and engagement was so high that it seemed it was contagious to the rest of the organization. Even though the nonparticipant did not partake in any training, they learnt from it anyways, through the engagement of the participating group. Furthermore, the success of an innovation initiative can be predicted by looking to the innovative readiness of the group or organization.

Keywords: Cultural characteristics, Formalization, Innovative readiness, Innovation management, Process development

Background

Innovation in healthcare is one of the most important developments for any modern society (Christensen, Grossman, & Hwang, 2009), especially when considering the baby boomers that are approaching. It is known among healthcare practitioners that most developed countries will be experiencing unprecedented growths in their elderly population from 2020 to 2050 (Kulik, Ryan, Harper, & George, 2014). However, what remains unclear is how these public organizations are going to meet these upcoming challenges. That is the aim of this study, to empirically test if formalization, by means of formal innovation training, will better prepare public organizations for the challenges to come. This aim will be tested by conducting an innovation intervention at a municipality that provides health care services for the elderly in their region. This study will measure the innovativeness between two groups within the same organization. One group will be participating in the innovation training, while the other group will be continuing work as usual or maintaining status quo. Each group's innovativeness will be measured, both before and after the innovation training is completed, to determine if the innovation intervention had an impact on either group's innovative capabilities.

The study makes an important contribution to innovation literature by testing a research question that has been posed and recommended for future research but has yet to be tested. A comprehensive review of innovation literature has failed to locate a single adequately conducted and reported intervention study (Anderson, Protocnik, & Zhou, 2014, pp. 1321). There is a need for a "fully functional, pre- and postmeasurement designs, preferably with the use of participant and control group designs in real life organizational interventions with the express aim of improving individual-, group-, or organizational-level innovativeness" (Anderson et al., 2014, pp. 1321; see also Pierce & Delbecq, 1977).

Literature review

The need for innovation in eldercare

Globally, the elderly population is expected to more than double, from 841 million people in 2013 to over 2 billion in 2050 (Nations, 2013). Most developed countries, like the USA, the UK, Australia, Japan, and Korea, are expecting their elderly population to double from 2013 to 2050 (Aging, 2014; Kulik et al., 2014). Norway is no different. From 2010 to 2050, their elderly population is expected to double (Statistics-Norway, 2012, 2014); the workforce is expected to decrease by 5% (Statistics-Norway, 2012), and municipalities have always struggled with filling enough municipal nursing vacancies due to poor perceptions of their working environment (Mæle 2014a, 2014b; Nordberg, 2013; Schultz, André, & Sjøvold, 2016; Sundberg & Samdal, 2013; Ulstein, 2006). The working environment for municipal nurses in Norway can be characterized by high stress, high absenteeism, little interest from newly educated nurses, high turnover, few educated nurses, and little emphasis on formal innovation training (Schultz, Sjøvold, & André, 2017). In general, Norwegian municipalities providing eldercare are or will be experiencing many infrastructural challenges. As a result, this study has located one Norwegian municipal manager who decided that the time to think new or differently about how to deliver eldercare services is now. Prior research in the Norwegian eldercare sector has revealed that municipalities have had a clear strategy of improving the

quality of care for the elderly using smart in-home technologies, but there has been little to no consideration given to the working environment (Schultz et al., 2016). Municipalities have acknowledged the need to think new or differently about the way they deliver healthcare services for their elderly but have yet to provide their employees with training on how to think innovatively (Schultz et al., 2016). This was the manager's wish, to build a culture or infrastructure for innovation within their department. This study hopes to fill that knowledge gap by providing formal innovation training.

Even though the municipality in this study agreed to participate in the formal innovation training, it is necessary to mention the inherent tension both in literature and in practice, between formalization and innovation. The tension stems from the belief that formal procedures create rigidity or unnecessary processes within an organization, and these additional loop innovators must jump through actually inhibit innovators from coming forward with their ideas (Pierce & Delbecq, 1977; Thompson, 1965). As a result, many managers have chosen more open, free, autonomous, and undefined processes for innovation. This belief is far from uncommon. There is a body of organizational literature supporting this line of thought that "[R]outine activities are not likely to induce creative problem solving for those who are directed by formalized role prescriptions… [L]ow formalization permits openness in the system and that this openness is a necessary precondition for idea initiation" (Pierce & Delbecq, 1977, pp. 31; see also Hage & Aiken, 1967; Knight, 1967; Shepard, 1967). But what if it was proven that formalization, by means of innovation training, could improve group- and organizational-level innovativeness? Additionally, what if the success of that innovation training could be predicted, prior to the start, merely by looking to the innovative readiness of the participants? Would formalization then be such a bad thing? This study will attempt to challenge the traditional assumption that formalization hinders innovation.

Formalization and its effects

Formalization is a form of bureaucratic control, which "refers to the degree to which a codified body of rules, procedures, or behavior prescriptions is developed to handle decisions and work processing" (Pierce & Delbecq, 1977, pp. 31). A common belief about formalization is that with more formalization comes more bureaucracy (Pierce & Delbecq, 1977; Thompson, 1965). The more bureaucracy, the less motivated innovators will be in coming forward with their ideas (Pierce & Delbecq, 1977; Thompson, 1965). This negative association between formalization and innovation has been around for more than half of a century (Thompson, 1965). Later empirical evidence has affirmed Thompson's findings that flexibility and low emphasis on work rules facilitate innovation (Hage & Aiken, 1967; Kaluzny, Veney, & Gentry, 1974) and low formalization permits openness, which encourages new ideas and behaviors (Knight, 1967; Pierce & Delbecq, 1977; Shepard, 1967). A comprehensive review of innovation processes suggested that the relationship between innovation and formalization is best explained in terms of Thompson's innovation process:

(a) *Initiation* of an idea or proposal that when adopted and implemented will lead to the enactment of some change within the organization
(b) *Adoption* of the idea or proposal represents a decision being made by the organization's appropriate decision-maker(s) providing mandate and resources for the change

(c) *Implementation*, the installation of the adopted idea into a sustained recognizable behavior pattern within the organization (Pierce & Delbecq, 1977, pp. 29; see also Thompson, 1965; Zaltman, Duncan, & Holbek, 1973, pp. 155)

The authors formulated a series of propositions, relating formalization to each stage of the innovation process: "Formalization will be negatively related to *initiations*, but will have a modest positive relationship to *adoption* and *implementation*" (Pierce & Delbecq, 1977, pp. 31).

However, these suggested propositions representing the relationship between innovation and formalization have their shortfalls. The termed phases have become too traditional. Understanding and applying these terms given modern developments in literature has become difficult. These traditional terms do not distinguish clearly between the selection and development phases of an idea; they merely speak to the selection or financial support from the organization. Since 1977, organizational and innovation literature has grown in both the development (Christensen & Raynor, 2003) and selection phases (Alexiev, Jansen, Van den Bosch, & Volberda, 2010; Smith & Tushman, 2005; West & Anderson, 1996), which has made distinguishing and measuring accurately between these phases all the more important. Hansen and Birkinshaw (2007) have developed the innovation value chain, a modernized conceptualization of Thompson's innovation process. The innovation value chain measures innovation in three phases: idea generation (replaces initiations), idea conversion (replaces adoption/diffusion), and idea diffusion (replaces adoption/implementation). Hansen and Birkinshaw (2007, pp. 3) further explain their modernization of the innovation process:

> The first of the three phases in the chain is to *generate* ideas; this can happen inside a unit, across units in a company, or outside the firm. The second phase is to *convert* ideas or, more specifically, select ideas for funding and developing them into products or practices. The third is to *diffuse* those products and practices.

Pierce and Delbecq (1977) suggested that the relationship between innovation and formalization is best explained in terms of Thompson's innovation processes. However, Hansen and Birkinshaw's (2007) conceptualization more clearly distinguishes between the development, selection, and diffusion phases. This modernization allows for a more accurate use and measurement of formal innovation processes, given modern developments in the literature. Additionally, their definition uses more modern termed phases, making the application of each phase in the process more intuitive. Unfortunately, there are apparent shortfalls with this model as well. There is a degree of ambiguity in determining where particular organizational or innovation literature should fit in the innovation value chain. For example, if an organization has difficulties in generating good ideas, creativity literature may shed light onto this, which would fit well within the idea generation phase (McAdam & McClelland, 2002). However, what if the issue is more systemic, and a change is needed throughout the entire organization? In this case, organizational culture (Christensen, 2000; Edmondson, 1999; Harrison & Carroll, 1991; Sørensen, 2002), organizational identity (Hannan & Freeman, 1984; Oliver, 1991), or strategic direction in specific industries (Schultz, André, & Sjøvold, 2015) may shed light onto the issue. If the issue is more systemic, it becomes more difficult to

determine where those theories or strategies should fit within Hansen and Birkenshaw's model (e.g., organizational culture or organizational identity).

Accordingly, a hybrid model has been adopted. The hybrid model combines the two aforementioned phases (Hansen & Birkinshaw, 2007; Thompson, 1965; Van de Ven, 2007). The main modification to the Hansen and Birkinshaw's model is the addition of one phase, innovation strategy. The addition of innovation strategy properly addresses issues that are more systemic to the organization. For example, if a manager wants to investigate the impact their organizational culture, identity, or strategic decision-making has on the firm's innovativeness. The addition of innovation strategy will accommodate for that.

These previous studies have described the relationships between innovation processes and formalization in depth, and they have made predictions about these relationships; however, these predictions have remained untested (Pierce & Delbecq, 1977; Thompson, 1965). The gap this study is going to fill is testing whether formal innovation processes, by means of an innovation intervention, can actually improve group-level and, possibly, organizational-level innovativeness. This construct will test whether formalization is positively related to innovation as first prescribed by Pierce and Delbecq (1977), but the name of the phases are modified due to the modernization of the terms.

Hypothesis (H) 1: Formalization is positively related to innovation strategy (previously not a classification).

H2: Formalization is positively related to idea generation (previously called initiations).

H3: Formalization is positively related to conversion (previously called adoptions but did not distinguish between selection and development clearly).

H4: Formalization is positively related to diffusion (previous classification unclear but likely implementation).

Innovation and its effects

Hansen and Birkenshaw's (2007) previously developed questionnaire will aid in measuring the intervention's participants' perceived impact that the formal innovation training has on the four defined stages. In addition to measuring the impact that formalization has on the different stages of the innovation process, this study would benefit by having a more objective measure of innovativeness, a measure more free from employee self-efficacy. For this reason, qualitative data will be gathered from management to measure more objectively if an innovation occurred per se. However, in order to determine if an innovation actually occurred, innovation first needs to be defined.

There is much ambiguity surrounding innovation; this definition varies dramatically depending on the context (Garcia & Calantone, 2002; Johannessen, Olsen, & Lumpkin, 2001; Ruvio, Shoham, Vigoda-Gadot, & Schwabsky, 2014). This study is not searching for harmony between the various definitions, nor is it distinguishing between innovation and innovativeness (Ruvio et al., 2014), rather, this study has adopted a well-recognized definition of innovation. Innovation is the development and implementation of new ideas within the organization (Van de Ven, 1986; Daft, 1982; Damanpour, 1991; Damanpour & Evan, 1984). If other forms of innovation are used, for example, innovativeness or innovative, they are being used in their literal, grammatical sense.

Development refers to the generation of new ideas, while implementation refers to the diffusion of the new idea within the organization (Johannessen et al., 2001; Van de Ven, 1986), rather than focusing on commercial success or diffusion into the marketplace (Garcia & Calantone, 2002). This part of the construct will measure whether formalization will lead to innovation(s), irrespective of improvements in innovation processes. Even though the formalization measures may show improvements in particular phases of the innovation process (or innovation potential), that does not necessarily mean the firm will be more innovative per se. To be innovative per se, the firm will have needed to develop a new idea(s) and implement and diffuse that idea within (or outside) the organization. This will be measured by gathering qualitative data from management.

H5: Formalization will be positively related to innovativeness.

Innovative readiness for change

Predetermining the success of any organizational initiative, prior to its implementation, is no easy task. Organizational readiness is one body of literature that seems to explore this issue. Organizational readiness refers to how an organization attempts to influence the beliefs, attitudes, intentions, and behavior of their organizational members (Armenakis & Bedeian, 1999; Armenakis, Harris, & Mossholder, 1993; Walker, Armenakis, & Bernerth, 2007; Weiner, 2009; Weiner, Amick, & Lee, 2008). At the core of readiness is the two-part message for change: (a) the need for change, which explains the discrepancy between the current state and the desired end-state, and (b) the individual and collective efficacy (or perceived ability to change) of the parties affected by the change (Armenakis et al., 1993). This concept was further operationalized by using group climate to explain part (b) of the two-part message for change test (Caliskan & Isik, 2016; Eby, Adams, Russell, & Gaby, 2000; Ingersoll, Kirsch, Merk, & Lightfoot, 2000; Jones, Jimmieson, & Griffiths, 2005). Subsequent research proposed that in theory, managers could predetermine the likelihood of success of an innovation initiative merely by looking to group climate, which should describe the group's innovative readiness for change (Schultz et al., 2017). Specifically, for one intervention study, it was hypothesized that the experimental group (those participating in formal innovation training) displayed group climate characteristics of innovative readiness for change, while the nonparticipant group (those that did not participate) did not (Schultz et al., 2017). To date, this theory has remained untested. This is an additional gap the study hopes to fill.

H6: Innovative readiness can be used as an indicator for predetermining the success of an innovative initiative?

Results

The results from this study, as illustrated in Table 1, show that both the participant group and nonparticipant group had statistical significance in innovation strategy (S1–S3). The participant group had significance for all the innovation strategy questions: S1 ($p < 0.001$), S2 ($p < 0.05$), and S3 ($p < 0.01$). The nonparticipant group also had significance for all the innovation strategy questions (S1–S3 ($p < 0.05$)).

The participant group had significance in four of seven idea generation questions (IG1–eIG2): IG1 ($p < 0.01$), IG2 ($p < 0.05$), IG3 ($p < 0.001$), and IG5 ($p < 0.01$). Additionally,

Table 1 The participant and nonparticipant group's innovation understanding, before and after the formal innovation training

Innovation phase	Code	The focus of each question	Part. (before)	Part. (after)	*t* test	Statistical significance	Nonpart. (before)	Nonpart. (after)	*t* test	Statistical significance
Innovation strategy (S1–S3)	SI	Understanding of current organization strategy	2.20	3.78	0.0001	***	2.10	2.91	0.0194	*
	S2	Long-term strategy	2.60	3.11	0.0414	*	2.52	3.33	0.0230	*
	S3	Time allocated towards thinking differently	2.47	3.33	0.0045	**	2.45	3.25	0.0165	*
Idea generation (IG1-elG2)	IG1	Internally, the openness of the working environment	2.93	3.S9	0.0099	**	3.50	3.92	0.0574	
	IG2	Internally, the extent of the organization to think differently	2.93	3.89	0.0201	*	3.24	3.67	0.0370	
	IG3	Internally, the quality of the organizations' ideas	2.40	3.44	0.0001	***	2.73	3.00	0.1846	
	IG4	Internally, the extent to which we partner with other departments	2.73	3.22	0.1078		2.81	3.18	0.0535	
	IG5	Other firms on normal and innovative projects	3.29	4.11	0.0062	**	2.95	3.33	0.0904	
	elG1	Importance of external ideas	3.00	2.44	0.0592		3.05	3.33	0.0903	
	elG2	Value given to ideas that come from outside the firm	2.64	2.67	0.4169		2.S6	2.50	0.0581	
Conversion (Sell-D3)	Sell	How easy it is to bring an idea forward to the org	2.53	3.44	0.0020	**	2.57	2.75	0.3079	
	Sel2	The importance of each individual's opinion in selection	3.40	4.11	0.0715		3.18	3.50	0.1113	
	Sel3	The importance of the group's opinion in selection	3.50	4.00	0.1708		3.45	3.75	0.0723	
	Sel4	The org understands why a particular idea is chosen	3.21	3.78	0.1290		3.41	3.75	0.1045	
	Sel5	Is the more conservative or risky idea more often chosen	2.13	2.00	0.2760		2.48	2.33	0.2643	
	D1	Using formal innovation processes to measure progress	3.00	3.00	0.4032		3.05	3.18	0.2328	
	D2	Ideas are generally developed on time, without delays	3.07	3.00	0.3638		2.81	3.00	0.2292	
	D3	Management generally has strong support in developing	3.21	3.78	0.1063		3.10	3.33	0.1368	
Diffusion (Diff1–Diff5)	Diff1	How fast the org is at bringing idea to the market	3.20	3.22	0.5000		2.95	3.33	0.0740	
	Diff2	How quickly our ideas are copied (e.g., by competitors)	2.92	2.89	0.3417		2.73	2.33	0.3291	
	Diff3	Extent maximizing value (e.g., markets, customers)	2.67	2.67	0.2873		2.70	2,91	0.2232	
	Diff4	Extent org discusses lessons learned with developing team	2.57	3.11	0.2292		2.57	2.92	0.1103	
	Diff5	Extent org discusses lessons learned with entire org	3.20	3.33	0.3802		3.19	3.42	0.2220	

Table 1 The participant and nonparticipant group's innovation understanding, before and after the formal innovation training *(Continued)*

Innovation attitude (A1–A2)	Al	Personal enthusiasm towards innovation	4.07	4.33	0.4696		3.45	3.17	0.1404
	A2	Optimistic attitude towards innovation education course	3.75	4.44	0.1087		2.75	2.33	0.3939
Control question	C	Experim. group has spoken to control group about	2.S3	4.33	0.0025	**	2.47	2.00	0.0702

*$p < 0.05$, **$p<0.01$, ***$p < 0.001$

the participant group had significance for one conversion question (Sel1) ($p < 0.01$) and the control question (C) ($p < 0.01$).

Table 2 lists the innovative ideas that emerged as a result of the formal innovation training, and the extent to which each innovative idea was implemented within the Norwegian municipality. Eight ideas emerged from the innovation training; all ideas were discussed, seven ideas were selected and/or were being further developed (ideas 1–3 and 5–8), and three ideas were implemented and diffused within the organization (ideas 2, 5, and 7).

Discussion

This study has explored the relationship between formalization and innovation, the impact group dynamics can have on the organization, and the prediction of the success of formalization initiatives. The most significant finding was that formalization improves both group- and organizational-level innovativeness, which is contrary to theory. Additionally, we found that if the group participating in the formalization has a dominant group characteristic of excitement and engagement, this characteristic was contagious to the rest of the organization's nonparticipants. The results are summarized in Table 3.

First, formalization has a positive effect on group-level innovativeness. Prior to any innovation training, both the participant group and nonparticipant group had a relatively similar understanding of innovation (Schultz et al., 2017). This meant that neither group had statistical significance or advantage in their understanding of innovation prior to any training. However, after the participant group completed their formal training on innovation strategy, both the participant group and the nonparticipant group improved their understanding of innovation strategy significantly, thus supporting H1 (Table 3).

At first glance, the positive relationship between formal innovation training and improved understanding of innovation strategy for the *participating group* may not be that surprising. It seems logical that those who are interested and willingly chose to participate in innovation training will likely learn from it. Even if this is true that the participant group was biased prior to the training, the results still show that innovation

Table 2 Innovation ideas that derived from the formal innovation training

Idea	Description of the idea	Extent implemented
1	Smaller units for elderly with dementia (with shielding protection needs)—units sue too large now	[b]
2	Changes in planning daily routines and tasks between day- and nighttime nurses	[c]
3	Have open dinner hours for 1–2 h to improve patients' appetite and to have less chaos in the dining room	[b]
4	Facilitate the receipt of patients with different backgrounds, today we are not prepared for more	[a]
5	Better estimates of food needs, waste less food	[c]
6	A more active use of PPS	[b]
7	Patient summary or overview completed in advance	[c]
8	Improve interdisciplinary (across department) collaboration	[b]

[a]Discussed
[b]Selected and development in progress
[c]Implemented and diffused

Table 3 An overview of the tested hypotheses

Hypotheses		Status
H1	Formalization is positively related to innovation strategy	Supported
H2	Formalization is positively related to idea generation	Supported, in part
H3	Formalization is positively related to conversion	Inconclusive
H4	Formalization is positively related to diffusion	Inconclusive
H5	Formalization is positively related to innovativeness	Supported
H6	Innovative readiness can be used as an indicator for predetermining the success of an innovative initiative	Supported

(strategy) can be taught using formal training. This is an important finding as prior research has argued for 50 years that flexibility and low emphasis on work rules facilitate innovation (Hage & Aiken, 1967; Kaluzny et al., 1974), and low formalization permits openness, which encourages new ideas and behaviors (Knight, 1967; Pierce & Delbecq, 1977; Shepard, 1967). Contrary to the formalization theory, the statistical significance in Table 1 and results in Table 2 show that the (high) formalization, in the form of innovation training, has facilitated innovation for the participant group. The formal training has improved their understanding of both innovation strategy and idea generation (Table 1), and that improvement in innovation understanding has led to an emergence of eight new ideas (Table 2), three of which were implemented and diffused within the organization. This supported H1 and H2 for the participant group (Table 3).

Are there alternative explanations for this significance? What if the participating group merely believed they were more innovative because they participated in innovation training? Could that account for their significance? Table 1 dismisses these claims. If that were the case that the participating group believed they were more innovative after having completed the course, they would have had similar statistical significance in all or many of the innovation phases. However, they did not. Neither group could identify which questions on the survey were related to which innovation phases. After the training was completed, the participating group was statistically significant in only two of the four phases: innovation strategy (the phase they were given training in) and idea generation ($p < 0.001$). The significance in idea generation can be explained by looking to the nature of the courses. Innovation strategy can be tied closely with idea generation phase depending on which theories were discussed. There are some innovation strategy theories that could influence and overlap with idea generation.

Additionally, the study showed that the formal innovation training had a positive impact on the *nonparticipant group's* understanding of innovation strategy ($p < 0.05$), thus supporting H1, but not H2 (Table 3). This was odd. Members from this group were given the opportunity to join the innovation training, but they willingly chose not to participate. This group prioritized status quo or continuing business as usual, rather than participating in the training. Despite this lack of interest in the innovation training, their statistical significance in innovation strategy, illustrated in Table 1, indicated they learned from the training anyways. The nonparticipant group's significance was difficult to understand when looking solely to their group's data. However, when the nonparticipant group's data was viewed in light of the participating group's data and work climate, an explanation emerged. It seems the participating group's work climate

as contagious to the nonparticipating group. The impact this had at the group level will be elaborated on below.

Second, formalization has a positive effect on organizational-level innovativeness. There were two indications that formalization affected the organizational-level innovativeness. First, Table 1 shows that the nonparticipant group has statistical significance ($p < 0.05$) in the innovation strategy phase, the same phase the participant group was taught. Here both groups, the participant and nonparticipant group, experienced statistical significance in the same phase. The combination of these two groups comprised the organization in this study. Meaning, learning reached the organizational level. This is fairly convincing evidence, as the nonparticipant group had no idea on which phase the participant group was participating in and could not determine which questions were associated with each phase on the questionnaire, and still, the nonparticipant group was only significant in one of the four phases on the questionnaire. If either group (the participant group or the nonparticipant group) really did not learn, and merely thought they were more innovative, more phases would have had significance. It is possible that this significance for both groups is a coincidence. However, when the evidence from Table 1 is viewed together with Table 2, the findings support the positive relationship for organizational-level innovativeness. Table 2 is an illustration of the qualitative data gathered from the management. Table 2 explains the ideas that emerged as a result of the formalization and the extent to which each idea was implemented within the organization. Table 2 shows that eight ideas emerged as a result of the training, seven ideas were further developed, and ideas 2, 5, and 7 were discussed, implemented, and diffused within the organization. Thus, formalization was positively related to organizational-level innovation as three new ideas were developed, implemented, and diffused within the organization, which supported H5 (Table 3).

Third, the results revealed that the group participating in the formalization had a dominant attitude of excitement and engagement towards the formalization; the evidence from this study suggests that this attitude was contagious to the rest of the organization's nonparticipants. Prior to any training, the participant group was clearly more enthusiastic about innovation than the nonparticipant group (Schultz et al., 2017). On average, each group member in the participant group was personally more enthusiastic and had a more optimistic attitude of the potential impact the formal innovation training course could have on their organization (Schultz et al., 2017). Thus, the participating group's work climate was clearly fostering an atmosphere of enthusiasm for innovation. Additionally, the participant group had a significant difference to the control question in Table 1. This question prompted the participant group to evaluate how often they spoke to the nonparticipant group about the innovation education that they received, and the participant group responded significantly ($p < 0.01$).

One possible explanation for the nonparticipant group's significance is that the participant group members contacted a number of nonparticipant group members and were able to educate them on innovation strategy. Participation in the formal innovation training was voluntary; the nonparticipant group members chose not to join. However, in the end, they learned anyways. It is difficult to understand how this learning came about, whether it was the nonparticipant group that eventually decided for themselves that they were ready to learn or whether the participant group had such a strong influence on the organization or nonparticipant group that they prevailed.

Alternatively, the nonparticipant group members could have experienced a feeling of being "left out" and thus become competitive and tried to do well on the assessments. According to this study's measures, it seems most likely that the participant group's engagement or enthusiasm for innovation was contagious to the nonparticipant group. There is a body of organizational literature that supports the proposition that engagement is highly contagious and transferrable to other members of an organization (Barrick, Thurgood, Smith, & Courtright, 2015; Pugh, 2001). However, this current study did not have these express measures in place to measure this issue accurately. For the aforementioned reasons, this phenomenon of an engaged or enthusiastic group influencing other nonparticipating members with their positive attitude to improve group or organizational innovativeness should be further explored.

Fourth, innovative readiness can be used to predict or predetermine if a group of participants are ready for innovative change. Prior to the intervention, both the participant group and nonparticipant group were classified in terms of their innovative readiness, based on their group climate (Schultz et al., 2017). It was determined that the participant group showed signs of innovative readiness for change, while the nonparticipant group did not (Schultz et al., 2017). This study confirmed this prediction for the participant group in Table 1. Table 1 shows that the participating group significantly improved their understanding of innovation ($p < 0.001$) in the innovation phase they were taught, and this led to organization-wide innovations in Table 2. When Tables 1 and 2 are viewed together, they confirm that the participating group's innovative readiness was in fact a positive indicator of their successful participation in the innovation initiative. However, it was also predicted that the nonparticipating group was not ready for innovative change, but Table 1 presumably shows that this group did in fact change. This study did not have the appropriate measures in place to determine accurately how the nonparticipant group did in fact learn, even though they did not participate in any training. It seems plausible from Table 1 that the control question (C) and the extent to which the participant group interacted with the nonparticipant group about what they learned from the intervention could have triggered this change for the nonparticipant group. If this were the case, it would not contradict the validity of innovative readiness. It would merely provide an explanation for an unexpected outcome. In this case, that one group's positive attitude was so strong that it convinced a group to be ready for innovation, even though they previously were not. Looking to group climate to predetermine innovative readiness for change was supported by H6 for the participant group, but H6 was inconclusive for nonparticipant group (Table 3).

Lastly, formalization focusing on one innovation phase can have a spillover effect to the other innovation phases. The relationship between "formalization and conversion" and "formalization and diffusion" was inconclusive as neither group received formalized training on either respective phase. Prior research identified innovation strategy as the weakest phase for this organization (Schultz et al., 2017). Accordingly, this organization received formal training only on innovation strategy. For this reason, the study's focus was on testing the impact that the formal training had on that phase of innovation. Even though the focus was on innovation strategy, all phases in the innovation process needed to be tested to account for possible spillover effects. This is one possible explanation for why the participant group had a significant improvement in their

understanding of the idea generation phase. For these reasons, H3 and H4 were inconclusive (Table 3).

Conclusions

With the elderly population expected to nearly double in many developed countries from 2020–2050, health care practitioners have stated they must think new or differently about how they deliver their healthcare services, both in terms of technology they use and method they implore. This study has offered one proven method that will aid health practitioners in thinking new or differently about how they deliver their services. The most important outcome from this study showed that innovation or innovative thinking could actually be taught by means of formalization. Contrary to formalization theory, formal innovation training had a positive relationship to both group- and organizational-level innovativeness.

Additionally, this study showed the impact that a group of engaged or enthusiastic employees can have on the organization. The participant group in this study had a dominant group characteristic of interest in innovation. This study indicates that the participating group's excitement and engagement for innovation was likely contagious to the nonparticipating group. Even though the nonparticipant group chose to not participate in the formal training, in the end, they learned from it anyways by means of the participant group.

Furthermore, this study showed that managers could predetermine the likelihood of success of an innovative initiative merely by looking to group climate, which will shed light onto their innovative readiness for change.

The outcomes from this study have important implications to both theory and practice. *Theoretically*, the study provides quantitative and qualitative data in an area where data has previously been lacking (intervention studies developed specifically to improve both group- and organizational-level innovativeness) (Anderson et al., 2014; Pierce & Delbecq, 1977; Schultz et al., 2016). Equally as important, the data from the study contradicts traditional formalization theory. Lastly, this study validates the determination of a group's innovative readiness by looking to their group climate. For *managers*, in the simplest terms, the study shows managers how they can start to think new or differently by implementing formal innovation training or a new innovation process within their organization. Interpreting the outcome one step further, the study could cause a shift on how organizations evaluate their workforce or hiring practices. This study shows that managers do not necessarily need to hire the most attractive or innovative employees available, rather, firms should try to first attempt to foster innovative growth from within the firm. Additionally, prior to putting time and money into a new innovation program, managers could now predetermine the likelihood of success of an innovative initiative merely by looking to their participating group's climate. These implications can have a significant impact on innovative development within organizations but also could shift hiring practices among firms attempting to become more innovative.

Limitations

The sample size is a limitation. There are not that many participants in this study ($N = 40$). Additionally, it may be a bit problematic to split the same department into two

groups, one participating in the intervention and the other not, and have both evaluate their perception of the same organization's understanding of different phases of innovation. Ideally, there would have been two groups from two different organizations, one participating in the study and the other being the control group. However, this was not practically possible; this study only had access to one institution.

An additional limitation was the relationships that were tested. The only relationships that were tested were the improvement in innovation understanding between the participant and nonparticipants, both before and after formal training was completed. There should have been two more groups participating. One group should have been required to join, even though they did not want, to empirically test that impact. Another group, and perhaps the most interesting group that should have been included in the study, was a combination of both the participant group and the nonparticipant group. It would have been interesting to see the impact on both innovation understanding and group cultural dynamics if the nonparticipants' passiveness or negativity towards innovation would have been destructive for the participant members. Alternatively, maybe the participant members could convince the nonparticipants to be more active or engaged.

Future research

Innovation literature could benefit significantly by increasing the sample size, monitoring a longer duration, studying three groups (participant group, nonparticipant group, and a group combining participant and nonparticipant members), and expanding the study to different industries. This would likely shed more light unto the impact and transferability that formal innovation training has on both group- and organizational-level innovativeness.

Additionally, the idea that innovation is contagious should further be explored. It was quite unexpected and surprising to think that the participating group's excitement and engagement for innovation was contagious to the nonparticipant group. This study was designed and structured more for measuring changes in group-level innovativeness, rather than the psychological factors influencing a nonparticipant group. It would be an interesting study to measure more precisely how the nonparticipant group learned what they did. There are many explanations: maybe the nonparticipant group merely learned how they wanted (from their colleagues) or that the participant group has so much influence over the organization that the nonparticipant group did not have a choice. Regardless, the finding was surprising and worth exploring further.

Lastly, innovative readiness needs to be further developed. It was accurate in predicting the success for the participating group, but the theory was inconclusive for the nonparticipating group, possibly due to the engagement from the participating group being contagious to the nonparticipant group. Before this theory can be validated, it needs to be further developed.

Methods

Mixed methods were used in conducting this formal innovation intervention (Brewer & Hunter, 1989). Quantitative methods were used for gathering data relating to the relationship between formalization and innovation. The quantitative data was gathered twice;

once prior to the innovation intervention and again after the intervention was completed. Lastly, qualitative data was gathered both from the ideas that surfaced during the workshop and from the management to more objectively determine if the formalization improved group- or organizational-level innovativeness.

Study design

After negotiations with management, it was determined that the municipality would allow 20 of their employees to participate in four, 2-h formal innovation training sessions. Management explained that this was all that was economically possible. If their employees are participating in the program, their wages need to be paid for that time; additionally, the municipality will need to find and pay for replacements for those shifts. The municipality solicited interest from their employees. For this reason, the study was broken into two groups: the participant group and the nonparticipant group. The participant group included those that volunteered to participate in the study, while the nonparticipant group included those employees that chose not to participate. It is important to note that the nonparticipant group is not a control group. The nonparticipant group did not know the content of the intervention, but they knew of the intervention's existence and willingly chose not to participate, thus shaping their attitudes prior to any measurements being taken. In actuality, we have two participant groups: one (the participant) group that chose to participate in the study and the other (the nonparticipant) group that chose not to participate. Prior to the intervention, both groups differed in their attitude towards the treatment. In this study, the organization as a whole is the combination of these two groups.

The participant group was exposed to four, 2-h formal training sessions. All four of the training sessions had a similar format. Each training session alternated between a lecture and group work approximately every 20 min throughout the 2-h session. Each small group was asked to apply the theories they learned from that day's lecture to different work-life scenarios. Each small group would come up with new ideas, based on that day's lecture (theory) and the task given to them. Each small group would then present their idea(s) to the others. After all the ideas were identified and discussed, the participant group as a whole would decide which idea(s) should be further developed.

The formalization of the training sessions lies in the structure (the process and measuring). First, prior to any innovation training, we identified the participants' level of innovation competence in four separate phases, based on a previously validated questionnaire (Hansen & Birkinshaw, 2007). This provided the anchor or reference points for later measuring the impact that the four training sessions had on innovative outcomes. Second, we identified the weakest innovation phase, based on the participants' evaluation. The weakest phase for this group of participants was previously identified as the innovation strategy phase (Schultz et al., 2017). This will aid in determining which academic theories the participant group will benefit most from. Third, the formal innovation training conducted, incorporating the academic theories that should improve the previously identified, weakest phase (Table 4). Fourth, after the training was completed, the impact of the training was measured using the same questionnaire as mentioned in step 1. Fifth, the results from before and after the training were compared

Table 4 Innovation theories related to each innovation phase

Academic theory	Activity	Innovation phase
Introduction (mapping the journey), organizational culture, organizational identity (organizational theory), slack resources, stretch goals, absorptive capacity, vicarious learning, disruptive innovation, transactional cost theory, the end of competitive advantage. Additional: eldercare theory, design thinking, blue ocean strategy	Firm individual strategy	Innovation strategy
Open innovation, user-driven lead innovation, service innovation (SDL), motivation (individual, group, and organizational), psychological safety, slack resources, team composition re-organizing the team, generating movement in discussions, and network propinquity (regional and relational)	In-house idea generation; In-house cross-pollination; External sourcing of ideas	Idea generation
Ambidexterity (exploitation and exploration), impact of management on innovation, and architectural modular innovation. Additional: eldercare theory	Selection & development	Conversion
Open innovation, organizational periphery, organizational learning, network propinquity (regional and relational), motivation (individual, groups, and organizations), and roles of managers	Diffusion	Diffusion

using *t* tests to identify significant changes. Sixth, gather qualitative data from management to more objectively determine if an innovation has occurred. Lastly, repeat the aforementioned steps as frequently as desired or needed; there should always be a phase in the process that can be improved. This structure needs to be strictly adhered to or this formalization will not have occurred properly.

Table 4 was originally developed in conjunction with the innovation value chain (Hansen & Birkinshaw, 2007, pp. 6). However, for the aforementioned reasons, the authors have amended the table so that it includes the newly added phase (innovation strategy) and the additional applicable academic theories. In Table 4, innovation and organizational theories were classified into one of the four innovation phases. The inclusion of the academic theories developed over time. Originally, the academic theories included in Table 4 were based on PhD courses that had innovation strategy and innovation management at the core. Additional theories were added if they were industry-specific, emerging, and relevant for this study. Thus, academic theories in Table 4 will vary and evolve over time due to different environments and industries. Theories can be added, omitted, or repeated in each of the phases, but a competent researcher in the field of innovation or organizational literature should do this carefully.

This study, in effect, has two measures explaining the relationship between formalization and innovation. Hansen and Birkinshaw's modified questionnaire quantitatively measures the impact that formalization had on each of the four phases in the innovation process based on the participants' perception of their organization. Hansen and Birkinshaw's questionnaire does not determine if an innovation actually occurred, rather, it explains the extent to which phases within the innovation process have been improved (or innovation potential). The qualitative interview attempted to measure innovation more objectively and concretely. The review with management did not measure improvements in each innovation phase; it merely measured the result, whether an innovation per se occurred.

Quantitative data

It can be difficult to quantitatively measure an organization's innovative culture, values, beliefs, or capabilities, as these concepts tend to be abstract or intangible in nature (Christensen, 2000; Gershon, Stone, Bakken, & Larson, 2004; O'Reilly & Tushman, 2004). It has been suggested that it is simpler to quantitatively measure innovative climate, rather than culture (Gershon et al., 2004). Innovative climate refers to the employees' perception or attitude of their organizations culture (Gershon et al., 2004). Accordingly, this study gathered quantitative data based on a previously developed questionnaire (Hansen & Birkinshaw, 2007) that measured the participants' perception of their organizations' innovative culture. The original questionnaire was modified due to the shortfalls mentioned in the theoretical section above. This resulted in the questionnaire containing 25-items, rather than the original 13-items. Additionally, the scale was widened, from a 3-point to a 5-point Likert scale. Likert scales can range from a 2-point to a 10-point scale (Preston & Colman, 2000). There has been a growing trend to scale up when using Likert scales (Preston & Colman, 2000). However, a 10-point scale has been shown to produce slightly lower scores in general as compared with 5- to 7-point scales (Preston & Colman, 2000). This can mean that 10-point scales have too much variability for the respondent. For these reasons, this study chose to use a 5-point Likert scale. The last modification was made to the style in which the question was prompted. Originally, the questions were prompted in the negative form. For example, "Your firm does not assign value to ideas that come from outside the firm (1 = disagree and 3 = agree). Many of these questions were difficult to understand, especially when the question was asked in the negative, and the first evaluation response was in the negative (1 = disagree). There is a prevailing conventional wisdom that a mixture of positively and negatively worded items can counteract acquiescence response bias in surveys (Schriesheim & Hill, 1981). However, empirical evidence shows that negatively worded items may not be an appropriate control for acquiescence response bias (Schriesheim & Hill, 1981). Furthermore, negatively worded questions have been shown to impair response accuracy or, in other words, lead to respondent confusion (Schriesheim & Hill, 1981). Consequently, the survey questions in this study were restructured so that they were posed in the positive form. The questionnaire measured the participants' individual perception of their organization's innovation competence in four different phases of innovation: innovation strategy, idea generation, conversion, and diffusion. The participants were unaware of these classifications or phases; however, our guide measured which questions corresponded with each innovation phase. The participants evaluated whether they strongly disagree (1), or strongly agree (5), with each posited innovation question. The data was collected twice; once prior to any formal training and, again, after the training was completed. The first questionnaire was given to both groups to determine which phase was evaluated as the weakest. The weakest phase was identified as innovation strategy (Schultz et al., 2017). The thought is that if an organization formalizes their innovation process, they will know which phase of the innovation needs the most improvement. After the weakest phase was identified (from the first questionnaire), the participant group received four, 2-h formal innovation training sessions on that phase. The attendance was taken at the beginning of each session. The second questionnaire was then administered to both groups after the formal training was completed to determine if the training had

any impact on either group or the organization as a whole. The questionnaire was administered in-person during the workshop for the participating group, while the questionnaire was sent electronically from the manager for the nonparticipating group. After the nonparticipating group's questionnaires were received, the data from the first and second questionnaires were compared to better understand the relationship that formalization had on the innovation process, both before and after the formalization.

This study compared each group's correlation significance (Cohen, Cohen, West, & Aiken, 2013). Prior to any formal innovation training, both groups (the participant and nonparticipant group) completed the questionnaire to determine each group's initial level of innovation understanding. It is suggested that a *t* test is an appropriate measure when distinguishing between two groups' innovative climate or perception of their innovative activity (André, Ringdal, Skjong, Rannestad, & Sjøvold, 2016). Accordingly, a *t* test was conducted to determine if there was any significant difference between either groups' innovation understanding prior to any training. After the formal innovation training was completed for the participant group, both groups completed the questionnaire once again. From the data gathered after the formal training, two additional correlation analyses were conducted. A correlation of each group's responses, both before and after the training, was conducted to determine if the formal training had any effect on either group's innovative climate. As suggested, *t* tests were conducted to test the correlation significance (Sjøvold, 2007). This tested how each group member in the participant group perceived their innovation understanding before and after the training. We conducted the same *t* test for the nonparticipant group, but the nonparticipant group never received any formal training; thus, it was expected that their responses for both the first and second questionnaire should remain relatively similar. This type of study, using a 5-point Likert scale to capture differences between two groups' innovative climate, using a *t* test as the statistical analysis, has been previously validated (Schultz et al., 2017).

Qualitative data

Two different types of qualitative data were collected. First, data was collected from the ideas that surfaced during the training sessions. The training sessions consisted of both lectures and group work. During the lectures, the participants learned about various relevant academic theories (Table 4). During the group work, the participants applied the theory they were taught to work-life scenarios. It is recommended to have other researchers review the qualitative data that has been gathered in relation to research interpretations for quality assurance (Brinkman & Kvale, 2015; Kvale, 1996). Obtaining other perspectives of the same qualitative data helps validate that the interpretations were accurate (Kvale, 1996). However, in this study, no interpretations were needed. Transcription of the group work was conducted with substantial attention given to preserving the meaning the participants gave to the ideas (Brinkman & Kvale, 2015; Kvale, 1996). The ideas that surfaced from this group work, in all four training sessions, were the ideas that were transcribed (Table 2). The second form of qualitative data was gathered from an interview with management, after all the formal training was completed. Each idea in Table 2 was analyzed to determine the extent of its development. First, the

management was asked if the idea was new and originated from this training session. Additionally, the management was asked to determine the extent of the idea's development in the organization: (1) only discussed; (2) discussed, selected, and developed in progress; and (3) discussed, selected, developed, implemented, and diffused within the organization. If an idea made it through step three, then an innovation occurred, and the formalization had a positive impact on innovation, irrespective of the participating group's self-efficacy. It was difficult to control for reliability and validity of this data (Brinkman & Kvale, 2015; Kvale, 1996), as the information that was transcribed was based solely on the manager's knowledge.

Subjects and data collection

An innovation intervention was conducted. Data was collected from 40 health care practitioners ($N = 40$), from a publicly owned retirement home located in a rural part of Trøndelag, in Norway. The practitioners were divided into two groups, the participant group ($N = 15$) and the nonparticipant group ($N = 25$). The participant group will be participating in a formal innovation education, while the nonparticipant group will be conducting business as usual or maintaining status quo. Both groups are comprised of a unit leader, registered nurses, nursing assistants, and others. Participation in the formal innovation training was voluntary, meaning, the nonparticipant group members chose not to join.

Prior to any formal training, both groups completed the first questionnaire. From the participant group, 15 of 15 (100%) responded to the questionnaire sufficiently. The response rate was likely so high as the questionnaire was completed at the start of the first innovation training course. From the nonparticipant group, 22 of 25 (88%) were sufficiently completed. The response rate could have been lower because the questionnaire was sent electronically, from the manager to the employees, and the questionnaire was completed on their own time. At the conclusion of the innovation course, 10 of 15 (67%) questionnaires were sufficiently completed from the participant group, while the nonparticipant group completed 12 of 25 (48%) sufficiently. The second questionnaire for each group was completed in the same manner as the first questionnaire. The participant group completed their second questionnaire at the conclusion of the last innovation training course, while the nonparticipant group completed an electronic questionnaire on their own time.

Participation in this study was voluntary, and the participants could withdraw from the study at any point. The participants were informed about what their participation in the innovation training entailed and that their participation was going to be measured, and the results might be published as research. All data were registered anonymously to preserve the confidentiality of the participants. Management from both the unit and municipality approved the study.

Authors' contributions

JS is the corresponding or the main author of this manuscript. He led the project in its initiation, writing, and gathering of the data. BA contributed significantly in developing the paper, in terms of developing concepts/theory, having better structure/organizing the content, and analyzing the data. ES established the contacts necessary for setting up the intervention by attending important meetings with the local mayor and managers of the municipality where the intervention was conducted. He also assisted in strategizing direction with concepts and advising which methods he thought were appropriate for analyzing our data. Without the authors named in this manuscript, this research could not have been conducted in the way it was. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

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Multiple peer effects in the diffusion of innovations on social networks: a simulation study

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Abstract

Peer effects in innovation adoption decisions have been extensively studied. However, the underlying mechanisms of peer effects are generally not explicitly accounted for. Gaps in this knowledge could lead to misestimation of peer effects and inefficient interventions. This study examined the role of two mechanisms—sharing experiences (namely, experience effect) and externalities—in the adoption of an agricultural innovation. By referring to the diffusion process of a new crop in Chinese villages, we developed a simulation model that incorporated experience effect and externality effect on a multiplex network. The model allowed us to estimate the influence of each specific effect and to investigate the interplay of the positive and negative directions of the effects. The main results of simulation experiments were the following: (1) a negative externality effect in the system caused the diffusion of innovation to vary around a middle-level rate, which resulted in a fluctuating diffusion curve rather than a commonly found S-shaped one; (2) in the case of full diffusion, experience effect significantly shaped the diffusion process at the early stage, while externality effect mattered more at the late stage; and (3) network properties (i.e. connectivity, transitivity, and network distance) imposed indirect influence on diffusion through specific peer effects. Overall, our study illustrated the need to understand specific causal mechanisms when studying peer effects. Simulation methods such as agent-based modelling provide an effective approach to facilitate such understanding.

Keywords: Peer effects, Innovation diffusion, Social network, Agent-based simulation

Background

Social interactions can significantly shape individuals' economic behaviours. This is especially true when an individual behaves upon situations with uncertainties. In particular, an individual's decision on whether to adopt an innovation (i.e. the idea, practice, or object that are perceived as new (Rogers 2003)) often depends on the decisions of their friends, relatives, colleagues, etc. Such social influence is referred to as *peer effects*. Existing studies have examined peer effects on the diffusion of innovations in varied settings, including products and services (Goolsbee and Klenow 1999; Sorensen 2006; Kremer and Levy 2008; Luan and Neslin 2009), technologies (Munshi 2004; Bandiera and Rasul 2006; Conley and Udry 2010), financial services (Banerjee et al. 2013), and social programmes (Dahl et al. 2014). In these studies, many forms of peer effects, including word of mouth (Luan and Neslin 2009; Banerjee et al. 2013), social learning (Bandiera and Rasul 2006;

Conley and Udry 2010), and network externalities (Goolsbee and Klenow 1999), are discussed[1].

The work by (Xiong et al. 2016) distinguishes three basic interactions through which peer effects take place in the diffusion of innovations: transmitting information, sharing experiences and externalities. They are termed as *information effect*, *experience effect*, and *externality effect*, respectively. Specifically, information effect refers to the influence of the transmission of awareness information of the innovation and general information about the cost and benefit of adopting the innovation. The effect can occur through any relationship ties through which individuals can communicate. Experience effect characterises the influence that one obtains by sharing experiential knowledge (e.g. know-how, localised techniques) or physical resources (e.g. seeds of a new crop, tools) from earlier adopters. Such knowledge and resource are generally scarce at this stage of the diffusion process. Experience effect thus mainly occurs through close social relationships, such as kinship or close friendship. In addition, an individual's adoption behaviour can lead to positive or negative externalities. They can affect other individuals regardless of whether those individuals also adopt the innovation. Negative externalities leads to the reduction of payoff when staying on the original choice, and consequently increases individuals' propensity to choosing the innovation, which in turn increases the diffusion in the group, generating a positive externality effect. Likewise, positive externalities can generate a negative externality effect. In empirical studies, negative externality effect is rarely considered mainly due to the difficulty of collecting data. In general, the three effects have significant impacts on different stages of the diffusion process. Information effect shapes the process mainly at the early stage, experience effect at the intermediate stage, and externality effect at the late stage as depicted in Fig. 1.

Peer effects were previously studied either as a composite of different mechanisms or in a specific form (such as social leaning or network externalities). Typically only one mechanism was considered. However, a diffusion process is very often shaped by multiple mechanisms simultaneously, and each mechanism could play a different role at a different phase of the evolution of the process. Different mechanisms may potentially have different policy implications (Carrell et al. 2013; Alcalde 2013). This paper is a theoretical study to examine the roles of multiple peer effects

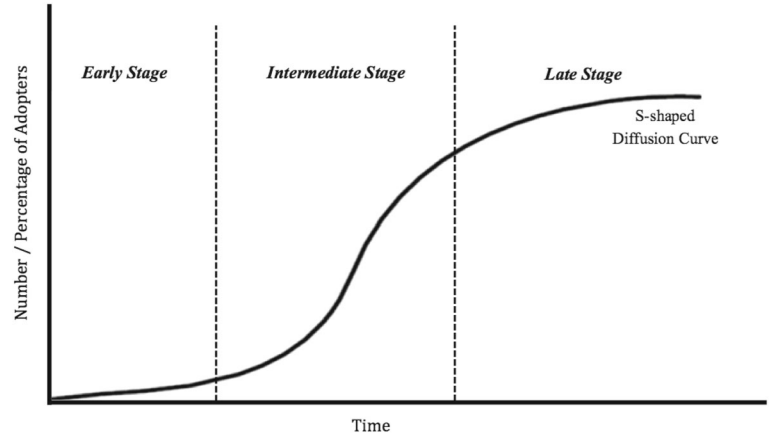

Fig. 1 Peer effects at different stages of the diffusion process

in the diffusion of innovations. We have chosen a case of the adoption of a new crop in rural China to set up our simulation model and to select key experimental parameters. In this case, all households were well informed of the new crop at the beginning of the diffusion, and thus, information effect is excluded from our model. Our model and estimation are therefore focused on experience effect and externality effect.

Background and data

This paper use the case of the diffusion of a high-value crop (a crop with high economic return) in 10 villages in rural China to demonstrate multiple types of peer effects in the adoption of an innovation. The farmers in these villages traditionally farmed staple rice and cotton. The new vegetable, *Artemisia selengensis* (AS), was introduced into the villages in 2001. To encourage farmers to grow AS, village leaders distributed some seed-stalks to each household for free. This action informed all households about the new crop. However, as the farmers were not certain about the profitability of farming a new crop, there were only one or two households in each village (the average number of households was 37, with a standard deviation of 14) who adopted in the first year. These earlier adopters were mainly motivated by the awareness information they obtained. Their adoption behaviour was thus the result of the information effect.

When other farmers realised that farming the AS was much more profitable, they also started to farm in subsequent years. However, they encountered difficulty in obtaining seed-stalks, which can only remain fresh for a few days. It turned out that the only reliable source at the time was the earlier adopters in their villages. The seed-stalks were so scarce at the time that a household could obtain them exclusively from its close relatives. Those who managed to obtain the seed-stalks in a given year then shared them with other households next year, and so forth. Meanwhile, new adopters were often benefited by obtaining techniques and tacit knowledge from their relatives and house neighbours who have adopted earlier. Overall, the sharing of such experiential resources provided the main motivation for farmers' adoption in this stage. By 2005, more than 70% of the households had adopted AS.

When the majority of the households by then had adopted, the non-adopters were put under some pressure to join in, mainly through the use of irrigation. There was nearly a half-year period during which both AS and cotton were active on the land. However, farming AS required much more water than farming cotton. A plot for farming cotton could thus be over flooded as its adjacent plots were planted with AS. Therefore, households farming cotton in this situation would be 'coerced' into adopting AS. Such adoption was thus attributed to positive externality effect.

Figure 2 presents adoption rates of the new crop throughout the entire diffusion period. It shows an S-shaped diffusion curve as many other studies do. This case provides an excellent demonstration for the study of different types of peer effects in a complete diffusion process.

The data collected from this case are used to calibrate the parameters in the model. They include the number of households (i.e. nodes in the social network), characteristics of household (e.g. risk preference) ratio of initial adopters (elaborated in the "Model parameterisation" section).

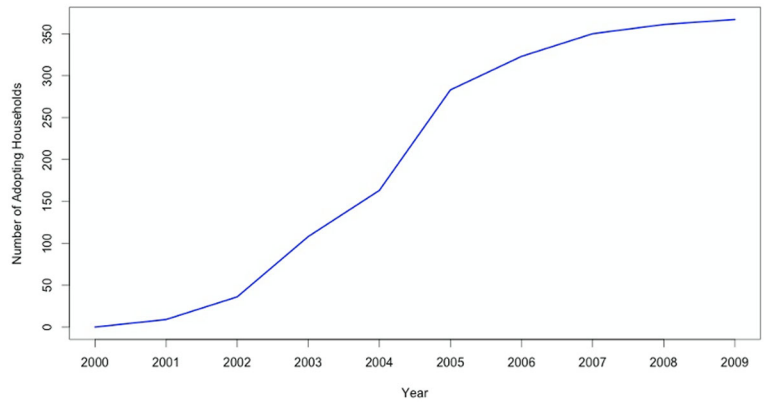

Fig. 2 Diffusion of the new crop in the Chinese villages

Methods and model

In this section, we first justify our choice of agent-based modelling for conducting this study. We then described how agents' behavioural environment (i.e. the social networks) and agents' decision-making are represented in our model. Finally, we present how parameters in the model are set up.

Agent-based modelling approach

The underlying mechanisms following which peer effects occur in a diffusion process are generally nuanced and subtle. Empirical analysis is largely restricted because of the difficulty of data collection. Moreover, traditional approaches such as regression analysis are not capable to explicitly represent dynamic behavioural mechanisms of such. Additionally, negative peer effects in diffusions seldom enter researchers' notice. This is because failed or incomplete diffusions, which negative effects often end up with, do not draw much attention. In this study, we conducted a theoretical study following the agent-based modelling approach. This approach is able to incorporate micro-level adoption mechanisms, individuals' heterogeneity, and social relationships among individuals (Kiesling et al. 2012). Particularly for this study, it allows for the incorporation of the negative externality effect. This approach has been used to examine, for instance, the negative effects of word of mouth (Goldenberg et al. 2001; Deffuant et al. 2005).

We developed an agent-based model with peer interactions being structured in a *multiplex network*, that is, a network consisting of multiple layers, on each of which a type of relationship is mapped (Arenas et al. 2014). This approach allows us to identify different peer effects in the system (Bramoulle et al. 2009; Goldsmith-Pinkham and Imbens 2013). To keep the model simple, we only include two effects: experience and externality. The development of our model is based on two assumptions.

Assumption 1: Peer effects exist and impose impacts on the diffusion process in the social system in study.

This assumption is made based on the theoretical analysis above as well as the observations from the real world. It permits us to circumvent the quagmire of *whether* peers affect each other and be focusing on the discussion on *how* this influence occurs (Guryan et al. 2008). This assumption is the prerequisite of to the simulation of the impact of peer effects, though it is often not explicitly stated in literature.

Assumption 2: Different types of specific peer effect (mainly) occur through different types of social relationship.

In our study, specific peer effects are distinguished according to the kind of social interactions through which they take place. It is observed that a particular type of social interaction tends to mainly take place through a particular type of social relationship (or a particular set of different types). Therefore, it is plausible that researchers are able to specify through which type(s) of relationship different specific peer effect occur in a system. This assumption enables us to model different specific peer effects on different network layers and examine how the characteristics of a network layer shape the peer effect on that layer.

Setup of network structure

We took the real-world case described in the "Background and data" section as a reference to design the simulation. We modelled the diffusion of the new crop using an agent-based model. In the model, the social system (environment) is village, represented as a social network. The agents were the households in the village, represented as nodes on the social network. In the villages, the interactions among households that substantially shape the diffusion mainly occurred through kinship ties, house neighbourhood ties and land plot neighbourhood ties[2].

In the model, a small portion of households are set to have adopted the innovation in the initial time. They can be considered as those adopted due to the awareness of the innovation. In other words, our model ignores information effect and focuses on experience effect and externality effect. According to the previous discussion, we reasonably assumed that experience effect occurs through kinship ties and house neighbourhood ties, whereas externality effect occurs through land plot neighbourhood ties. Since the kinship ties and house neighbourhood ties are highly overlapped in these villages (as the land for building houses were to large extent allocated based on extended family, house neighbours are often family members), we term the network consists of the two types of ties as kinship network for the sake of simplicity. The network consists of land plot neighbourhood ties is thus termed as neighbourhood network. The social network on which the peer effects occur are structured thus has two layers: the kinship network layer and the neighbourhood network layer, as demonstrated in Fig. 3.

We then simulated the kinship network as a Watts-Strogatz (WS) small-world network (Watts and Strogatz 1998) and simulated the neighbourhood network as an Erdös-Rényi (ER) random network (Erdős and Rényi 1959). These settings are reasonable. First, the kinship networks in these villages are very similar to small-world networks according the empirical study (Xiong and Payne 2017) and this finding echoes the classic theory of 'acquaintance society' on the structure of traditional Chinese structure. Second, the land plot neighbourhood networks are close to random networks according to the same empirical study. This is the case because the plots were originally distributed by lot. The parameters defining the network structures were roughly calibrated according to the network characteristics of the villages in our real-world case.

Simulation of agents' decision-making

Two approaches are widely utilised to describe diffusion in social groups. One is a probability-based approach (e.g. (Banerjee et al. 2013; Peres 2014)), where individuals'

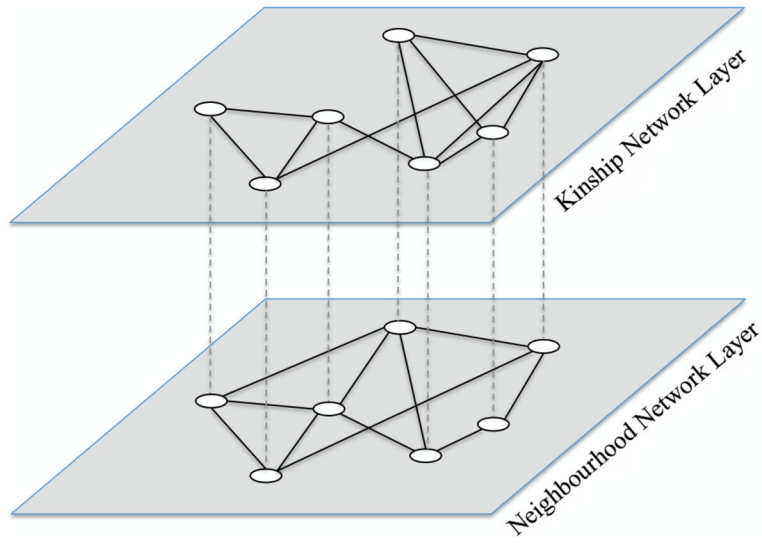

Fig. 3 A two-layer multiplex network

probability of adopting the innovation increases as the fraction of peers that adopt increase. The other is a threshold-based approach (e.g. (Granovetter 1978; Singh et al. 2013)), where individuals change their adoption state when a certain threshold of utility is reached. In the case of this study, on the kinship network, the more an individual's peers have adopted the new crop, the more likely that the individual gains information and thus follow suit. We therefore simulated experience effect on the kinship network following the probability-based approach. The probability for an individual to adopt is proportional to the fraction of his family members who have adopted. Meanwhile, the externalities of planting the new crop are mainly determined by the nature of the crop itself, such as its compatibility with the existing crop. This can be viewed as a threshold that all practitioners face. Once the fraction of one's neighbours who adopt reaches the threshold, an individual will adopt for sure. Thus, the externality effect occurring on the neighbourhood network is modelled using a threshold.

Suppose there are N nodes in the network, i.e. on each of the two layers. On the kinship network, node (household) i chooses to adopt the innovation with a probability p_i. The probability is determined by the fraction of his adopting peers f_i^{kin} as well as his risk preference (a representative of the individual's personal characteristics) $x_i \in (0, 1)$. Therefore, $p_i = \theta f_i^{\text{kin}} x_i$, where $\theta \in (0, 1)$ is a coefficient indicating the degree of information effect (namely *information coefficient*). On the neighbourhood network, household i changes his adoption state when the fractions of his adopting neighbours f_i^{geo} reaches a unified adoption threshold (namely *externality threshold*, denoted by δ), which is determined by the characteristics of the new crop. When the threshold is reached, in the scenario of the positive externality effect, the *non-adopters* switch to adopting state; in the scenario of negative externality effect, the *adopters* change back to non-adopting.

A household has two adoption status: *adopting* or *non-adopting*. We track households' adoption states and the ratio of adopting households (namely the *adoption rate*) at the village level. The basic algorithm of the simulation is as follows:

(i) Initial time $t = 0$

A fraction λ of seed adopters is selected from the population of the households at random. Meanwhile, their adoption states are set to be adopting.

(ii) Iteration at time t,
Households update their state through kinship ties and neighbourhood ties simultaneously.

(a) Updating on the kinship network
The non-adopters adopt with probability $p_{it} = \theta f_{it}^{\text{kin}} x_i$.

(b) Updating on the neighbourhood network
In the scenario of positive externality effect, non-adopting household i transmits to adopting state once the fraction of his adopting neighbours reaches the externality threshold, i.e. $f_{it}^{\text{geo}} > \delta$.
In the case of negative externality effect, adopting household i transmits to non-adopting state once the fraction of his adopting neighbours reaches the externality threshold, i.e. $f_{it}^{\text{geo}} > \delta$.

The two updating mechanisms occur simultaneously in reality, so we set the order to be random when updating on the two layers in the model. The process repeats until any of the following termination rules is satisfied: (i) the adoption rate is lower than 5% (which is the lowest ratio of seed adopters), (ii) the adoption rate is higher than 95% (i.e. complete diffusion), and (iii) it iterates for 20 times—this is sufficient for the system to converge in most cases (both in the simulation and in the real world).

Model parameterisation

The parameters in the simulation model are set using the survey data from the 10 reference villages. Parameter values are set to the mean estimates from the data. The parameters were set up as follows:

- Number of nodes (the population) $N \in [\,20 : 20 : 80]$
- Fraction of rewiring nodes in the generation of WS small-world networks $WS_f \in \{0.05, 0.s, 0.15\}$
- Rewiring probability in the generation of ER random networks $\text{ER}_{\text{prob}} \in \{0.10, 0.15, 0.20\}$
- Experience coefficient $\theta \in [\,0.05 : 0.05 : 0.25]$
- Externality threshold $\delta \in [\,0.6 : 0.05 : 0.80]$
- Ratio of seed adopters $s \in [\,0.05 : 0.05 : 0.20]$
- Risk preference of household i, x_i. The value is generated as a positive random number with normal distribution (mean 1 and standard deviation 0.3; truncated to 0 and 2 for values less than 0 and greater than 2 respectively).

We run each parameter combination 100 times. There are 3600 (full factorial) combinations in total, and the model runs each of these combinations 100 times. Finally, 360,000 sets of simulation results were generated.

Results and discussion

Convergence adoption rates and diffusion curves

Scenario of positive externality effect

Convergence adoption rates. The densities of convergence adoption rates and convergence rounds are presented in Fig. 4. The left panel shows that approximately 85% of the

runs converge to *full adoption* (that is, as we defined, more than 90% of the population have adopted) within 20 iterations. It means that most individuals adopt eventually. The right panel indicates how many rounds it takes for the runs to converge. More than 40% of the runs converge in five rounds. The density decreases with the number of rounds[3]. In this scenario, both the two diffusion mechanisms are positive feedback mechanisms, so it is very likely that the system will converge to complete diffusion.

S-shaped diffusion curves. The S-shaped adoption curve is a typical pattern of the diffusion. It holds because most innovations bear the following feature: The adoption rate grows slowly at the beginning of the diffusion process. When the diffusion reaches the *critical mass*, it will have a sharp increase. After that, it will slowly approach complete diffusion. The variance lies in the slope of the curve. The innovations diffusing rapidly generate steep curves, whereas those diffusing slowly generate flat curves. Our simulations successfully generate S-shaped diffusion curves. Figure 5 displays the curves for the diffusions converge at the sixth round, and the ratio of seed adopters is 0.05 and 0.1, respectively[4].

Scenario of negative externality effect

Convergence adoption rates. The diffusion converges to diverse adoption rates in this scenario. As shown in Fig. 6, nearly 70% of the simulations converge to an adoption rates between 40 and 80%. Specifically, more than 25% converge to a value in the interval of $50-60\%$ and more than 25% converge to a value between 60 and 70%. Only about 5% end up with full adoption. More than 90% of the simulations converged within 20 rounds.

When a negative effect is introduced, the diffusion curve dramatically changes its shape. Converging to full adoption is not a certain outcome any more. At which adoption rate the diffusion will converge depends on the competition between the positive effect and the negative effect. This result provides an interpretation of the incomplete diffusion phenomena in the real world. For instance, in the case of mircofinance (Banerjee et al. 2013), the average take-up rate is 18.5% over all rural communities that were studied. Most innovations end up with not been taken up by all potential adopters in the social group. New fashionable clothes can be a typical example. When they go from high fashion to street

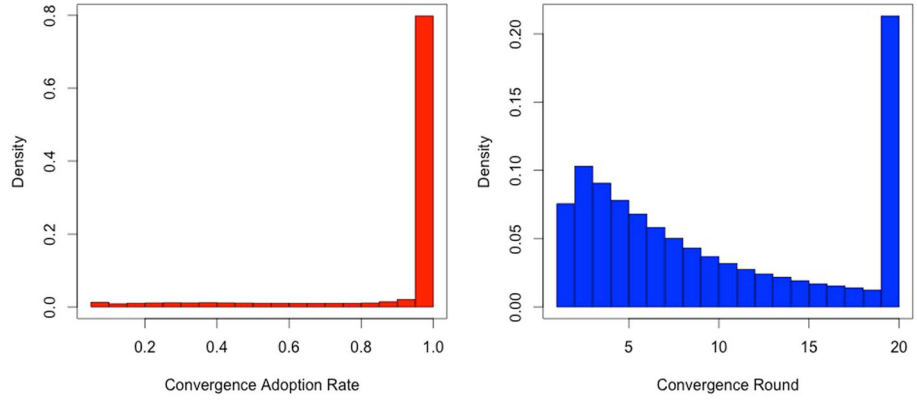

Fig. 4 Histograms of convergence adoption rates and convergence rounds (positive externality effect)

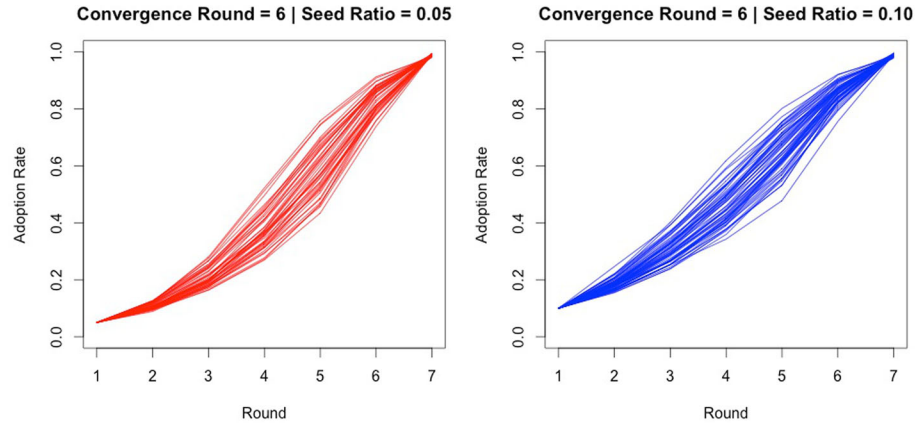

Fig. 5 S-shaped diffusion curves (convergence round = 6)

fashion, they are not considered fashionable any more, and thus become less attractive. This negative effect leads the diffusion to converge before reaching full adoption.

Fluctuating diffusion curves. Figure 7 displays the diffusion curves for the simulations that converge, again, at the sixth round with the ratios of seed adopters 0.05 and 0.1, respectively. To exhibit the trends of the curves, the adoption rates after the convergence are also plotted. The graph shows that the diffusion curves fluctuate around a value in the middle of 0 and 1 (approximately 0.6 in our case). The specific convergence value depends on the relative strength of the two opposite effects in the diffusion process.

Overall, when all specific diffusion mechanisms in the system are in favour of diffusion, the system will almost always converge to complete diffusion, and an S-shaped diffusion curve will be generated. When there is a negative mechanism, it reshapes the diffusion to fluctuate around a middle-level rate, hence generating fluctuating diffusion curves.

Experience effect and externality effect

We explore how experience effect and externality effect influence the effectiveness of diffusion, which is measured by the reach of the diffusion and its speed. The two measures are both related to *adoption rate*, the fraction of households that have adopted at a round

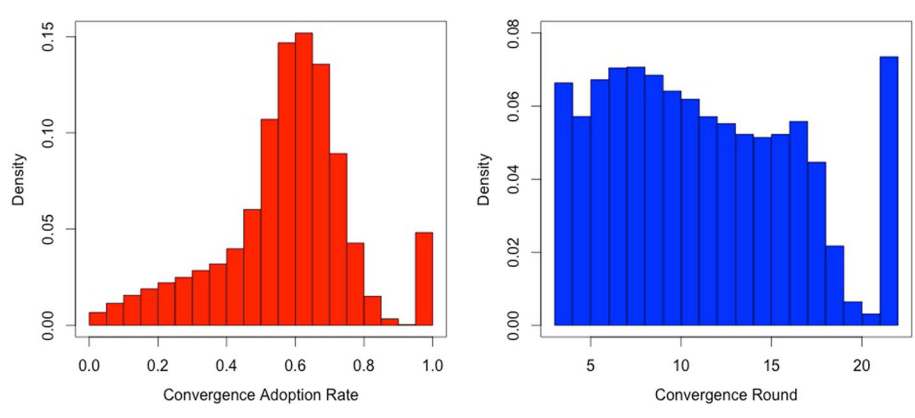

Fig. 6 Histograms of convergence adoption rates and convergence rounds (negative externality effect)

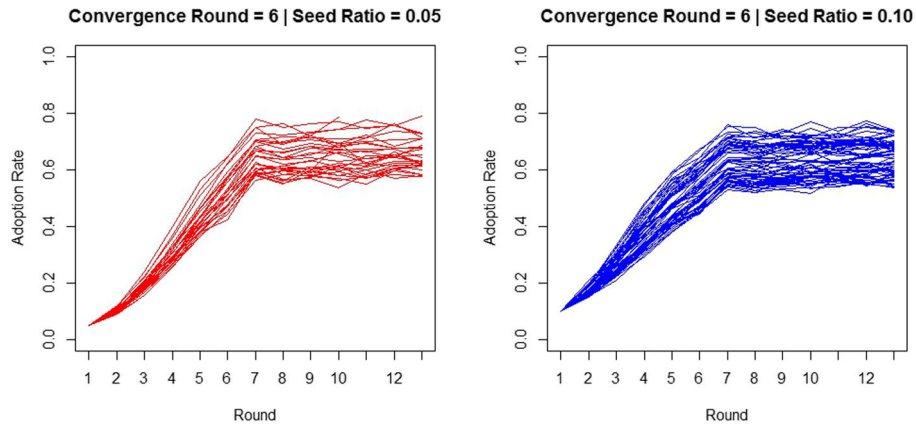

Fig. 7 Fluctuating diffusion curves (convergence round = 6)

to the whole population. Specifically, *convergence adoption rate*, reflecting the reach of the diffusion, is defined as the adoption rate at which the diffusion converges. *Diffusion speed* is defined as the increase of the adoption rate per round, or namely, the expression of the adoption rate achieved by the number of rounds to achieve it[5]. However, the two metrics cannot be both used in positive and negative externality effect at the same time. When the externality effect is positive, the diffusion almost always converges to 100%, so the convergence adoption rate is not a feasible metric. Likewise, the diffusion speed does not apply when the externality effect is negative because the adoption rate oscillates over the diffusion process, but we can use *convergence speed* (how fast the diffusion process converges) as a substitute. It is the quotient of convergence adoption rate by the number of rounds it takes to achieve the rate. Therefore, the diffusion speed is used in the scenario of positive externality effect, whereas the convergence adoption rate and convergence speed are employed in the scenario of negative externality effect.

In the model, the experience effect and the externality effect are reflected by the experience coefficient and the externality threshold, respectively. Higher experience coefficient indicates higher experience effect, whereas higher externality threshold indicates lower externality effect. To estimate their impact on the effectiveness of diffusion, we run a multivariate regression using the following equation:

$$y = \alpha_0 + \alpha_1\theta + \alpha_2\delta + \alpha_3 s + W'\alpha_4 + \epsilon \tag{1}$$

where y is the diffusion speed (in the scenario of positive externality effect) or the convergence adoption rate (in the scenario of negative externality effect), θ is the experience coefficient, δ is the externality threshold, s is the ratio of initial seed adopters, and W' is the network characteristic controls, including number of nodes N, parameters used in generating ER network (i.e. rewiring probability $\mathrm{ER}_{\mathrm{prob}}$), and WS network (i.e. fraction of rewiring nodes WS_f).

We note that the traditional null hypothesis test is not well suited for simulation studies because with a sufficient number of simulated trajectories one can make the p value arbitrarily small (Heard et al. 2014). Thus, we conduct a traditional minimum-effect test. We test that the difference is bigger than an a priori defined minimal meaningful effect (MME). Parameter values significantly smaller than the MME signify no effect. Parameter

values significantly large than MME signify significant difference, and when the statistical significance is not achieved, it signifies that no conclusion could be made given the data. Under such paradigm, the increase in the number of simulations will increase the precision and reduce the *p* values but will not produce artificially significant small-effect sizes (Wellek 2010). Such approach is also the basis for a classic power analysis, which requires to explicitly define a minimally meaningful effect size. In our study, we have selected the MME to be 0.1 standard deviation. Our judgement on the significance of estimated values in the regression results in this study are based on the minimum-effect test (whether they are significantly larger than the minimal effect defined as 0.1 of the standard deviation).

Scenario of positive externality effect

We regress the diffusion speed when the adoption rate reaches 30%, 40%, up to 90%. Table 1 presents the results[6]. First, all the estimated values were significantly larger than the minimal effect defined as 0.1 of the standard deviation. Specifically, both the experience coefficient and the externality threshold in the simulation are highly significantly associated with the diffusion speeds, and the signs are in accordance with expectations. This indicates that they both impose a significant influence on the diffusion. More importantly, we found the influence of the experience effect wanes as the adoption rate increases (i.e. the diffusion process), while the influence of the externality effect continuously grows. At the earlier stage, the adopters are few, so only a small number of households can reach the externality thresholds. Consequently, the externality effect has a limited impact on the diffusion. Meanwhile, the experience effect, which is continuous and steady, has a major contribution. At the later stage, there are more adopters; thus, more households can reach the externality threshold. Externality effect, therefore, become relatively higher. However, this could undermine the influence of experience effect, because the two effects can substitute each other—a household can make the adoption decision because of either experience effect or externality effect. Such a substitution effect becomes larger as the adoption rate increases.

Scenario of negative externality effect

We run the regression also using Eq. (1). The same explanatory variables as in the scenario of positive externality effect (the experience coefficient, the externality threshold, the ratio

Table 1 Regressions of adoption speed at different diffusion levels (positive externality effect)

	Model 1 (30%)*	Model 2 (40%)	Model 3 (50%)	Model 4 (60%)	Model 5 (70%)	Model 6 (80%)	Model 7 (90%)
(Intercept)	− 0.53	− 0.50	− 0.47	− 0.45	− 0.43	− 0.32	− 0.32
Number of households	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ratio of seed adopters	0.90	0.84	0.81	0.80	0.78	0.57	0.57
Experience coefficient	2.04	2.02	2.01	1.99	1.94	1.54	1.54
Externality threshold	− 0.18	− 0.21	− 0.23	− 0.25	− 0.26	− 0.28	− 0.28
% of neighbours to connect in WS	3.23	3.24	3.23	3.21	3.16	2.53	2.53
Rewiring probability in ER	− 0.15	− 0.14	− 0.12	− 0.10	− 0.08	0.09	0.09
R^2	0.75	0.78	0.80	0.80	0.80	0.72	0.72

*The adoption rate level for diffusion speed in the present regression. This is the same for Tables 4, 5, and 6

of initial seed adopters, and the network characteristics) are employed. They are regressed against two response variables, the convergence adoption rate (model 1 in Table 2) and the convergence speed (model 2 in Table 2). The results show that both the experience effect and the externality effect are significantly correlated to these response variables with expected signs, suggesting that they both have significant impacts on diffusion[7].

Network characteristics and peer effects

The diffusion of innovation is usually influenced by the structure of the network in which it takes place (Peres 2014). We measure the structure of the networks used in our simulation using three metrics: average degree, clustering coefficient, and average path length. They are chosen because they reflect different aspects of the characteristics of a network: average degree indicates how connected the network is (i.e. the connectivity); clustering coefficient measures how clustered the nodes are and thus how well the information can transmit (i.e. the transitivity); and average path length represents how many intermediaries it needs for one node to reach another (i.e. the network distance).

To estimate the impact of these network topological metrics on the corresponding network layer, we introduce a interaction term into the regressions. The interaction term is generated by multiplying the experience coefficient or the externality threshold by each of the topological metrics on the corresponding network layer. The interaction effect can be interpreted from the regression coefficients of the interaction terms. As different topological metrics and the network generation parameters are highly correlated with each other (as presented in Table 3 for the scenario of positive externality effect, and those for the scenario of negative externality effect are similar), we run the regression for each topological metric separately (and drop the network generation parameters served as controls).

The resultant regression equation is the following:

$$y = \beta_0 + \beta_1\theta + \beta_2\delta + \beta_3 Net\_char + \beta_4 Inter\_term + \beta_5 s + \epsilon \tag{2}$$

where *Net_char* denotes the vector of topological metrics on the kinship network and the neighbourhood network, respectively, and *Inter_term* denotes the vector of interaction terms. The interaction term is the product of a topological metric and the corresponding peer effect indicator occurring on the network. For instance, the interaction term of average degree and peer effect on kinship network is $(\textit{average degree of kinship network}) \times \theta$. One topological metric is run for each regression. As there are two scenarios, the regression runs in a total of 6 times (3×2).

Table 2 Regressions of convergence adoption rate and convergence speed (negative externality effect)

	Model 1 (Conv. Adp. rate)	Model 2 (Conv. speed)
(Intercept)	0.90	− 0.31
Number of households	0.00	0.01
Ratio of seed adopters	0.17	0.57
Experience coefficient	0.19	1.53
Externality threshold	− 0.05	− 0.28
% of neighbours to connect in WS	0.39	2.53
Rewiring probability in ER	− 0.02	0.06
R^2	0.11	0.72

Table 3 Correlations between network characteristics (positive externality effect)

	(Var 1)	(Var 2)	(Var 3)	(Var 4)	(Var 5)	(Var 6)	(Var 7)	(Var 8)
WS_f	1							
Avg. Dg. of Kin.	0.65	1						
Clu. Coef. of Kin.	0.83	0.69	1					
APL of Kin.	− 0.73	− 0.64	− 0.86	1				
ER_{prob}					1			
Avg. Dg. of Nei.					0.49	1		
Clu. Coef. of Nei.					0.71	0.43	1	
APL of Nei.					− 0.65	− 0.76	− 0.58	1

Scenario of positive externality effect

As discussed previously, we use the diffusion speed as the response variable in the regressions. Results for average degree, clustering coefficient, and average path length are displayed in Tables 4, 5, and 6, respectively.

First, the coefficients of all the interaction terms with the three metrics are significant, indicating that interaction effects do exist. Specifically, average degree significantly enhances both the experience effect and the externality effect, that is, with the increase of average degree, their impacts on diffusion speed grow. As the system proceeds to a higher diffusion level, the interaction effect on the experience effect shrinks, while that on the externality effect grows. The degree of clustering also strengthens these two effects, although the influence is not significant for the externality effect when the diffusion is at the early stage. As the overall adoption rate grows, it turns significant and becomes stronger, while the influence for the experience effect falls gradually. The distance between households also significantly affects the performance of the two effects, but in an opposite direction (i.e. a lower distance corresponds to a higher experience effect or externality effect and vice versa). Comparing the three metrics, the clustering coefficient produces a much higher impact (while it is significant) than the others, whereas the average degree and the average path length have a weak influence. In other words, the transitivity of the network matters more than the connectivity and the distance in shaping peer effects.

Table 4 Regressions of adoption speed on average degree (positive externality effect)

	Model 1 (30%)	Model 2 (40%)	Model 3 (50%)	Model 4 (60%)	Model 5 (70%)	Model 6 (80%)	Model 7 (90%)
(Intercept)	− 0.07	− 0.05	− 0.04	− 0.03	− 0.01	0.02	0.02
Number of households	− 0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ratio of seed adopters	0.90	0.84	0.81	0.80	0.78	0.57	0.57
Experience coefficient (Var 1)	0.87	0.99	1.07	1.08	1.02	0.74	0.74
Externality threshold (Var 2)	− 0.16	− 0.19	− 0.21	− 0.23	− 0.23	− 0.22	− 0.22
Average degree of Kin. (Var 3)	0.01	0.01	0.02	0.02	0.01	0.01	0.01
Average degree of Nei. (Var 4)	− 0.00	0.00	0.00	0.00	0.00	0.01	0.01
Var 1 × Var 3	0.12	0.10	0.10	0.09	0.09	0.08	0.08
Var 2 × Var 4	− 0.01	− 0.00	− 0.00	− 0.00	− 0.00	− 0.01	− 0.01
R^2	0.80	0.81	0.82	0.82	0.82	0.75	0.75

Table 5 Regressions of adoption speed on clustering coefficient (positive externality effect)

	Model 1 (30%)	Model 2 (40%)	Model 3 (50%)	Model 4 (60%)	Model 5 (70%)	Model 6 (80%)	Model 7 (90%)
(Intercept)	− 0.17	− 0.17	− 0.17	− 0.16	− 0.15	− 0.08	− 0.08
Number of households	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ratio of seed adopters	0.91	0.84	0.81	0.80	0.78	0.57	0.57
Experience coefficient (Var 1)	0.21	0.35	0.43	0.45	0.41	0.31	0.31
Externality threshold (Var 2)	− 0.18	− 0.20	− 0.21	− 0.22	− 0.23	− 0.25	− 0.25
Clustering coefficient of Kin. (Var 3)	0.12	0.22	0.29	0.31	0.30	0.24	0.24
Clustering coefficient of Nei. (Var 4)	− 0.10	− 0.03	0.04	0.07	0.12	0.22	0.22
Var 1 × Var 3	7.06	6.47	6.10	5.9	5.80	4.77	4.77
Var 2 × Var 4	− 0.00	− 0.08	− 0.16	− 0.20	− 0.24	− 0.25	− 0.25
R^2	0.70	0.72	0.74	0.75	0.75	0.68	0.68

Scenario of negative externality effect

In the scenario of negative externality effect, the converged adoption rate and the speed of convergence are used as response variables to run regression using the Eq. (2). Results are presented in Table 7 (average degree), Table 8 (clustering coefficient), and Table 9 (average path length).

We also found that interaction effects with all the three metrics are significant. Specifically, on the kinship network, average degree undermines the impact of experience effect on the converged adoption rate, but enhances its impact on convergence speed. On the neighbourhood network, the average degree enlarges the impact of externality effect on converged adoption rate, but dilutes its impact on convergence speed. Interaction effects with clustering and distance between households are more prominent. On the kinship network, the interaction effect largely reduces the impact of experience effect on the converged adoption rate and raises it on diffusion speed, thus contributing to a reduced converged adoption rate and helping speed up the convergence of the system. On the neighbourhood network, interaction effect amplifies the impact of externality effect on converged adoption rate and largely reduces that on diffusion speed, which leads the adoption rate to converge to a lower value but at a higher speed. The interaction effect with average path length follows the same pattern but in an opposite direction. The shorter path length is generally associated with lower converged adoption rate and higher

Table 6 Regressions of adoption speed on average path length (positive externality effect)

	Model 1 (30%)	Model 2 (40%)	Model 3 (50%)	Model 4 (60%)	Model 5 (70%)	Model 6 (80%)	Model 7 (90%)
(Intercept)	− 0.18	− 0.08	− 0.01	0.03	0.06	0.23	0.23
Number of households	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ratio of seed adopters	0.90	0.84	0.81	0.80	0.79	0.57	0.57
Experience coefficient (Var 1)	4.29	4.11	3.99	3.91	3.84	3.05	3.05
Externality threshold (Var 2)	− 0.25	− 0.30	− 0.34	− 0.36	− 0.39	− 0.50	− 0.50
APL of Kin. (Var 3)	0.01	− 0.01	− 0.02	− 0.02	− 0.02	− 0.02	− 0.02
APL of Nei. (Var 4)	0.00	− 0.01	− 0.02	− 0.02	− 0.03	− 0.07	− 0.07
Var 1 × Var 3	− 1.01	− 0.94	− 0.89	− 0.87	− 0.85	− 0.68	-0.68
Var 2 × Var 4	0.03	0.04	0.05	0.05	0.06	0.09	0.09
R^2	0.67	0.69	0.71	0.72	0.72	0.65	0.65

Table 7 Regressions of convergence adoption rate and convergence speed on average degree (negative externality effect)

	Model 1 (Conv. Adp. rate)	Model 2 (Conv. speed)
(Intercept)	0.85	0.08
Number of households	0.00	0.00
Ratio of seed adopters	0.50	0.34
Experience coefficient (Var 1)	0.50	0.90
Externality threshold (Var 2)	− 0.05	− 0.28
Average degree of Kin. (Var 3)	0.01	0.02
Average degree of Nei. (Var 4)	0.01	− 0.01
Var 1 × Var 3	− 0.03	0.02
Var 2 × Var 4	− 0.04	0.09
R^2	0.11	0.74

diffusion speed. Overall, these results suggest that stronger connectivity, higher transitivity, or shorter distance shape the peer effects in a way that the system converges at a lower adoption rate and more speedily.

Conclusions

This study distinguishes three basic underlying mechanisms through which peer effects in the diffusion of innovation occur: information transmission, experience sharing, and externalities. Correspondingly, peer effects are classified as information effect, experience effect, and externality effect. In the case of diffusion of a rural innovation, we found that each of the three effects played a dominant role at the early, intermediate, and late stages, respectively. Peer effects can be better understood by investigating the specific effects and their roles at different stages of the dynamic diffusion process.

By referring to the diffusion process of a rural innovation in the real world, we developed an agent-based model that incorporates experience and externality effects on a multiplex network. The model allows us to estimate the influence of each specific effect and investigate the interplay of positive and negative effect. In particular, we examined how experience effect and externality effect shape the diffusion jointly. By conducting experiments using the model, we obtained several findings. First, our model successfully replicates the widely acknowledged S-shaped diffusion curve in the scenario of positive

Table 8 Regressions of convergence adoption rate and convergence speed on clustering coefficient (negative externality effect)

	Model 1 (Conv. Adp. rate)	Model 2 (Conv. speed)
(Intercept)	0.78	− 0.18
Number of households	0.00	0.00
Ratio of seed adopters	1.02	0.24
Experience coefficient (Var 1)	0.20	1.43
Externality threshold (Var 2)	− 0.05	− 0.28
Clustering coefficient of Kin. (Var 3)	0.66	0.79
Clustering coefficient of Nei. (Var 4)	0.00	− 0.08
Var 1 × Var 3	− 3.29	1.29
Var 2 × Var 4	− 0.10	0.72
R^2	0.18	0.66

Table 9 Regressions of convergence adoption rate and convergence speed on average path length (negative externality effect)

	Model 1 (Conv. Adp. rate)	Model 2 (Conv. speed)
(Intercept)	1.28	0.04
Number of households	0.00	0.00
Ratio of seed adopters	− 0.98	0.97
Experience coefficient (Var 1)	− 0.44	2.87
Externality threshold (Var 2)	− 0.05	− 0.28
APL. of Kin. (Var 3)	− 0.10	− 0.10
APL. of Nei. (Var 4)	− 0.04	0.08
Var 1 × Var 3	0.52	− 0.18
Var 2 × Var 4	0.28	− 0.59
R^2	0.22	0.63

externality effect. This finding is consistent with the pattern argued in the theory of diffusion of innovations (Rogers 2003). However, when there is a negative effect in the system (the negative externality effect, in our case), the diffusion will vibrate around a middle-level rate between 0 and 100%. Accordingly, the diffusion curve will be a fluctuating one. This curve demonstrates the trajectory of the interplay of opposite effects. In reality, many innovations do not end up being adopted by the whole population of potential adopters. This could be accounted for by the existence of negative effects. However, the role of negative effects is usually left undiscussed in literature.

Second, our simulation results show that experience effect has a relatively higher influence on diffusion at the earlier stage, whereas externality effect dominates at the later stage in the scenario of positive externality effect. Along with the findings regarding the information effect we learnt in the real-world case, it is likely to be true that each of the three effects plays a dominant role at a different stage of a complete diffusion process, one after another. This pattern is not found in the scenario of negative externality effect, although both influences are still significant. This is perhaps due to the fact that the opposite effects can offset each other in the diffusion process, which leaves the feature associated with the strength of the effects inconspicuous. In general, the result suggests that a diffusion process should be examined from a dynamic perspective, and the influence of each specific peer effect needs to be estimated by the period in the diffusion process. Although a couple of attempts to distinguishing mechanisms underlying peer effects can be found (Banerjee et al. 2013; Bursztyn et al. 2014), none of them examines the mechanisms at different periods of the diffusion process.

Third, we found that network properties of connectivity, transitivity, and network distance can indirectly influence diffusion through the specific peer effect that occurs on the network. Specifically, in the scenario of positive externality effect, both experience effect and externality effect are generally enhanced in networks that are well connected, highly transitive, and with low distance between individuals. The effectiveness of the diffusion is thus improved. These findings are in line with existing studies (Janssen and Jager 2003; Laciana et al. 2013; Peres 2014). However, we find no studies considering the negative effect. In the case of negative effect, our work shows that these characteristics shape the two effects in a way that helps speed up diffusion, but tends to lower the coverage it

could reach. These together suggest that each specific peer effect is reshaped by the structure of the network where it occurs. This could further influence the effectiveness of the diffusion.

Overall, our study shows that it needs to delve into the specific underlying causal mechanisms when we study peer effects. The influence of each underlying mechanism varies by the stages of the diffusion process and by the topological characteristics of the underlying network. In addition, the negative effect, if exists, should be taken into account. It can substantially modify how the diffusion proceeds and its outcome. Our study also suggests that it could be an effective approach to investigate specific peer effects by conducting simulation on social networks.

Endnotes

[1] Refer to Xiong et al. (2016) for a detailed survey.

[2] This is what is found in the empirical study. Refer to Xiong and Payne (2017) for a detailed discussion.

[3] The density at the 20th round is as high as over 15% because it also contains the cases that take more than 20 rounds to converge and those do not converges to full adoption.

[4] To have a better visualisation, we average the adoption rates over repetitive runs. The speed at which the adoption rate grows varies significantly over different settings, so a fat midsection of the integrated graph is observed when plotting all the curves in one frame of axes.

[5] To measure the number of rounds over all runs with a unified standard, we split the values of adoption rate into 10 diffusion bins. The values higher than 10% and less than 20% are in the 10% bin, those higher than 20% and less than 30% are in the 20% bin, and so on, up to the 90% bin. For instance, it takes 4 rounds for the diffusion to first achieve the diffusion level of, say, 58%. The actual adoption rate at the 4th round is 58%. Suppose the seed ratio is 10%, then the growth rate for the system to achieve 50% diffusion in this setting is $(58\% - 10\%)/4 = 12\%$. There are cases that the diffusion speed is the same for several diffusion bins. For instance, suppose the adoption rate jumps from 34 to 66% at the fourth round, and the seed ratio is 10%, the diffusion speed for the 30% bin is thus $(34\% - 10\%)/3 = 8\%$, and that for the 40%, 50%, and 60% bins are all $(66\% - 10\%)/4 = 14\%$.

[6] All effect sizes reported in the table were significantly larger than the minimally meaningful effect of 0.1 standard deviations. This is the same for all the following tables that report regression results.

[7] The quality of fit for the models using convergence adoption rate as the response variable (model 1 in Table 2, 7, 8, and 9) is low. Other factors or non-linear structures could provide a better model fit. However, in here, we have focused on specific models, and the exploration of the best fitted models is beyond the scope of the study.

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Authors' contributions
HX led the writing of the manuscript with all other authors contributing to ideas and writing. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

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Empirical study on innovation motivators and inhibitors of Internet of Things applications for industrial manufacturing enterprises

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Abstract

Industrial manufacturing enterprises in export-oriented economies rely on product or service innovation to maintain their competitive advantage. Decreasing costs of computing power, connectivity and electronic components have facilitated a wide range of innovations based on Internet of Things (IoT) applications. However, only few successful IoT applications specific to industrial manufacturing enterprises are known. Although academics have been investigating challenges related to realising IoT, existing literature does not explain this situation integrally. Therefore, interest and engagement in and motivators and inhibitors of IoT application development and deployment are investigated based on a literature review and empirically based on a survey with $N = 109$ participants from enterprises in the Swiss metal, electrical and machine industries. Most enterprises are interested and are often engaged in IoT application development. Improving service and aftersales activities through IoT applications is a common motivator. Inhibitors from four domains hinder the development of IoT applications: business, organisational, technological and industrial. Business and organisational inhibitors are perceived to be more challenging than the technological and industrial ones. The business and organisational issues presented herein have essential impacts on the success of innovation in IoT applications. The results indicate future research directions for the innovation and development of IoT applications, and they can be used by organisations interested in IoT-based innovations to refine policy and decision-making.

Keywords: Internet of things, Digitalisation, Industry survey, Innovation, Motivators, Inhibitors

Background

Context

The decreasing costs of computing power, connectivity and electronic components have facilitated the realisation of the vision of Internet of Things (IoT) and have created potential for all sorts of applications. Various media channels, the World Economic Forum (Schwab 2015) and academic researchers (Brynjolfsson and McAfee 2014) have claimed that a technology-driven revolution is underway that would change the way mankind lives and runs the economy. At the core of this revolution is the merger of physical and

digital spaces as cyber-physical systems. "Cyber-physical systems (CPS) will transform how humans interact with and control the physical world" (Rajkumar et al. 2010). The term is defined as follows: "cyber-physical systems (CPS) are physical and engineered systems whose operations are monitored, coordinated, controlled and integrated by a computing and communication core" (Rajkumar et al. 2010). The communication capabilities of such systems drive the technological revolution because they allow multiple systems to be connected, thereby creating the IoT. The IoT paradigm is the result of the convergence of three perspectives: (1) thing-oriented, (2) Internet-oriented and (3) semantic-oriented (Atzori et al. 2010). In other words, physical things can be sensed or can sense data automatically (1). The data are then communicated automatically to other things or humans (2). The data are interpreted and evaluated automatically to derive meaning (3). These three perspectives help realise the vision of an Internet containing information about the physical world without depending on human input (Ashton 2009). Technological progress in the information and communication technology (ICT) domain has reduced the costs of computing power, connectivity and electronic components. This decrease has helped the IoT to become increasingly real and has created potential for a wide range of promising innovations. Unsurprisingly, there is a lot of hype about IoT (Burton and Walker 2015). Clearly, several IoT applications are appearing in domains such as smart homes, wearables and smart cities. Well-known IoT applications are often desirable consumer gadgets (e.g. colour-changing light balls or fitness trackers). Known applications with a positive economic or ecological impact remain scarce (e.g. parking or bin fill level monitoring) (SAS Institute Inc 2016). In industrial manufacturing enterprises of specialised and export-oriented economies, even fewer IoT-based innovations are known, despite the opportunities offered by various technological enablers. The question then is, what inhibits the development and deployment of IoT applications in industrial manufacturing enterprises and thus prevents potential innovations—missing motivation or existing inhibitors?

Need

Although the potential of IoT and the challenges associated with realising it have been reviewed and discussed conceptually (Saarikko et al. 2017; Russo et al. 2015; Lee and Lee 2015; Li et al. 2014; Perera et al. 2014; Khan et al. 2012), the literature does not cover well the motivators and inhibitors of IoT application development and deployment among industrial manufacturing enterprises. The scope of the key challenges identified is generic and valid for the entire IoT ecosystem—for example *Naming and Identity Management* (Khan et al. 2012)—but it might not be equally relevant for individual enterprises aiming to develop specific IoT applications. The existing theoretical work is based mainly on conceptual models and is not backed up by empirical data. Existing empirical works on digitalisation, the fourth industrial revolution and IoT do not or only partially cover interest, engagement, motivators and inhibitors of the development and deployment of IoT applications among industrial manufacturing enterprises (Table 1). Studies that do cover motivators and inhibitors do not focus specifically on IoT application development among industrial manufacturing enterprises (Geissbauer et al. 2016; Weiss et al. 2016); instead, they target all sorts of industries (Twentyman and Swabey 2015; SAS Institute Inc 2016)—for example healthcare, retail and consumer goods—or they survey large enterprises (LEs) only.

Table 1 Comparison of existing empirical studies on IoT development and deployment, IoT in general, digitalisation and fourth industrial revolution

Publication	Main focus	Covers interest and engagement	Covers motivators	Covers inhibitors and challenges	Participant's role	Enterprise type	Industry	Location (2 digit ISO)	textitN (approx.)	Type of research
(Dijkman et al. 2015)	IoT business models, building block identification	No	No	No	IoT professionals	n/a	n/a	Global (mainly NL, US)	103	Academic
(Geissbauer et al. 2016)	4th industrial revolution, expectations in 5 years	No	(Yes)	Yes	Chief digital officers, senior executives	LE	Industrial product suppliers	Global	2000	Industrial
(Gepp et al. 2015)	Engineering trends, 4th industrial revolution	(Yes)	No	No	Engineering professionals	LE	Engineering-to-order (ETO)	DE	30	Academic
(Greif et al. 2016)	Digitalisation, degree of digitalisation	No	No	(Yes)	Industry professionals	SME	All	CH	300	Industrial
(Hsu and Lin 2016)	IoT services, usage intentions of consumers	No	No	No	Consumers	n/a	n/a	TW	508	Academic
(Kinkel et al. 2016)	Digitalisation, competencies for digitalisation	(Yes)	No	No	Industry professionals	LE and SME	MEM	DE	150	Industrial
(SAS Institute Inc 2016)	IoT deployment process	No	Yes	Yes	IoT professionals	LE	All	Global	75	Industrial
(Skinner 2016)	IoT as service, service provider perspective	No	No	No	Industry professionals	LE and SME	ICT and IoT service providers	Global	900	Industrial
(Twentyman and Swabey 2015)	IoT products, smart product development	Yes	Yes	Yes	R&D, innovation, product development executives	n/a	Retail, healthcare, manufac-turing	Global (mainly US, GB)	200	Industrial
(Weiss et al. 2016)	Digitalisation, degree of digitalisation	No	(Yes)	(Yes)	Senior executives	SME	All	IT	53	Academic

Small- and medium-sized enterprises (SMEs) with fewer than 250 employees have not surveyed in this regard, although the exports of high-wage economies are dominated by industrial manufacturing SMEs—for example, the Swiss metal, electrical and machine industries (MEM) are responsible for more than 30% of the total goods exports, and the majority of the enterprises in these industries are SMEs (Swissmem 2016). Export-oriented industrial manufacturing enterprises rely on innovations to maintain their competitive advantage in current globalised markets (Kaleka 2002). Raymond et al. (2018) argued that information technology (IT) capabilities can be used for innovation purposes in industrial SMEs. Thus, IoT-based innovations can help achieve competitive advantages in globalised markets.

Studies in the literature do not exhaustively cover the motivators or inhibitors of IoT-based innovations but focus on a limited range of topics such as privacy issues or data analytics capabilities. By focusing on IoT products (smart products) only and excluding enterprise-internal IoT applications, Twentyman and Swabey (2015) analysed one perspective on IoT application development in depth but missed out on providing a holistic view. A holistic and consolidated study on the motivators and inhibitors of IoT application development from the perspective of manufacturing enterprises is needed to understand the entire system of technology-based innovations, such as access to technology, business and financial issues and research and development knowledge and skills. Only a holistic view of the system allows us to compare the relevance of individual motivators and inhibitors effectively, as well as to define measures that can foster IoT-based innovations in industrial manufacturing enterprises.

Task

The present study investigates the interests and engagement of industrial manufacturing enterprises in IoT-based innovations and aims to provide a holistic understanding of the motivators and inhibitors of innovation in IoT application development and deployment in these enterprises. This knowledge is necessary to refine policy and decision-making in governments or industry associations interested in fostering IoT-based innovations or in enterprises operating and innovating in the era of technology-driven digital transformation. The authors address three specific research questions (RQ). They investigate (1) interest and engagement in, (2) motivators and (3) inhibitors of development and deployment of IoT applications in industrial manufacturing enterprises by presenting two conceptual models based on a literature review—one on motivators and one on inhibitors—and empirical data from a survey with 109 participants from Swiss MEM industries.

1. RQ1. Are manufacturing enterprises interested and engaged in the development and deployment of IoT applications?
2. RQ2. What benefit (added value) do enterprises expect from the development and deployment of IoT applications?
3. RQ3. Which inhibitors hinder the development and deployment of IoT applications?

Interest and engagement (RQ1)

The first RQ targets the interest and engagement in the development and deployment of IoT applications. In relation to the first RQ, three hypotheses (H) can be formulated. These hypotheses claim differences in interest and engagement based on the type of

enterprise (SME or LE) and based on the importance rating of manufactured products integrated into an IoT application (digitalised products). Developing and deploying IoT applications is a form of innovation. Heck (2017) discussed the characteristics relevant to the innovation capabilities of SMEs, which differ from those of LEs. These differences allowed us to hypothesise different interests and levels of engagement in IoT application development and deployment for SMEs and LEs.

- H1a. Importance of digitalised products is rated differently depending on the type of enterprise.
- H1b. Level of engagement in IoT application development and deployment differs depending on the type of enterprise.
- H1c. Enterprises that assign more importance to digitalised products are more likely to engage in the development of IoT applications.

Motivators (RQ2)

The second RQ targets the reasons and motivators for the development and deployment of IoT applications. A conceptual model is needed to holistically collect and map the motivators driving the development and deployment of IoT applications. Thus, the first step to answering RQ2 would be the development of a conceptual model capturing motivators (RQ2a). The differences between SMEs and LEs allow us to hypothesise different motivators for different enterprise types (H2a). Furthermore, engaged enterprises may have different motivators than non-engaged enterprises (H2b).

- RQ2a. Which conceptual model allows us to holistically collect and map motivators?
- H2a. SMEs and LEs rate the importance of motivators differently.
- H2b. Engaged enterprises and non-engaged enterprises rate the importance of motivators differently.

Inhibitors (RQ3)

The third RQ targets the inhibitors and challenges associated with the development and deployment of IoT applications. Inhibitors can be identified and collected from the literature on the topic. A conceptual model is needed to map the inhibitors exhaustively (RQ3a). Furthermore, inhibitors can be identified based on the statements of industry members (RQ3b). Not all inhibitors are expected to have the same significance (H3a).

- RQ3a. Which conceptual model allows us to holistically collect and map inhibitors?
- RQ3b. Which inhibitors are perceived by industrial manufacturing enterprises?
- H3a. Some inhibitors are perceived to be more challenging than the others.

Results

Conceptual frameworks

The term IoT application as used in this study is defined in this section. In addition, a literature review on motivators and inhibitors of the development and deployment of IoT applications and two resulting conceptual models are presented. An extended value-chain model for motivators and four domains of inhibitors emerged from the literature review.

Definition of IoT application

The term IoT application used in this study is defined based on three main elements: (1) physical object, (2) data processing functionality and (3) added value (Heinis et al. 2017). The second element contains three functional sub-elements: (2.1) data sensing, (2.2) data transmission and (2.3) data evaluation. This framework allows us to capture and describe IoT applications integrally, covering the technological, business, engineering design and innovation aspects.

Motivators along value-chain

A list of eight motivators (m1–m8) related to the development and deployment of IoT applications, as well as the potential added value of IoT applications, emerged from the literature presented in the "Background" section (Table 2).

The extended value-chain model is introduced as a conceptual model that allows us to capture exhaustively the motivators of IoT application development (Fig. 1). In theory, enterprises conduct activities or investments only if they expect added economic value. This theory is true for engagement in IoT application development and deployment. Thus, by implication, expected added value underlies each motivator to develop or deploy IoT applications. The value-chain framework describes the activities conducted by an enterprise to generate value (Porter 1985). Added value is created within an enterprise by increasing the efficiency or effectiveness of value-chain activities or by defining new value-generating activities. Therefore, the value-chain model allows us to allocate the relevant enterprise-internal motivators of IoT application development and deployment. The traditional value-chain model proposed by Porter (1985) does not explicitly cover the creation of added value for enterprise customers. External motivators based on added value for the customer cannot be allocated. In the MEM industries, customers are typically other enterprises that use a product or service to create value for their downstream customers. The relevant activities for allocating potential external motivators are thus related to product or service usage. By extending the value-chain model with product or service usage activities according to the ideas of McPhee and Wheeler (2006), potential internal or external IoT applications can be identified.

Inhibitors in four domains

A conceptual model consisting of four domains of inhibitors allowed us to cluster into four domains the wide range of inhibitors of IoT application development and deployment

Table 2 Possible motivators of development and deployment of IoT applications presented to survey participants for selection

Motivator ID	Motivators
m1	Offer shared products and services as an alternative to individual ownership
m2	Use collected data to improve decision-making
m3	Gain revenues through new or different business models
m4	Improve manufacturing and production process
m5	Enhance market research for better customer segmentation or pricing strategies
m6	Monitor product state and usage for predictive maintenance and repair
m7	Assess product usage and performance to improve product design and development
m8	Track product location to improve logistics
mOT	Other

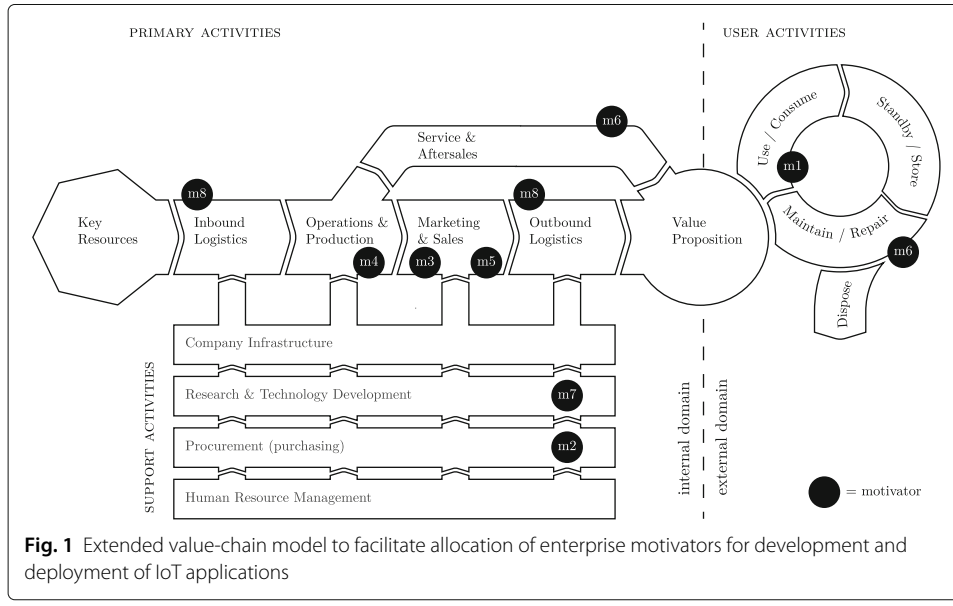

Fig. 1 Extended value-chain model to facilitate allocation of enterprise motivators for development and deployment of IoT applications

identified in literature: organisational, business, technological and industrial (Table 3). The model helps cover a wide range aspects of technology-based innovations.

Organisational domain Seven unique inhibitors (o1–o7) belonging to the organisational domain were identified in the literature (Table 3). Geissbauer et al. (2016) reported a lack of clear vision and strategy for digital operations and a lack of leadership from top management as important inhibitors. An unsuitable organisational structure or missing key functional areas were identified as inhibitors by Porter and Heppelmann (2015) and by Twentyman and Swabey (2015). A non-existent digital culture and lack of training were mentioned as inhibitors in multiple studies (Geissbauer et al. 2016; SAS Institute Inc 2016; Twentyman and Swabey 2015). Another inhibitor mentioned in multiple sources is the lack of in-house expertise or skills (Geissbauer et al. 2016; Porter and Heppelmann 2015; Curran et al. 2015; Twentyman and Swabey 2015). Pech (2016) stated that the adoption of disruptive technologies decelerates when special training is involved. Data analytics capabilities is a more specific but indispensable skill (Geissbauer et al. 2016). Integration between physical product development and software development processes is essential for the development of IoT applications. This can be difficult when product design and engineering occur over a lengthy, linear development cycle, as opposed to digital and software design, which proceed in short, modular development loops (Hui 2014).

Business domain Seven unique inhibitors (b1–b7) belonging to the business domain were identified in the literature (Table 3). Expectations related to the impact of IoT applications on demand and revenues are contradictory (Twentyman and Swabey 2015). The same applies to the expected impact on cost: decrease (Geissbauer et al. 2016) versus increase (Twentyman and Swabey 2015). There is considerable uncertainty around revenues and costs. This could inhibit enterprises from deploying IoT applications because of the higher perceived risk and volatility of IoT investments. Enterprises face challenges

Table 3 Conceptual model covering inhibitors of development and deployment of IoT applications

Inhibitor ID	Organisational inhibitor
o1	Lack of clear digital operations vision/strategy
o2	Unsuitable organisational structure or missing key functional areas
o3	Lack of leadership from top management
o4	Lack of digital culture and training
o5	Lack of in-house expertise or skills
o6	Lack of capabilities in data analytics
o7	Lack of integration between physical product development and software development
oNA	Not applicable
Inhibitor ID	Business inhibitor
b1	Insufficient information to predict demand and revenues, resulting in high uncertainty
b2	Weak value proposition of IoT applications and resulting low customer demand
b3	Difficulty in identifying market opportunities
b4	Insufficient information to predict costs or required investment
b5	Issues related to monetisation under current business model
b6	Issues related to collaboration with suppliers or partners on digital solutions
b7	Issues related to choosing level of vertical integration for IoT applications
bNA	Not applicable
Inhibitor ID	Technological inhibitor
t1	Availability of basic infrastructure technologies
t2	Difficulties related to selecting enabling technologies to realise IoT applications
t3	Difficulties related to interoperability with internal or external systems
t4	Need for standardised identification and addressing protocols
t5	Internet scalability to handle increase in traffic and requests
t6	Issues related to physical product design measures to prevent unauthorised data access
t7	Issues related to software measures to prevent unauthorised data access
t8	Insufficient tools to manage user authentication process
t9	Difficulties related to integration of digital components into physical product
t10	Access to tools and database to handle big data
tNA	Not applicable
Inhibitor ID	Industrial inhibitor
i1	Undefined regulations and laws around customer privacy and data collection
i2	Undefined regulations and laws around the use and sharing of data
i3	Lack of comprehensive and widely accepted service intermediaries
i4	Lack of certification to improve trust among customers and industry participants
i5	Potential loss of intellectual property
iNA	Not applicable

in terms of identifying market opportunities, establishing appropriate channels, defining the value proposition of IoT applications and handling the new demands associated with a closer customer relationship (Porter and Heppelmann 2015; Fleisch et al. 2015; SAS Institute Inc 2016; Twentyman and Swabey 2015). Fleisch et al. (2015) reported that IoT changes existing business models. The business model of an industrial manufacturing enterprise is usually based on product sales, and service-oriented business models are rare (Adrodegari et al. 2014). Enterprises thus face issues with monetisation, for example, of data under current business models (Tobler et al. 2013). Enterprises face issues in terms of collaborating with suppliers or partners on digital solutions. Missing digital expertise

forces industrial manufacturing enterprises to collaborate with new suppliers and partners. The bargaining power of these suppliers can be high, thus allowing them to capture a large share of the IoT applications' value (Porter and Heppelmann 2014). Developing IoT applications can expand the range of activities of an enterprise, which is necessary to create value. Given the broad range and complexity of activities and limited resources, SMEs, especially, may face challenges in terms of choosing the level of vertical integration to develop IoT applications.

Technological domain Ten inhibitors (t1–t10) can be assigned to the technological domain (Table 3). As mechanical parts are replaced with software, the physical complexity of a product usually diminishes (Porter and Heppelmann 2015). IoT applications may have fewer physical components, but the number of sensors required and the pervasiveness of software use rise. These requirements create new challenges for industrial manufacturing enterprises because digital components must be integrated in physical products. Several studies have explored open issues related to middleware or architecture for IoT (Atzori et al. 2010; Bandyopadhyay and Sen 2011; Khan et al. 2012) that impede IoT deployment. Given the complexity of IoT middleware, industrial manufacturing enterprises face the challenge of identifying the appropriate architecture and selecting enabling technologies. The sheer volume of data available from IoT applications and the business impacts of its use go hand-in-hand with the challenges pertaining to handling and analysing data (Gubbi et al. 2013; Lee and Lee 2015). In addition, the integration of IoT applications with existing internal or external software systems necessary to create a lasting business impact is challenging. The complexity and availability of infrastructure technologies can pose a significant challenge for industrial manufacturing enterprises. Essential connectivity requirements include internet scalability and the need for standardisation to connect and integrate technologies (Bandyopadhyay and Sen 2011, Atzori et al.2010, Porter and Heppelmann 2015). Additional technological inhibitors are based on the implementation of hardware or software measures to prevent any unauthorised data access. Atzori et al. (2010) outlined the various reasons why IoT applications are especially vulnerable to attacks. First, the physical components of an IoT application are mostly exposed and unattended, and it is difficult to protect them with physical measures. Second, communication is often wireless, which arguably makes it easy for unauthorised persons to intercept them. Last, IoT components cannot implement complex schemes to support security because they typically have limited energy and computing resources.

Industrial domain Five inhibitors (i1–i5) belonging to the industrial domain were identified in literature (Table 3). These inhibitors affect the industry overall and are largely external to the enterprise. The lack of clear regulations on the collection, sharing and use of data can pose significant legal challenges for enterprises developing IoT applications. Issues pertaining to data access and collection are tied to the basic right to privacy, which includes concealing personal information and the ability to control what happens with this information (Weber 2010). IoT applications will remain limited to a few niche markets if there is continued public concern about privacy (Sundmaeker et al. 2010). The lack of comprehensive, trustworthy and widely accepted service intermediaries prevents the

deployment of IoT applications (Haller et al. 2009). The lack of a method for certification of IoT applications can pose a challenge to enterprises trying to establish credibility and improve customer trust in their IoT applications. A few emerging certification programs for IoT-specific applications are available (Underwriters Laboratories 2016; ICSA Labs 2017; IoT Security Foundation 2017). However, these certification programs are in the early stages of development, and they may not have a significant impact on the market acceptance of IoT applications. Data ownership and intellectual property issues within the IoT domain are important and widely discussed topics which could inhibit enterprises from developing IoT applications (Porter and Heppelmann 2014; Geissbauer et al. 2016).

Empirical evidence

This section presents the results of our survey and statistical evaluation of the gathered data in three subsections, one each on (1) interest and engagement, (2) motivators and (3) inhibitors.

Interest and engagement

Survey respondents from SMEs are not more likely to rate the importance of digitalised products differently than LEs, even though the values for each category differ (Table 4). The null hypothesis corresponding to H1a is not rejected. There is no significant difference between SMEs and LEs (Mann-Whitney $U = 1176.5$, $p = 0.075$, $\alpha = 0.05$, two tailed).

Survey respondents from SMEs are more likely to not engage in IoT application development. The results do not contradict hypothesis H1b. Two chi-square tests of independence were performed to examine the relationship between enterprise type and the level of interest and engagement. The level of interest and engagement in IoT application development is one categorical dependent variable, and it is measured based on the selection of five possible answers (*no plans and no interest*, *no plans but interest*, *plans*, *in progress*, *experienced*) (Table 5). The relationship between enterprise type and level of interest and engagement is significant, $\chi^2\,(4, N = 109) = 11.45^*$, $\alpha = .05$, $p = 0.0219$. A second dependent variable can be obtained by dividing the participants into two groups (*non-engaged*, *engaged*) based on their levels of interest and engagement (Table 6). Participants who selected *in progress* or *experienced* were assigned to the *engaged* group, and the rest were assigned to the *non-engaged* group. The relationship between enterprise type and level of interest and engagement based on the two groups is very significant, $\chi^2\,(1, N = 109) = 7.85^{**}$, $\alpha = .01$, $p = 0.00508$.

Survey respondents who assigned higher importance to digitalised products are more likely to engage in the development and deployment of IoT applications. These results do not contradict hypothesis H1c. Again, two chi-square tests of independence were performed to examine the relationship between the importance of digitalised products and the level of interest and engagement. The two dependent variables describing the level of

Table 4 Importance of digitalised products separated by type of enterprise

Enterprise type	*N*	Not important (%)	Somewhat important (%)	Important (%)	Very important (%)
SME	60	8	25	32	35
LE	49	0	12	45	43
All	109	5	19	38	39

Table 5 Interest and engagement in developing IoT applications separated by enterprise type

Enterprise type	*N*	No plans and no interest (%)	No plans but interest (%)	Plans (%)	In progress (%)	Experienced (%)
SME	60	28	12	22	15	23
LE	49	6	10	18	29	37
All	109	18	11	20	21	29

interest and engagement used to test H1b were used to test H1c as well. The relationship between the importance of digitalised products and the level of interest and engagement is significant, $\chi^2\ (12, N = 109) = 24.73^*, \alpha = .05, p = 0.0162$ (Table 7). The relationship between the importance of digitalised products and the level of interest and engagement based on the two groups is very significant, $\chi^2\ (3, N = 109) = 11.96^{**}, \alpha = .01, p = 0.00751$ (Table 8).

Motivators

In total, 91 statements extracted from the open-ended question on motivators and expected added value of IoT application development and deployment were coded and assigned to a value-chain activity (Table 9). Of these statements, 56% (51) were assigned to the domain of primary activities. The highest number of statements was assigned to the *marketing and sales* activity segment (26%, 24). Examples include the expectation of new business models, competitive advantage, strengthening of market position and better access to customer data. Other important activity segments are *service and aftersales* (16%, 15) and *operations and production* (11%, 10). Examples include predictive maintenance and improved manufacturing. In total, 31% (28) of the statements exhibited strong customer or product user focus and were allocated to user activities. Not all statements could be assigned to one specific activity (e.g. *use/consume*, *standby/store*). Statements related to the entire domain of user activities were thus assigned to all three activities, but with a weight of one third only (e.g. increased customer benefit). Only 13% (12) of the statements were assigned to support activities. Noteworthy is the motivation to use IoT applications for research and technology development (8%, 7). Participants revealed that they expect to use the data generated by IoT applications to improve products or services.

Based on participants' selections, the top three motivators for developing IoT applications are (1) monitoring product state and usage for predictive maintenance and repair (m6, 69%), (2) using collected data to improve decision-making (m2, 61%) and (3) improving manufacturing and production processes (m4, 60%) (Table 10). On average, participants selected M=3.74 motivators (SD=1.92). The number of motivators selected by participants does not depend either on enterprise type (SME, LE) or on engagement of an enterprise (*not engaged*, *engaged*).

There are significant relationships between enterprise type (SME, LE) and selection of the motivators m2, m3 and m7. The relationship between enterprise type and selection of

Table 6 Engagement in IoT application development separated by enterprise type

Enterprise type	*N*	Non-engaged (%)	Engaged (%)
SME	60	62	38
LE	49	35	65
All	109	50	50

Table 7 Relationship between importance of digitalised products and level of interest and engagement

Importance of digitalised products	*N*	No plans and no interest (%)	No plans but interest (%)	Plans (%)	In progress (%)	Experienced (%)
Not important	5	60	20	0	0	20
Somewhat important	21	38	10	24	24	5
Important	41	12	15	27	22	24
Very important	42	10	7	14	21	48
All	109	18	11	20	21	29

m2 *use collected data to improve decision-making* is very significant, $\chi^2(1, N = 109) = 9.7217^{**}$, $p < .01$. LEs are more likely than SMEs to select m2. The relationship between enterprise type and selection of m3 *gain revenues through new or different business models* is significant, $\chi^2\ (1,\ N = 109) = 4.4793^{*}$, $p < .05$. LEs are more likely to select m3. The relationship between enterprise type and selection of m7 *assess product usage and performance to improve product design and development* is very significant, $\chi^2(1, N = 109) = 7.1376^{**}$, $p < .01$. Again, LEs are more likely to select m7. For all other motivators, no significant difference was found between SMEs and LEs ($p > 0.05$) (Table 11).

There are significant relationships between the level of engagement of an enterprise (*non-engaged*, *engaged*) and selection of m3 and m7. The relationship between the level of engagement of an enterprise and selection of m3 *gain revenues through new or different business models* is significant, $\chi^2\ (1, N = 109) = 5.736^{*}$, $p < .05$. Engaged enterprises are more likely to select m3 than non-engaged enterprises. The relationship between enterprise type and selection of m7 *assess product usage and performance to improve product design and development* is very significant, $\chi^2\ (1, N = 109) = 7.940^{**}$, $p < .01$. Again, engaged enterprises are more likely to select m7 than non-engaged enterprises. For all other motivators, no significant differences were found between engaged and non-engaged enterprises (Table 12).

Inhibitors

An open-ended question before the closed-ended questions on inhibitors was included in the survey to determine the key inhibitors before presenting our response options. In total, 120 statements were collected and coded into the four inhibitor domains (Table 13). A total of 37.6% of respondents indicated an inhibitor that fit into the business domain. Common responses included the weak value proposition of IoT applications and issues with the existing business model. After the business domain, 26.4% of the collected statements were related to technological inhibitors. Statements covering organisational or industrial inhibitors were the least represented at 21.6% and 14.4% of the responses,

Table 8 Relationship between importance of digitalised products and level of engagement

Importance digitalised products	*N*	Non-engaged (%)	Engaged (%)
Not important	5	80	20
Somewhat important	21	71	29
Important	41	54	46
Very important	42	31	69
All	109	50	50

Table 9 Assignment of statements from open-ended question on motivators and expected added value of IoT application development to value-chain activities

Activity domain	# statements	% statements	Value-adding activities	# statements	% statements
Primary activities	51	56%	Inbound logistics	1	1%
			Operations and production	10	11%
			Service and aftersales	15	16%
			Outbound logistics	1	1%
			Marketing and sales	24	26%
Support activities	12	13%	Company infrastructure	1	1%
			R&D development	7	8%
			Procurement (purchase)	2	2%
			Human resource management	2	2%
User activities	28	31%	Use/consume	10	11%
			Standby/store	7	8%
			Maintain/repair	10	11%
Total	91	100%		91	100%

respectively. Inhibitors identified in response to this question have largely been covered in the response options. Other commonly cited inhibitors include a lack of knowledge, data security and regulatory issues.

With a weighted score of 267, the business domain is the most important domain of challenges. The organisational domain is the second most challenging with a score of 235, followed by the technological domain with a score of 198. The industrial domain ranked the last with a score of 190. The differences in the ranking of the domains are highly significant (Friedman test: χ^2 (3, $N = 89$) = 25.57***, $p < 0.001$) (Table 14). Even though the ranking and the relative ranking scores of SMEs and LEs deviate from the ranking of all enterprises, a chi-square test did not show any significant differences in the selection of rankings depending on the enterprise type (SME or LE).

In the domain of organisational inhibitors, the top three inhibitors are based on the weighted score: (1) lack of clear digital operations vision/strategy with a score of 377, (2) lack of in-house expertise or skills with a score of 309 and (3) lack of integration between physical product development and software development processes with a score of 231 (Table 15). The differences in the ranking of the inhibitors are highly significant (Friedman test: χ^2 (7, $N = 89$) = 52.16***, $p < 0.001$).

Table 10 Ranking of motivators for IoT application development and deployment based on selection frequency

Rank	Motivator ID	# selections	% of $N = 109$
1st	m6	75	69%
2nd	m2	67	61%
3rd	m4	65	60%
4th	m3	59	54%
5th	m7	47	43%
6th	m5	29	27%
7th	m1	28	26%
8th	m8	27	25%
9th	mOT	11	10%

Table 11 Comparison of ranking of motivators for IoT application development and deployment for SMEs and LEs based on selection frequency

SMEs		$N = 60$	55%	LEs		$N = 49$	45%	Compared		
Rank	Motivator ID	# selections	% of N	Rank	Motivator ID	# selections	% of N	Delta %	Chi-square (1, $N = 109$)	Significance
6th	m1	17	28%	8th	m1	11	22%	− 6%	0.489	
3rd	m2	29	48%	1st	m2	38	78%	29%	9.722	**
4th	m3	27	45%	3rd	m3	32	65%	20%	4.479	*
1st	m4	40	67%	5th	m4	25	51%	− 16%	2.743	
7th	m5	16	27%	6th	m5	13	27%	0%	0.000	
2nd	m6	39	65%	2nd	m6	36	73%	8%	0.901	
5th	m7	19	32%	4th	m7	28	57%	25%	7.138	**
8th	m8	15	25%	7th	m8	12	24%	− 1%	0.004	
9th	mOT	8	13%	9th	mOT	3	6%	− 7%	1.546	

In the domain of business inhibitors, the top three inhibitors are based on the weighted score: (1) insufficient information to predict demand and revenues, resulting in high uncertainty with a score of 265; (2) issues related to monetisation under current business model with a score of 261; and (3) difficulty in identifying market opportunities with a score of 224 (Table 15). The differences in the ranking of the inhibitors are very significant (Friedman test: $\chi^2\,(7, N = 89) = 24.28^{**}, p < 0.01$).

In the domain of technological inhibitors, the top three inhibitors are based on the weighted score: (1) difficulties related to interoperability with internal or external systems with a score of 385, (2) difficulties in selecting enabling technologies to realise IoT applications with a score of 351 and (3) availability of basic infrastructure technologies with a score of 320 (Table 15). The differences in the ranking of the inhibitors are highly significant (Friedman test: $\chi^2\,(10, N = 89) = 41.55^{***}, p < 0.001$).

In the domain of industrial inhibitors, the top three inhibitors are based on the weighted score: (1) undefined regulations and laws around customer privacy and the collection of data with a score of 230, (2) undefined regulations and laws around the use and sharing of data with a score of 175 and (3) potential loss of intellectual property with a score of 159 (Table 15). The differences in the ranking of the inhibitors are very significant (Friedman test: $\chi^2\,(5, N = 89) = 19.95^{**}, p < 0.01$).

Table 12 Comparison of ranking of motivators for IoT application development and deployment for non-engaged and engaged enterprises based on selection frequency

Non-engaged		$N = 54$	50%	Engaged		$N = 55$	50%	Compared		
Rank	Motivator ID	# selections	% of N	Rank	Motivator ID	# selections	% of N	Delta %	Chi-square (1, $N = 109$)	Significance
7th	m1	12	22%	7th	m1	16	29%	7%	0.673	
3rd	m2	31	57%	2nd/3rd	m2	36	65%	8%	0.745	
4th	m3	23	43%	2nd/3rd	m3	36	65%	23%	5.736	*
1st	m4	36	67%	5th	m4	29	53%	− 14%	2.199	
5th	m5	17	31%	8th	m5	12	22%	− 10%	1.303	
2nd	m6	35	65%	1st	m6	40	73%	8%	0.795	
6th	m7	16	30%	4th	m7	31	56%	27%	7.940	**
8th	m8	10	19%	6th	m8	17	31%	12%	2.245	
9th	mOT	4	7%	9th	mOT	7	13%	5%	0.850	

Table 13 Assignment of statements from open-ended question on inhibitors to four inhibitor domains

Inhibitor domain	# statements	% statements
Business	47	38%
Organisational	27	22%
Technological	33	26%
Industrial	18	14%
All	125	100%

Discussion

Large enterprises (LEs) show higher levels of interest and engagement in IoT application development than SMEs. The limited financial and human resources of SMEs, which hinder R&D activities, might explain this result (Hausman 2005; Massa and Testa 2008; Laperche and Liu 2013). SMEs focus strongly on customers (Scozzi et al. 2005). In combination with the difficulty of predicting demand for and revenues of potential customer-oriented IoT applications, the strong focus of SMEs on customers does not have a positive impact on their levels of interest and engagement. However, SMEs are more flexible and can adapt quickly to changes in technologies or markets (Scozzi et al. 2005). Owing to this innovation advantage, SMEs could be expected to be more experienced in developing or deploying IoT applications.

The relatively high levels of interest and engagement in IoT application development and deployment reported in the survey may be ascribed to a selection bias, in that enterprises interested in deploying IoT applications are more likely to participate in the survey. The results in "Interest and engagement" section show that LEs have a higher interest and are more engaged in IoT application development than SMEs. The sample contains larger share of participants working in LEs than can be expected from the target population. A total of 33% of the employees in the Swiss MEM industries work in LEs (Swissmem 2016). By contrast, 45% of the survey participants work in LEs. The larger share of participants from LEs could be an indicator of selection bias. Apart from that, selection bias is hardly measurable.

The open-ended and the close-ended questions on motivators delivered consistent results. The top motivator from the responses to the close-ended question is monitoring product state and usage for predictive maintenance and repair (m6). The highest number of statements from the open-ended question were indeed assigned to the *marketing and sales* activity segment. However, most statements assigned to this activity segment are vague and not very specific. A wide range of statements could thus be assigned to this segment. The activity segment that follows is *service and aftersales*. The statements belonging to this segment are more specific and often mention predictive maintenance. A few of the answers to the open-ended question cannot be assigned to an activity segment.

Table 14 Ranking of inhibitor domains ($N = 89$)

Rank by score ***($p < 0.001$)	Inhibitor domain	Ranking score	Ranking score %	# 1st	# 2nd	# 3rd	# 4th	# total
1st	Business	267	100%	34	29	18	8	89
2nd	Organisational	235	88%	28	22	18	21	89
3rd	Technological	198	74%	13	21	28	27	89
4th	Industrial	190	71%	14	17	25	33	89

Table 15 Ranking of inhibitors based on ranking scores of all four inhibitor domains ($N = 89$)

Rank by score ***($p < 0.001$)	Inhibitor ID	Ranking score	# selections	avg score per selection	avg score per participants
1st	o1	377	51	7.39	4.24
2nd	o5	309	46	6.72	3.47
3rd	o7	231	37	6.24	2.60
4th	o4	191	30	6.37	2.15
5th	o6	184	31	5.94	2.07
6th	o2	149	22	6.77	1.67
7th	o3	140	23	6.09	1.57
8th	oNA	56	7	8.00	0.63
Rank by score ***($p < 0.001$)	Inhibitor ID	Ranking score	# selections	avg score per selection	avg score per participants
1st	b1	265	38	6.97	2.98
2nd	b5	261	39	6.69	2.93
3rd	b3	224	32	7.00	2.52
4th	b4	219	32	6.84	2.46
5th	b2	213	31	6.87	2.39
6th	b7	146	24	6.08	1.64
7th	b6	138	22	6.27	1.55
8th	bNA	64	8	8.00	0.72
Rank by score ***($p < 0.001$)	Inhibitor ID	Ranking score	# selections	avg score per selection	avg score per participants
1st	t3	385	40	9.63	4.33
2nd	t2	351	35	10.03	3.94
3rd	t1	320	32	10.00	3.60
4th	t9	261	30	8.70	2.93
5th	t4	248	26	9.54	2.79
6th	t7	212	24	8.83	2.38
7th	t6	200	22	9.09	2.25
8th	tNA	99	9	11.00	1.11
9th	t8	98	12	8.17	1.10
10th	t10	96	12	8.00	1.08
11th	t5	83	11	7.55	0.93
Rank by score ***($p < 0.001$)	Inhibitor ID	Ranking score	# selections	avg score per selection	avg score per participants
1st	i1	230	41	5.61	2.58
2nd	i2	175	34	5.15	1.97
3rd	i5	159	31	5.13	1.79
4th	i4	129	25	5.16	1.45
5th	iNA	90	15	6.00	1.01
6th	i3	74	16	4.63	0.83

This could indicate that the value-chain model is not conceptually suitable for capturing motivators and expected added value, which is not the case. Most of these answers do not cover motivators or expected added value at all. A few are extrinsic motivators such as "this is the future", "we cannot ignore this trend", or "market pressure", which probably do not lead to a lasting engagement in IoT application development.

The results of the open-ended question on inhibitors are aligned with the finding from the close-ended questions that business inhibitors are the most challenging. The result related to the second-ranked inhibitor domain from the open-ended question does not

align with the result obtained from the close-ended question. Participants answered the open-ended question before being presented the inhibitor domains and the full set of inhibitors. An insight from informal interviews with industry representatives is that the perception of IoT is technology-dominated. This could explain why inhibitors stated in response to the open-ended question are more technology-oriented. After being confronted with all inhibitor domains and the entire collection of inhibitors, the participants may reassess their opinion.

The results obtained in study show that business and organisational inhibitors hinder the realisation of IoT applications decisively and, therefore, hinder innovations based on IoT applications. This insight is not well represented in extant academic literature. The literature identifies challenges mainly in the technological or industrial domain (Atzori et al. 2010; Bandyopadhyay and Sen 2011; Khan et al. 2012; Sundmaeker et al. 2010; Miorandi et al. 2012) and considers the realisation of the IoT as the application of a certain technology (Lee and Lee 2015). Of course, the technological and industrial challenges outlined in existing literature must be solved to facilitate the development of IoT applications. However, the landscape of existing and economic IoT technology available in the market is already well developed. Consequently, researchers should focus increasingly on the business and organisational aspects of IoT application development and deployment.

There are a few limitations of the present study. The sample population was created through non-random convenience sampling. In addition, the results of the survey may not be replicable. While we recognise the downside of non-random sampling, this sampling method was selected from the viewpoint of practicality considering the study duration, resources at hand, and availability of the subjects. Although we cannot effectively comment on the parameters of the entire Swiss population or the industrial manufacturing enterprises of other nations, the results of the survey do provide meaningful insights about enterprises already interested or engaged in IoT. Moreover, it can be argued that the selection bias in non-random sampling is unlikely to have any effect on the sections pertaining to motivators and inhibitors. For example, enterprises that encounter technological challenges are not more likely to participate in the survey than those who encounter business challenges. Thus, apart from the results related to interest and activity, the results of all other sections of the survey should represent the trends among the industrial manufacturing enterprises who are already interested in IoT.

Conclusions

The results of this study show that among LEs in the Swiss MEM industries, the level of interest and engagement in developing IoT applications is generally higher than that among SMEs. The main motivation to develop IoT applications is implementing or improving *service and aftersales* activities in the value-chain of the enterprises by offering predictive product maintenance, for example. Four domains that covered exhaustively the inhibitors that hinder the development and deployment of IoT applications were identified from the literature: business, organisational, technological and industrial. Business and organisational inhibitors proved to be more relevant than technological and industrial ones. The authors identified business inhibitors, such as *insufficient information to predict demand and revenues, resulting in high uncertainty* and *issues with monetisation under current business model*, to be the most challenging ones. The

domain of organisational inhibitors tied in second with relevant inhibitors such as *lack of clear digital operations vision/strategy* and *lack of in-house expertise or skills*. The most relevant technological inhibitors were *difficulties related to interoperability with internal or external systems* and *difficulties in selecting enabling technologies to realise IoT applications*. The industrial domain of inhibitors was found to be the least challenging with inhibitors such as *undefined regulations and laws around customer privacy and data collection*.

The approach of addressing exhaustively the motivators and inhibitors related to the development and deployment of IoT applications and comparing their relevance led to the insight that innovation for the IoT is not only about developing technology and overcoming privacy regulations, as is often discussed in academic literature, but also about developing and deploying successful IoT applications. The challenges relevant to this end at the enterprise level are not mainly about technology or regulations but about business and enterprise organisation. Business as well as enterprise organisation are driven by human behaviour and, therefore, deserve the increased attention of non-technical research fields, as is happening already in the field of innovation management (e.g. IoT business models). The potential of IoT applications in industrial manufacturing enterprises is not yet fully exploited. The extended value-chain model used in this study could help to identify novel IoT applications other than the well-known ones, such as predictive maintenance.

The results of this study imply that the identified inhibitors can be used by governments or industry associations interested in fostering IoT-based innovations or by enterprises operating in and innovating during the era of technology-driven digital transformation to refine policy and decision-making. Especially, governments and industry associations can define their supportive role for a future digital economy—as proposed by Hanna (2018)—based on the learnings gained from this study. Two possible directions for future work can be derived from this study. The first is research on the tools and methods to overcome the inhibitors identified herein. The unpredictability of demand and revenues and the corresponding high degree of uncertainty could be addressed by using agile development methods, which facilitate rapid incorporation of user feedback. The challenge associated with that approach is managing the different paces of iteration cycles for hardware and software development. To help enterprises to overcome the lack of in-house expertise and skills, methods that allow organisations to acquire new knowledge quickly must be investigated. Second, the extended value-chain model can be investigated as a tool not only for allocating motivators but also for systematically searching for novel IoT applications along the entire value-chain.

Methods

General approach

The design of our empirical study is based on the sequential explorative research design described in Teddlie and Tashakkori (2006). This approach is favoured because academic literature covering the motivators and inhibitors of the development and deployment of IoT applications integrally is non-existent, and the possible range of results must be defined first. Two main working steps were taken to answer the RQs. First, the literature was reviewed to collect a broad spectrum of possible motivators and inhibitors of IoT application development and deployment and to develop a conceptual model

which allows us to cover the inhibitors and motivators exhaustively. Second, based on the first step, a survey was designed and used to collect quantitative data for validating and measuring the relevance of the identified motivators and inhibitors and to test the formulated hypotheses.

Data measurement

A structured survey questionnaire containing four sections relevant to this study was designed and deployed: *demographics*, *interest and engagement*, *motivators* and *inhibitors*. The questions were designed to cover a wide range of answers because this work is an explorative empirical study on the topic, and the aim is to provide a general overview. Most questions were close-ended, except for the first question in the section pertaining to motivators and inhibitors. There, an open-ended question was used to allow participants to mention motivators and inhibitors without being biased by the answer options of the close-ended questions. The statements from the open-ended questions were coded manually into categories. Participants with no intentions to develop IoT applications (Table 5, *no interest and no plans*) were not asked to provide any answers on inhibitors because their insights were not expected to be valuable. In the section pertaining to interest and engagement, participants were asked to select the statement best describing their situation (single option selection). The close-ended question on motivators presented a set

Table 16 Participants' demographic profile

Measure	Items	# selections	% of $N = 109$
Title	Executive	36	33%
	Department head	29	27%
	Staff	23	21%
	Unit head	12	11%
	Other	9	8%
Functional area	Management	31	28%
	Research and development	34	31%
	Information technology	6	6%
	Production	5	5%
	Quality engineering	2	2%
	Marketing and communication	4	4%
	Sales	10	9%
	Other	17	16%
MEM industry domain	Mechanical engineering	34	41%
	Electrical engineering/electronics	24	29%
	Precision instruments, apparatus and devices	16	20%
	Metals	6	7%
	Vehicles	2	2%
	Other	27	33%
Product/service category[a]	Power engineering transmission	21	19%
	Assembly and factory automation	17	16%
	Machine tools and manufacturing technology	16	15%
	Process engineering equipment	15	14%
	Precision tools	11	10%
	Remaining/other	139	128%

[a] Multiple selections allowed

of motivators to the participants from which they could select multiple options. The relevance of a motivator was determined based on its overall selection frequency. In the section on inhibitors, participants were asked to select the relevant inhibitors and rank the selected ones. For the inhibitor domains, participants were asked to state the rank of each domain. The overall rank of an inhibitor or domain was calculated based on the ranking score (Hillmer 2017).

Sample

The target population of the survey comprised small-, medium- and large-sized enterprises from the MEM industries in Switzerland. The estimated size of the target population was 4000 enterprises (Swissmem 2016). The survey was accessible online between 21 February 2017 and 13 April 2017, and it was available in the three languages, namely, English, German, and French. To limit survey access to the target population, the survey was distributed through organisations related closely to the MEM industries. Links to the survey were shared through newsletters or mailing lists of the organisations, for example, INNOVATION NETWORK, SWISS ENGINEERING and INDUSTRIE2025. In addition, the online survey was distributed directly to members of the Zurich IoT Meetup Group and members of SWISSMEM.

Non-probability, convenience sampling was used to generate the sample. The number of complete survey responses and the resulting sample size of the study amounted to 109 enterprises. The enterprises ranged in size up to 350,000 full-time employees (FTEs) ($M = 6913$, $Mdn = 220$, SD = 37867). Of all enterprises, 55% were SMEs with up to 250 FTEs ($M = 81$, $Mdn = 215$, SD = 81). Forty-five percent of the enterprises with over 250 employees were LEs ($M = 15278$, $Mdn = 1500$, SD = 55646). More than 20% of SMEs did not have a research and development (R&D) department, compared to only 2% of the LEs. On average, there were 15 FTEs in the R&D departments of the SMEs. LEs had larger R&D departments with an average of 600 FTEs. More than 70% of the survey respondents reported that their positions were at the executive or managerial level (Table 16). The majority of the respondents worked in R&D (31%) or management (28%).

Abbreviations

FTE: Full-time employees; H: Hypotheses; ICT: Information and communication technology; IoT: Internet of things; LEs: Large enterprises; MEM: Metal, electrical, and machine; RQ: Research question; R&D: Research and development; SMEs: Small- and medium-sized enterprises

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Authors' contributions

TBH is the main author of the article and is responsible for the conceptual architecture, data evaluation, conclusions and writing. JH helped with the questionnaire design and operative execution of the survey. MM co-designed the conceptual architecture. All authors reviewed and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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Technology roadmap for smart electric vehicle-to-grid (V2G) of residential chargers

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Abstract

Smart grid is defined as the overlaying of a unified communications and control system onto the existing power delivery infrastructure to provide the right information and the right entity at the right time. It helps even out demand spikes and uses resource mix more efficiently. It is a better integration, or "system balancing," of variable resources, like wind power. Many of the advanced applications of smart grid are expected to develop in an evolutionary manner based on current technologies available and the needs of the market, for example, electric vehicles (EVs) or plug-in hybrid electric vehicles (PHEVs). It is likely that we will see a simpler associated application (i.e., smart battery charger) before the market matures to support a more complex form of the application vehicle-to-grid (V2G). The objective of this paper is to develop a technology roadmapping (TRM) process for smart electric V2G technologies in Oregon and the Pacific Northwest (PNW). The research focuses on the application of V2G in the residential chargers. It introduces the market drivers, products, and technology analysis and also provides research on the necessary resources needed within R&D in the coming years (next 10 years).

Background

One million electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) are expected to be in use by individuals and fleets by 2015 (United States Department of Energy 2011). Unmanaged EV charging will add to peak grid load and would require additional generation capacity (Kiviluoma & Meibom 2011; Kintner-Meyer et al. 2007). Charging must be scheduled intelligently in order to avoid overloading the grid at peak hours and to take advantage of off-peak charging benefits. EVs can also serve as an energy resource through vehicle-to-grid (V2G) operation by sending electricity back into the grid, thereby preventing or postponing load shedding (Kempton & Tomić 2005; Guille & Gross 2009a). Charging and V2G services must be optimized for grid load while guaranteeing owner schedule and range requirements are met. A system encompassing EV owner input via a mobile application, an aggregation middleware, a charge scheduling, and V2G operation algorithm, and radio-frequency identification (RFID) reader, is proposed (Ferreira et al. 2011).

Recent technological advances in electricity distribution and load management, referred to as "smart grids," promise to facilitate the integration of EVs into electricity load and to lower costs. Electric utilities have already begun to deploy smart grid

technologies to better manage commercial and household load using intelligent metering and communications systems in order to save energy, cut emissions, and reduce peak loads. More widespread deployment would enable EV charging to be scheduled intelligently. In addition, it could—at least in principle—enable the storage capacity of the batteries in EVs to be used as a supplementary source of power at times of peak load; the residual charge in those batteries could be fed back into the network during the evening peak and the battery recharged at night. There may also be scope for exploiting this storage potential to compensate for the variability of electricity supply from variable renewable energy sources such as wind and solar. In this way, smart grids and EVs could be mutually beneficial: EVs could both benefit from and help to drive forward investment in smart grids (Trevor 2012).

In this paper is presented the technology roadmapping of a smart battery charger for EVs or PHEVs, aiming their integration in smart grids. The battery charging process is controlled by an appropriate control algorithm, aiming to preserve the battery lifespan. The main features of the equipment are the mitigation of the power quality degradation and the bidirectional operation, as grid-to-vehicle (G2V) and as V2G. The V2G mode of operation will be one of the main features of the smart grids, both to collaborate with the electrical power grid to increase stability and to function as a distributed Energy Storage System (ESS) (Vítor et al. 2012).

Therefore, EVs could play a central role in decarbonizing road transport in the near future. To establish the appropriate strategies for research and development (R&D) is required. According to Phaal et al., technology roadmapping is a proper tool to build up strategic and long-term planning by assessing potentially disruptive technologies and market changes (Phaal et al. 2004). Accordingly, the objective of this paper is to develop a technology roadmap for smart grid technology. In particular, this research focuses on the application of smart grids in the EV charging for the residence.

Methods

Our research is focused on the residential charging aspect of smart grids which entails technology in the car and at home, communication to the utility, the utility, and communication with other utilities. Since the residential chargers are estimated to account for 65–80 % of EV charging, this includes simple level 1 chargers using standard 110-V wall outlets, and level 2 chargers use 220 V and charge about twice as fast. These are residential chargers which apply to off-street parking in personal garages or assigned spaces in housing building. Payment is through the utility companies, so no complex new systems are needed for this. And, the equipment is user-owned.

Our research methodology is a combination of in-depth literature reviews backed up by online research. By tapping into a diverse set of articles, along with online information, we were able to follow the many suggestions of previous roadmapping research techniques by not relying too much on one particular set of research findings to draw significant conclusions. We were able to cross-reference and corroborate findings among these articles/comments.

Literature research

Smart grid

A smart grid is an electricity network that incorporates a suite of information, communication, and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users. Smart grids allow for better coordination of the needs and capabilities of all generators, grid operators, end users, and electricity market stakeholders in operating all parts of the system as efficiently as possible, minimizing costs and environmental impacts while maximizing system reliability, resilience, and stability (Energy Agency 2011a).

Battery electric vehicles

The EV, as defined by the Encyclopedia Britannica, is a motor vehicle powered by a battery that originated in the late 1880s and that has been used for private as well as public transportation. An electric vehicle can be a bicycle, a motorcycle, or any type of four-wheeled automobile, being private or commercial. Battery-powered electric vehicles are different than hybrid or fuel cell vehicles for this application in that they do not generate electricity. They are instead a distributed storage medium that time-shifts the generation and consumption of electrical energy, providing, for example, peak power, reliability, distributed storage, and reactive power (AC Propulsion, Inc. 2009a).

V2G

Electric-drive vehicles have within them the energy source and power electronics capable of producing the 60-Hz AC electricity that powers our homes and offices. When we allow this electricity to flow from cars to power lines, we call it "vehicle-to-grid" power or V2G (Thomas B. Gage 2003). V2G is a technology that makes clean and efficient electric-powered transportation possible by allowing electric vehicles to power and be powered by the grid. AC Propulsion is currently working with V2G research and development programs throughout the USA to supply V2G-capable vehicles, evaluate V2G functionality, and develop the communications and control systems that are necessary to enable electric vehicles to support the power grid (AC Propulsion, Inc. 2009b).

Results and Discussion

In developing our roadmap, we analyzed market drivers as they are indicators of the basic criteria to meet a potential buyer's needs. In the recent decade, car buyers have inclined using EVs due to several drivers in the US environment. These drivers have emerged from social, technological, and economic environment. To explain how these drivers affect the electric car market, Table 1 demonstrates the primary market drivers behind V2G in an EV application as we have discovered through the research conducted for this paper. We also analyzed the challenges for regional V2G roadmap between the current state of technology against the EV context. The aforementioned efforts allow us to develop the technology roadmap as presented below.

Market drivers

Marketing is all about creating value for the customer and striving to meet and then exceed customer expectations. And, market drivers are considered at the time

Table 1 Market drivers

Info. object catalog	Market drivers
Environment	Electric cars
	Renewable (intermittent) generation resources online
	Differential cost of peak vs. off-peak power
Consumers	Prevent "empty battery" range anxiety
	Ease of use
	Lowest cost ownership
	Be green
Utility	Reliability
	Risk reduction
	Lowest operating cost

envisaging and establishing value of a product/service that is to be marketed. These drivers are primarily trends that cause an existing or new market to develop (William M. Luther 2010). Based on current research and development in the V2G industry, we identified three categories as the primary drivers behind this technology roadmapping (TRM). Table 1 demonstrates the primary drivers for regional V2G roadmap.

Market drivers—environment

Electric cars Rapid growth in the number of EVs in use would have a significant impact on the need for investment in electricity network capacity and smart grid technologies. EVs as one of the green transportation have been noticed widely by societies and governments, so that annual sales of different types of electric cars including EVs will have a remarkable growth by 2050 and the number of sold conventional gasoline and diesel cars will be decreased dramatically by that time (International Energy Agency 2011). International Energy Agency's study shows that the number of EV and PHEV cars sold globally by 2050 would be around 106.4 million cars—Fig. 1.

Renewable (intermittent) generation resources online The most important role for V2G may ultimately be in emerging power markets to support renewable energy. The

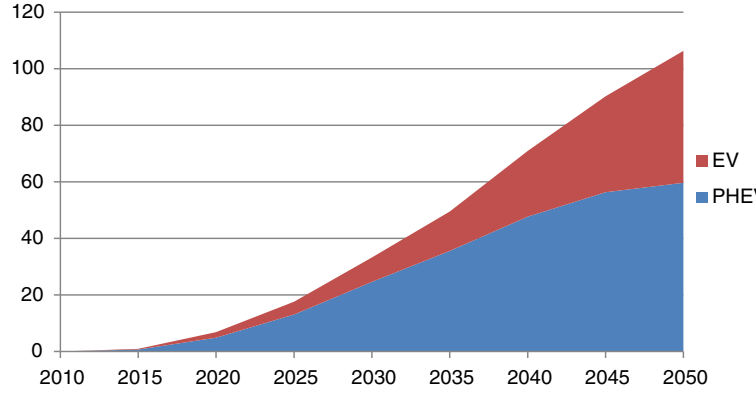

Fig. 1 Annual global EV and PHEV sales in BLUE Map scenario

two largest renewable sources likely to be widely used in the near future, photovoltaic (PV) and wind turbines, are both intermittent (Kelly & Weinberg 1993). Intermittency can be managed either by backup or storage. In terms of V2G, backup can be provided by the fueled vehicles (fuel cell and hybrid running motor-generator). Storage can be provided by the battery vehicle and the plug-in hybrid running V2G from its battery (Bossel 2004).

Differential cost of peak vs. off-peak power There are two main categories of grid support for which V2G might be useful. One of the categories is providing peak power because meeting the demands of peak power currently is a very expensive obligation for utilities. If EVs could be charged during off-peak times and then discharged selectively to "shave the peak," the utility could potentially forego the need to start up a peaking plant, which would save on operation and maintenance costs and yield significant environmental benefits (Kempton et al. 2001). For the residential charging, it is expected that the majority of EV owners will decide to charge their vehicle when they arrive home from work whether immediately during peak load hours or overnight during off-peak hours (Smart et al. 2010) because the PUC will price peak power higher to get people to use energy off-peak.

Market drivers—consumers

Prevent "empty battery" range anxiety Range anxiety in EVs refers to "[road users] continual concern and fear of becoming stranded with a discharged battery in a limited range vehicle" (Tate et al. 2008). The existence of range anxiety is related to the technical limitations of the batteries of EVs (Botsford & Szczepanek 2009). The V2G technology allows EVs to both draw electricity from and return electricity to the grid. Furthermore, V2G technology may allow utility companies to increase their use of intermittent renewable energies, such as wind and solar (Guille & Gross 2009b). Therefore, we think early consumers will tolerate hassle, and later, consumers will not because there will be a new technology to resolve it. According to some experts, vehicle-to-home (V2H) technology is therefore likely to be successful in a shorter term, as the technology operates independently from the utility company and can already manage energy flows within the home effectively (Jorrit J. Bakker 2011).

Ease of use Ease of use is a major factor and can include the physical hardware, software programming, and integration of communications systems, V2G program administration, standardization of programs across utilities, and other issues. Ideally, there would be little or no additional hardware, so the customer could plug in as they would for a normal charge. The customer will need software tools to program when and what they need in terms of driving range. They also need these tools to be user-friendly and provide multiple means of access (i.e., at the vehicle, charger, online, home area network system, and through mobile applications). It is important for as much of the process to be automated as possible (Adrene et al. 2012).

Lowest cost ownership An EV or PHEV uses its excess rechargeable battery capacity to provide power to the electric grid in response to peak load demands. These vehicles

can then be recharged during off-peak hours at cheaper rates while helping to absorb excess nighttime generation. The vehicles serve as a distributed battery storage system to buffer power. The recharge scheduling is to minimize the generation cost which includes generation production cost and V2G discharge payment (Siddhartha et al. 2012).

Be green The results of the study show that V2G, in addition to providing valuable grid services, could also prove to be a prominent application in the global transition to the emerging green and sustainable energy economy (Willett et al. 2008a). Consumers will want to be green. Americans are becoming increasingly concerned about the environment. Studies have shown that the percentage of Americans who worry about the environment "a great deal" or "a fair amount" has increased from 62 to 77 % between 2004 and 2006 (Bill 2006). More people are making their homes energy efficient, driving more fuel-efficient cars, focusing more on recycling, and buying products that are healthier and less harmful to society and the environment.

Market drivers—utility

Reliability Most cities have embarked on policies to encourage the development and spread of electric-drive and low-pollution vehicles. The goal is to reduce air pollution from mobile sources. These policy initiatives, advances in power electronics, and the opening of electricity markets across the country create opportunities for electric-drive vehicles to reduce air pollution and at the same time increase the reliability and efficiency of the electric power system. This opportunity is based on using the electric storage of battery vehicles, or the generation capacity of hybrid and fuel cell vehicles, for ancillary services and/or peak power (Letendre & Kempton 2002).

Risk reduction Developing V2G technology of residential chargers will help to reduce the environmental risks. At the same time, V2G vehicles also could provide their owners with greater security, by using the V2G connection for vehicle-to-building (V2B) operation in an emergency and by knowing that the environmental benefits of V2G decrease the risk of political and financial disruptions due to global warming (Zpryme 2010).

Lowest operating cost The V2G system can provide the operating reserve. The operating reserve is the generating capacity that is available to come online within a short time in cases of generator failure or other disruptions to the electricity supply (Letendre & Denholm 2006). There are two types of services, known as ancillary services, which apply to V2G systems and operating reserve—regulation and spinning reserve. The services that are potentially available from V2G would have the effect of reducing the electrical utilities' capital costs of building power plants and reducing the operating costs of these plants (Adrene et al. 2012).

Product analysis

The value of a product reflects the owner(s)/buyer(s) desire to retain or obtain a product (Halil Shevket Neap & Tahir Celik 1999). The best product value propositions focus on the key benefits—not features or attributes—that matter most to buyers in the target

market. Moreover, the best value propositions specifically document the worth/superiority of the seller's offering, relative both to competitors and to customer needs (Jakki Mohr 2016). According to the researched market drivers in V2G industry, we have pointed out two main features of the key product features: customer and utility (see Table 2) for short- and long-term viability within the market place. Based on these features, we grouped and concluded the features, factors, and its needs and defined our future product (see Table 3).

Table 2 is an overview of the key product features. There is a need to schedule vehicle charging. It needs to evolve from current simple (or dumb) technology to smart technology communicating the grid and interacting with it efficiently. Then, ultimately, products could also be made more aware of the users' personal schedules. Therefore, the key needs for EV charging include dealing with the range anxiety issue, ease of use, low cost, and green products. For the utility feature, it includes demand management, such as at least limited abilities to control loads, incorporation of real-time pricing, and dealing with green signals. This allows utilities to increase reliability, decrease cost, and decrease risk. Furthermore, the increased system control, such as power feed-in, and better ability to deal with time of use pricing can further help deal with reliability, cost, and risk.

Technology analysis

How to utilize or develop existing or new technologies to realize future products is a critical problem. We pointed out the existing technologies to support each product component where permissible. Then, we tried to find the opportunities for the future development of existing or related technologies and threats from the development of new technologies which may cause the potential substitution on existing technologies. We discussed an overview of some of the technologies needed to fill gaps and enable our products. Table 4 maps the existing or developed technologies to the defined product features.

Table 2 Product features

Product features	Factors
Customer features	Scheduling: dumb (L1/L2)
	Scheduling: smart (L1/L2)
	Scheduling: aware (L2)
	Scheduling: green
	Pricing: dumb time of use (TOU)
	Pricing: smart time of use (TOU)
	Pricing: R/T (real time)
	Pricing: feed-in
Utility features	Demand management: limited load control
	Demand management: R/T (real time)
	Demand management: green
	System control: feed-in
	Pricing: time of use (TOU)
	Pricing: R/T (real time)

Table 3 Product and needs

Product	Features	Factors	Requirements
Smart residential EV charging	Customer	Scheduling	Anxiety, ease, cost, green
		Pricing	Cost
	Utility	Demand management	Reliability, cost, risk
		System control	
		Pricing	

Charger/car (consumer)

It is important to perform intelligent scheduling for charging and discharging of EVs. Intelligent scheduling for EV charging and discharging has become a vital step towards smart grid implementation. The essential principle in intelligent scheduling is to reshape the load profile by charging the EV battery from the grid at the time when the demand is low and discharging the EV battery to the grid when the demand is high (Li et al. 2010; Shireen & Patel 2010). We will spend three periods to develop the scheduling of the EV charging.

V2G is a continuum, ranging from simple remote "on/off" management of the charger to adjustable high-power electricity feed-in during peak demand periods. One of the extended forms of V2G is the ability of the system to use a large part of the battery state of charge (SOC) for power feeding to the grid (SPINNOVATION 2012). Our final aim is to develop a standard connector.

Communication (both)

Unlike other communications networks, the V2G communication has its own characteristics that the vehicular network differs in size and vehicular speed, as well as relevance of their geographic positions (Huaqun et al. 2011). It also has the ability to adapt the EV charging process in near real time in case of grid violations through V2G communication by rescheduling or demand-limit renegotiations (Sebastian et al. 2011). V2G communication enabled EVs to serve as ideal actors for demand- side management (DSM) systems (International Energy Agency Demand Side) because of their high battery capacities, high charging powers, comprehensive availability with increasing market penetration, and their capability to quickly adapt charging currents to given demand boundaries (Kempton & Tomic 2005). The TRM will focus on the EVs' residential charging speed and information for both consumer and utility.

Table 4 Technology analysis

Technology features		Technologies
Charger/car (consumer)	Schedule	1.0, 2.0, third party API
	Feed-in	Standard connector
Communication (both)	Speed	1-way, 2-way; minutes, seconds
	Information	Usage, demand requirements, TOU rate, R/T price, demand shedding, green, system control
Computing (utility)	Data	Data warehouse, R/T availability
	Management	Demand management
	Market	Local rate market, regional imbalance market

Computing (utility)

In most areas of the USA, the Independent System Operator (ISO) provides an electronic signal to request frequency regulation, reserves, and other forms of fast-response, high-value power. Additionally, a local utility may want to signal for other V2G services, such as peak load shedding or relief on targeted parts of the distribution system. V2G needs the computing to mediate driver and grid. There must be intelligent mediation between driver and grid operator needs (Zpryme 2010). We will develop our TRM in three aspects for utility: data, management, and market.

Resource analysis

After integrating technology roadmapping process, the three main levels of the roadmap, which are market driver, product feature, and technology, also require extra factors in order to increase market opportunity and approach the development of new technologies. Technology resources are addressed as significant sources because they have potential to fill the technology gaps and deliver good roadmaps. Moreover, having sufficient resources will allow capability of technology to overcome the barriers of technology application and also improve the diagnosis and treatment of patients. To realize the product features, we need to understand the current and required level of technological capabilities and its gaps. We developed the resources requirements (see Table 5) to analyze the technological capabilities, i.e., the resources, which are composed of a variety of sources of knowledge. The resource analysis must not only give attention to economic costs but also has to determine if it is feasible to obtain the needed physical material and manpower in the required time period.

Labs

From the viewpoint of public role in technology innovation, the investment or funds in the V2G technology have been drawn by governmental organizations and the academic world (university labs) in the USA, for example, Sandia National Laboratories and University of Delaware. In May 2007, the University of Delaware, PHI, and other partners, established the Mid-Atlantic Grid Interactive Car Consortium (MAGICC) to prove the V2G concept. MAGICC activities are funded by awards of $200,000 of the Delaware Green Energy fund, $250,000 from PHI, and $150,000 from Google.org, for R&D and demonstration purposes (Willett et al. 2008b). Their goals are to educate about the environmental and economic benefits of V2G and enhance the product market.

Third party S/W

In common with governmental organizations and academia, numerous companies who have the V2G technology trials like PG&E and Xcel Energy companies have developed and invested some products in the V2G technology. Furthermore, automobile companies have announced new products adopting the V2G technology such as Ford and Toyota's PHEVs. By showing their future concepts or applications, they can not only advertise their ability but also lead markets and suppliers.

Standards

V2G is in an early stage, which means companies such as auto, smart grid technology integrators and telematic manufacturers can prepare themselves for market entry by closely monitoring government legislation, standards, smart grid and charging station

Table 5 Resources analysis

Resources		Requirements
Labs	Government and university labs	Demand management/data
		Demand control
		Feed-in charger
		Feed-in car
		Imbalance/power market
Third party S/W	Independent S/W company	R/T data collection
		Demand management
		Demand control
		Imbalance/power market
Standards	Standards organizations: IEEE, ITU, NIST, ANSI	Demand management
		Demand control
		Feed-in charger
		Feed-in car
		Imbalance/power market
		Third party API
Utility	Local utility company	R/T data collection
		Demand ,management
		Demand control
		Imbalance/power market
Charger	Residential charger companies	Charger schedule S/W 1.0
		Demand data
		Feed-in charger
		Feed-in car
Car	Auto companies	Car schedule S/W 1.0
		Car schedule S/W 2.0
		Third party API
		Demand data
		Feed-in car

rollouts, and security (Zpryme 2010). Especially, typical automotive component markets require more strict standards in quality management. There are several standards organizations: IEEE, ITU, NIST, and ANSI. V2G technology advancement and adoption will be driven by universal standards adoption in the near future. Also, universal standards adoption will play a significant role in driving down R&D costs. Further, commoditization of core technologies will allow auto manufactures to lower their overall production costs, thus reducing the overall price of V2G EVs for consumers and business customers (Zpryme 2010).

Utility

There are lots of local utility companies like DTE Energy in Detroit and REV Technologies who have already started their research on V2G technology for EVs. For example, REV Technologies' vision is something called intelligent charge control, which involves harnessing a fleet of at least 100,000 electric vehicles and, in response to signals from the grid operators, taking energy out of the grid or putting energy into it (REVE 2015).

Charger

For the next 5 years, the market for residential charging stations will provide a greater opportunity than commercial charging stations. The hardware/software industry is relatively untapped in the V2G space, but companies such as AC Propulsion and Azure Dynamics are two that have established footprints in this industry. AC Propulsion is currently the only manufacturer of V2G-capable power electronics, but Azure Dynamics, Siemens, and even GM have given indications that they are thinking about the market (Zpryme 2010). They are keeping their cards close to their vests as well as according to the marketing trends.

Car

More and more automobile companies are committed to research and develop V2G technology for EVs. For example, AC Propulsion of California has designed an electric-drive system using mass-produced 18,650 lithium-ion batteries and a patented power electronics unit that is ideally suited for V2G. They have also created electric and plug-in hybrid vehicles by converting existing gasoline vehicles (Willett et al. 2008b). Other manufacturers, including global auto manufacturers such as Renault/Nissan, Mitsubishi Motors, and BMW, are producing all-electric vehicles for some markets and have announced full-scale production plans for all-electric vehicles.

Technology roadmap

The method of roadmapping consists of time usage in connection with dimension gathering for a technology strategy structure. Once the overall characterization of technology roadmaps had been described, the structural pattern of exploring and communicating the relationships among markets, products, and technologies evolved and developed into an easier implementing tool (Choomon & Leeprechanon 2011).

The integrated roadmap of smart electric V2G of residential chargers is shown in Fig. 2, and we also attach the complex TRM in Additional file 1.

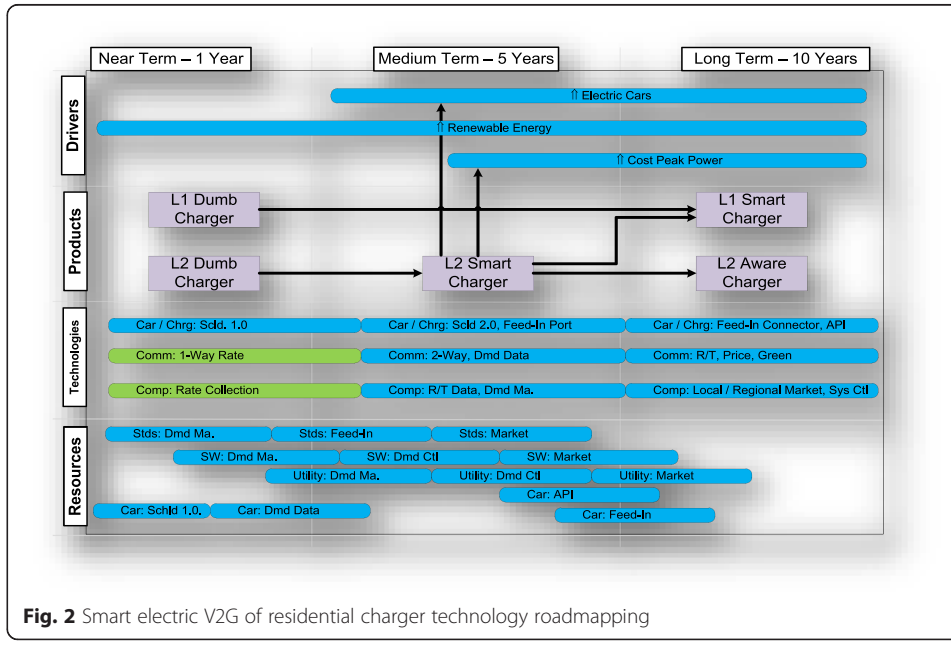

Fig. 2 Smart electric V2G of residential charger technology roadmapping

Conclusions

Electric-drive vehicles can become an important resource for the electric utility system, with consequent air pollution, system reliability, and economic benefits. Both consumers and utilities will benefit from efficient V2G. The V2G features meet both consumer and utility requirements. The technical requirements are needed to realize the most value from vehicle power. There are some gaps that exist in all three key technology areas: computing, communication, and residential V2G components. V2G technology development needs to progress from labs to commercialization to deployment. To set up some standards for the V2G technology is necessary because the smart grid will touch so many aspects of life in the twenty-first century and the development of standards involves a wide range of stakeholders—national and international, private and public, large and small. Also, early development of standards is the key to not delaying deployment. Preparing for rapid growth in electric vehicle use is necessary since new and upgraded supporting infrastructure, whether charging stations, generating capacity, or enhanced transmission systems, require time for deployment.

As stated in the beginning, the objective of this report is to develop a roadmap for the smart electric V2G of residential chargers. The research met the goal by collecting, analyzing, and presenting the research data in the form of a technology roadmap. The paper presents the current state of V2G technology in the automotive industry and where the industry should and will be heading in the next 5 years. Factors like V2G technology and the related research by industry and government-industry-academia partnership are well accounted.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
All authors contributed to this project equally from the inception to the end. All authors read and approved the final manuscript.

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The impact of corporate characteristics on the financial decisions of companies: evidence on funding decisions by Italian SMEs

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Abstract

Small and medium enterprises (SMEs) represent a large percentage of the corporate tissue of developed countries, but they do not have adequate attention. In fact, various researchers have focused their studies on larger and well-known companies. This paper aims to investigate the impact of corporate characteristic on the financial choices of SMEs, with a specific focus on agro-food micro companies. Access to finance is vital in business start-up, development and growth for SMEs, all with very different needs and facing different challenges in terms of finance compared to large companies. The lack of equity invested in small enterprises makes them more dependent on other external sources (e.g. bank loans, overdraft, factoring and leasing). The limitations of the paper are the result of its very nature: it is a largely conceptual paper. Empirical research is therefore needed to test and validate the essentially preliminary framework.

Keywords: Capital structure, Internal source, External source, Bank loans, Agro-food firms, SMEs

Background

Small and medium enterprises (SMEs) represent a large portion of the corporate tissue of developed countries. In fact, the 20 million European SMEs play an important role in the European economy. In 2012, they represented 99.8 % of the total number of companies, and 66.5 % of all European jobs for that year (European Commission 2013b). During 2012, the SME sector as a whole contributed to 57.6 % of the gross value added (Table 1) generated by the private, non-financial economy in Europe 2012 (Eurostat 2013).

The role of SMEs is crucial for recovery of the European economy: their number, employment capacity and added value constitute a large share of the European economy. Providing the right conditions in which SMEs can flourish is paramount for ensuring a sustained recovery and achieving prosperity for all EU citizens.

Recent studies on SMEs and their contribution to growth have shown that framework conditions within which they operate, and the entrepreneurial culture are key factors in establishing the extent of SME performance and consequently their contribution to macroeconomic growth. Even in the presence of a strong entrepreneurial culture, however,

Table 1 Companies, employment and gross value added of SMEs in the EU-27, 2012

	Micro	Small	Medium	SMEs	Large	Total
Number of enterprises						
Number	18,783,480	1,349,730	222,628	20,355,839	43,454	20,399,291
%	92.1 %	6.6 %	1.1 %	99.8 %	0.2 %	100 %
Employment						
Number	37,494,458	26,704,352	22,651,906	86,814,717	43,787,013	130,601,730
%	28.7 %	20.5 %	17.3 %	66.5 %	33.5 %	100 %
Value added at factor costs						
Million Euros	1,242,724	1,076,388	1,076,270	3,395,383	2,495,926	5,891,309
%	21.1 %	18.3 %	18.3 %	57.6 %	42.4 %	100 %

Source: Eurostat, 2013

SMEs would struggle to perform if basic framework conditions were not present (European Commission 2013a).

All these figures highlight the importance of these companies, but they are not always given the right attention. The emphasis on big companies undermined the development of young and small companies that do not have access to public markets (Zingales 2000).

Many financial scholars have investigated debt policy decisions made in companies. There are also many empirical studies on the financing decisions of large and listed companies (Bradley et al. 1984; Auberbach 1985; Friend and Hasbrouck 1988; Titman and Wessels 1988; Barclay et al. 1995; Rajan and Zingales 1995; Graham 1996; Chen et al. 1998; Wald 1999; Rossi et al. 2012; Rossi 2014), but the scientific community has only recently started to study the financial structures of the small companies. In spite of this, there are a considerable number of relevant empirical works worldwide such as Constand et al. (1989), van der Wijst (1989), Walker (1989a, b), Holmes and Kent (1991), Chittenden et al. (1996), Calcagnini and Iacobucci (1997), Hamilton and Fox (1998), Jordan et al. (1998), Michaelas et al. (1999) and López and Aybar (2000).

Following this research, this paper aims to study the determinants of the financial choices of the SMEs. The structures of the remainder of the paper are as follows: "Financing lifecycle: financial sources for companies" section describes the financing lifecycle and internal-external financial resources. "The Italian agro-food system" section presents the Italian agro-food system and the Italian agro-firm structure. "Access to finance for Italian SMEs" section explains the main problem related to access to finance for Italian small companies. The research methods and results are discussed in "Methods" section. "Conclusions and research limitations" section concludes the paper.

Financing lifecycle: financial sources for companies

The absence of economic capital is one of the most important obstacles to growth. The management of the capital factor, from acquisition until the time of its use, will require a decision-making process focused on quantitatively and qualitatively capital resources observed both in their origin—sources—and in their destination—uses. Funds differ in various stages of a company's life cycle (Fig. 1).

In the start-up phase, the family of the owner and/or business angels are the main investors of a new company. Start-up financing is used for product development and

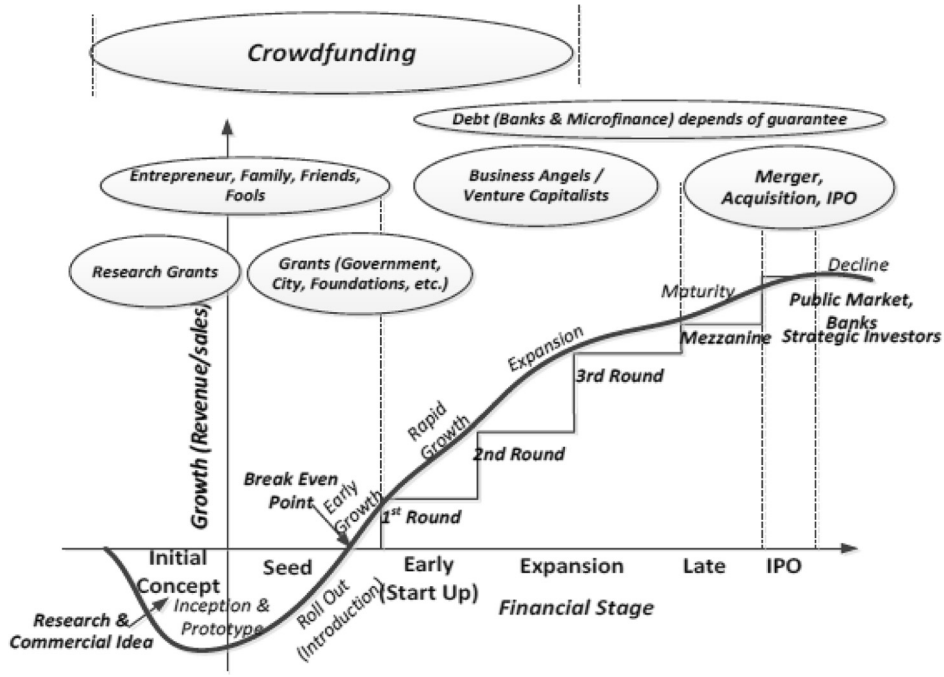

Fig. 1 Financing lifecycle. Source: Lasrado, 2013

initial marketing activities. Companies may still be in their creation phase or have just started operations, without having sold their product. At this stage, money is important to pursue R&D activities. When the product has taken form, a certain number of venture capitalists will join the company: they want to set up the company. After training, the company has developed its product and it requires more financial resources in order to market it. The company that has not yet generated any profit as the expansion-development step is a high progression process. At this stage, capital is used to increase production, to develop new services/products, to finance acquisitions and/or to increase the working capital of the business (Rossi, 2015).

Companies require different forms of capital in different stages of their life. Financial resources can be classified into external sources and internal sources; the internal sources include all the financial resources from inside the business, external sources include all of the financial tools from outside the business (Fig. 2).

Internal finance tends to be the cheapest form of finance since a business does not need to pay interest on the money. However, it may not be able to generate the money that the company is looking for, especially in the case of large amounts. There are three internal sources of finance:

- Retained profits
- Sale of existing assets
- Cut down in stock levels

External sources can be divided into long-term, medium-term and short-term. Short-term financing has a repayment period of less than 1 year. Medium-term financing

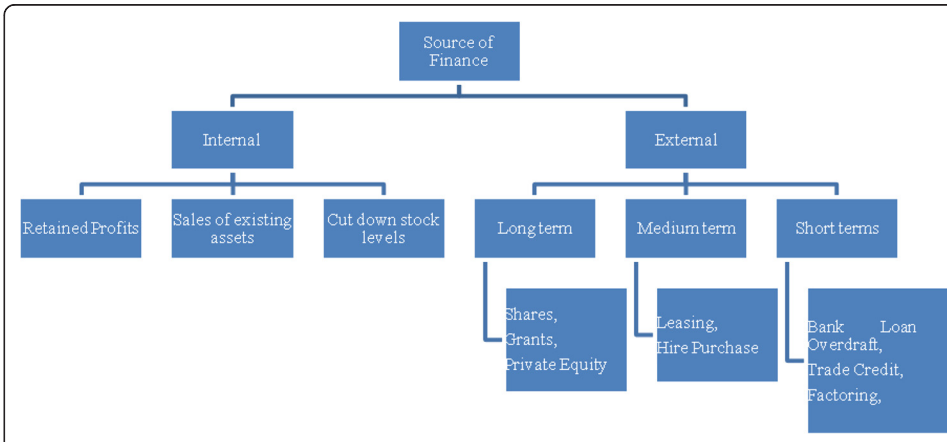

Fig. 2 Sources of finance. Source: authors' calculation

includes those with a maturity period of more than 1 year but less than 5 years. Long-term financing includes those with a maturity period of 5 years or more.

There are a lot external sources of finance:

- Bank loan or overdraft
- Trade credit
- Factoring
- Leasing
- Hire purchase
- Shares
- Long-term bank loans
- Grants
- Private equity, venture capital, business angels

The use of external financial resources is linked to the main of internal resources (Table 2).

In fact, internal resources are limited in volume, and this requires external investors. External financing can help jump-start of business, but it also has drawbacks (Table 3).

Starting from the seminal papers of Modigliani and Miller (1958, 1963), a lot of financial research has focused attention on optimal capital structure. One of the most important research projects was conducted by Myers and Majluf (1984); they argued that a hierarchy exists in loan funds for companies. Due to information-related asymmetries, companies prefer internal than to external capital sources. The limitation of

Table 2 The advantages and disadvantages of internal sources

Advantages	Disadvantages
Capital available	Expensive: is not tax-deductible
No interest	No increase of capital
Spares credit line	Not as flexible as external financing
No control procedures regarding creditworthiness	Losses are not tax-deductible
No influence of third parties	Limited in volume

Source: author's calculation

Table 3 The advantages and disadvantages of external sources

Advantages	Disadvantages
Faster growth	Loss of ownership
Greater economies of scale	Loss of control
Leveraged return	Cost
	Cash flow

Source: author's calculation

internal resources led the owners of SMEs to select external capital sources. In these cases, they chose short-term debt, because it does not reduce managers' operability.

The Italian agro-food system

The Italian food industry is a fundamental part of the country's economic system and represents an important sector of its manufacturing industry (Crescimanno et al. 2015). In recent years, the food industry has been affected by the wider decline and loss of competitiveness of the Italian industry.

Product of designated origin

Italy continues to maintain the largest share in the market for protected designation of origin (PDO) and protected geographical indication (PGI) products in the EU (that is 1167, including also traditional specialty guaranteed (TSG)), recording a further increase to 252. Most of the specialties deal with fruit and vegetables and cereals (almost 40 %), cheese (18 %), extra virgin olive oil (17.6 %) and cold meats (over 14 %). Mozzarella and pizza napoletana are the only recognized Italian traditional specialty guaranteed (across the EU, they amount to 38). The regions with the most PDO and PGI products were Emilia-Romagna and Veneto, with 35 and 33 products, respectively.

In 2013, there were 80,435 certified operators, of these, 91.2 % were exclusively involved in production activities and 6.6 % in product transformation; the remaining 2.2 % performed both activities (ISTAT, 2014). Among producers (75,156 units), the cheese sector was rather highly represented (27,190 units, with the equivalent of 36.2 % of the total), along with olive oil (19,083 or 25.4 %) and fruit, vegetables and cereals (17,076 or 22.7 %). Transformers (7090 units) were also more frequent in the extra virgin olive oil (1863 or 26.3 % of the total), cheese (1691 or 23.9 %) and fruit, vegetables and cereals (1165 or 16.4 %) sectors. Overall, the stable number of producers registered between 2012 and 2013 was the result of a fall in Northern (−4.2 %) and Central areas (−1 %) compared with a rise in South and Islands area (+7.5 %). The slight increase in the number of transformers was due to an increase in the Centre and North, exceeding the fall in the South and Islands area (Table 4).

ISMEA figures on demand for PDO/PGI products indicate a drop in domestic consumption and an increase in value, caused by higher average retail prices. The number of the Italian quality wines increased in both PDO and PGI. There are 476 registrations considering the Denominazione di Origine Controllata e Garantita (DOCG), Denominazione di Origine Controllata (DOC) and IGT wines. With a production of 15.5 million hectolitres of DOC-DOCG at the end of the decade, they account for 40 % of all wines produced in Italy. The North is still in first place in terms of quality production

Table 4 Number of PDO and PGI products by regions—2013

Region	Fruit, vegetables and cereals	Olive oil	Cheese	Prepared meats	Other products	Total
Piedmont	6	–	8	4	1	19
Valle d'Aosta	–	–	2	2	–	4
Lombardy	2	2	11	9	1	25
Liguria	1	1	–	–	1	3
Trentino-Alto Adige	3	1	5	2	1	12
Veneto	16	2	7	7	1	33
Friuli-Venezia Giulia	1	1	1	3	–	6
Emilia-Romagna	11	2	4	13	5	35
Tuscany	7	5	2	4	7	25
Umbria	2	1	1	2	2	8
Marche	2	1	2	4	2	11
Lazio	7	4	3	4	7	25
Abruzzo	2	3	–	1	3	9
Molise	–	1	1	2	2	6
Campania	11	5	3	–	2	21
Puglia	6	5	3	–	2	16
Basilicata	4	1	3	–	1	9
Calabria	4	3	1	4	2	14
Sicily	15	6	4	1	2	28
Sardinia	1	1	3	–	2	7
Italy[a]	100	43	44	36	29	252

Source: INEA, 2014
[a]Some products are inter-regional, so, the total of PDO/PGI by region does not correspond to the total for Italy

with 9.3 million hectolitres, or 62 % of the national DOC production. Wines of controlled origin (especially red wines) continue to be among Italy's best-selling exports, with a total value of nearly 1.4 billion euro.

Land market and investments in the sector

In 2012, the Italian land market has been characterized by a fall in sales and a reduction in prices. The national average of the land value decreased by 0.1 % year by year, reaching approximately € 20,000/ha. However, reduction in real terms was stronger (−3.1 %). The main factors that have contributed to this slowdown are related to the general economic crisis and to the new scenarios that have characterized agriculture in the last decade (Trequattrini et al. 2012). In particular, the difficulty of access to credit limits the demand from the professional farmers, while uncertainties on profitability of the sector affect the activity of the non-agricultural actors (Rossi et al. 2014).

In 2012, gross fixed investments in agriculture, in real terms, have marked a 9.6 % decrease considerably larger than the one registered in the previous year (−1 %). Compared with 2011, the share of agricultural investment in total investments decreased, dropping to 3.5 % as did the relation with the agricultural added value (from 34.2 % in 2011 to 32.4 % in 2012).

In 2011, the allocation by type of asset, referring to all economic activities, showed a slight decrease for investments in crops and livestock (−0.7 %), after the positive results

shown in the three previous years. On the other hand, other sectors show a much more negative trend with a decrease of 12.2 % for transportation, 10.7 % for machinery and equipment and 6.3 % for non-residential buildings and other works.

Despite the downward trend compared to 2011, the amount of investments per worker in the primary sector which has increased in recent years deserves to be mentioned, essentially due to a fall in employment in the sector. As a result of the reduction of manufacturing employment, there has been an increase in the capital stock in agriculture (+1.6 %), in real terms and net of depreciation.

The Italian agro-industrial system

The agro-industrial system is made up of a number of activities through which agriculture interacts with all the sectors connected to it, up and down the supply chain: from the industry inputs (fertilizers, pesticides, animal feed, energy, etc.) to the food processing, distribution and catering industries. The agro-food sector has an estimated value of approximately 266 billion euro (almost 17 % of GDP). The main contributions were approximately 28.1 billion euro from agricultural added value (VA), 25 billion euro from intermediate consumption in agriculture, 17.8 billion euro from agro-industrial investments, 25.7 billion euro from VA in the food industry, 43.8 billion euro from VA in the catering industry and 108.2 billion euro from marketing and distribution (Fig. 3).

The Italian agro-firm structure

The sixth General Agricultural Census shows a structural framework characterized by a strong decrease in the number of farms (−32.4 %) compared to 2000 and a more modest decline in UAA (−2.5 %). The phenomenon is the result of a multi-year process during which agricultural lands and farms were concentrated in a substantially smaller number of farms (Fig. 4a). It has resulted in an increase of the average farm's UAA that grows from 5.5 to 7.9 ha. Although there has been an increase in companies with larger size (more than 30 ha), Italian agriculture continues to be characterized by a very large number of very small companies that affect the economic performance of the sector. Companies with a standard value production of less than 8000 euro represent 62 % of the total farms, and they account for only 5.3 % of the total standard production of domestic agriculture

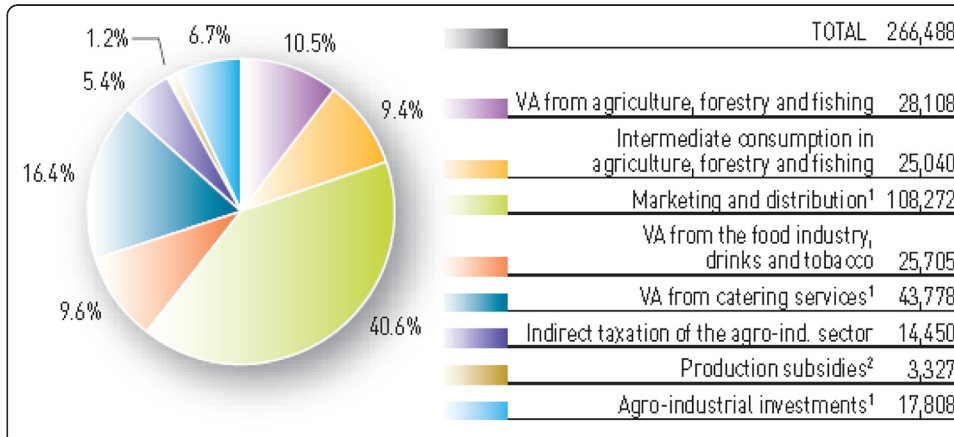

Fig. 3 Main components of agro-industrial system at basic prices (million euro)—2012. Source: INEA, 2014

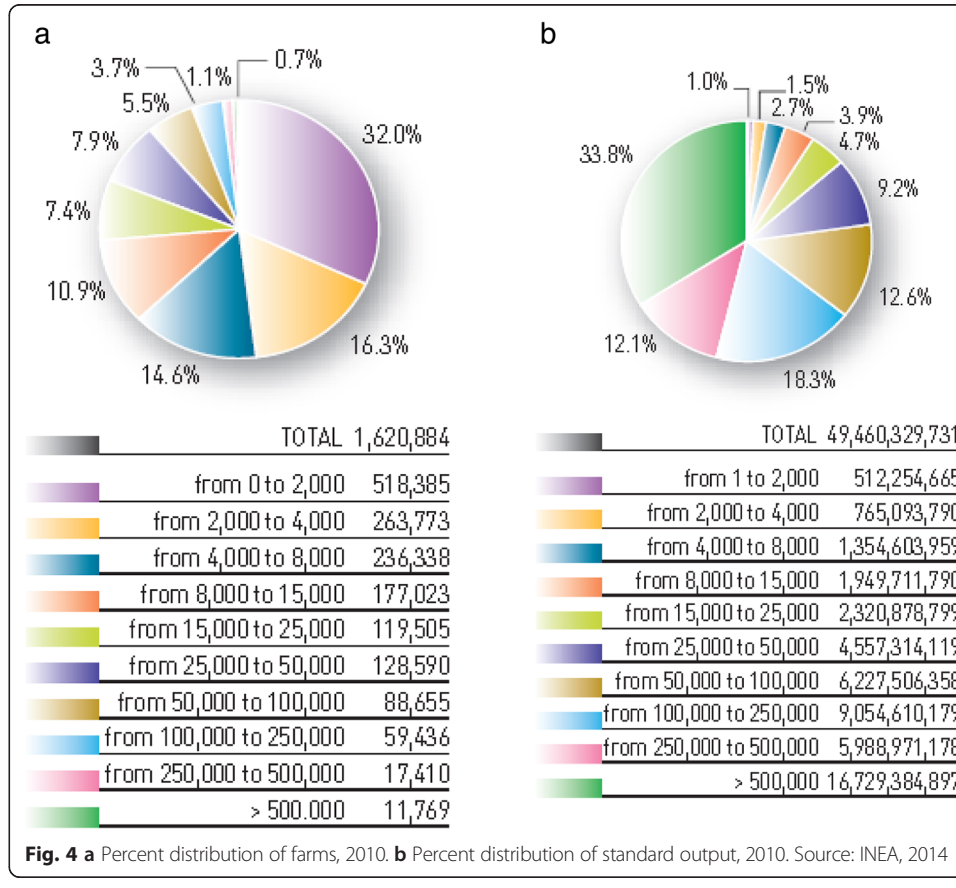

Fig. 4 **a** Percent distribution of farms, 2010. **b** Percent distribution of standard output, 2010. Source: INEA, 2014

(Fig. 4b). It is clear that companies that have such a modest economic weight, although they play an important role in protecting the landscape, are mainly aimed at the production for self-consumption. Only 310,000 companies (19% of the total) can be considered as real "business". These companies account for almost 90 % of the value of the Italian standard production (whose total value amounts to approximately 49 billion and 500 million euro).

The structure of agricultural and livestock Italian companies is characterized by individual companies (96 %), mainly run by the owner or his family (95.4 %). The family plays a central role for the programming and the management of agriculture, as much as 76 % of the total workforce comes from the owner and his family.

Most company leaders have a level of education less or equivalent to that of the middle school (71.5 %), only 0.8 % seems to have a degree or diploma in agriculture. The title of the post-secondary school is not always connected to specific studies in agriculture: only 4.2 % of the company leaders have a specific qualification in the sector, the remaining 24.3 % have qualifications other than agriculture. Although a higher level of education can be found in larger companies, it should be said that even in these companies (>500,000 euro of standard production) most of the company leaders have a low degree of education that is almost half of the total number of farms (46 %).

Access to finance for Italian SMEs

Access to finance is one of the most important problems for Italian SMEs. Italy performs well below the EU average, with signs of increasing deterioration (Fig. 5).

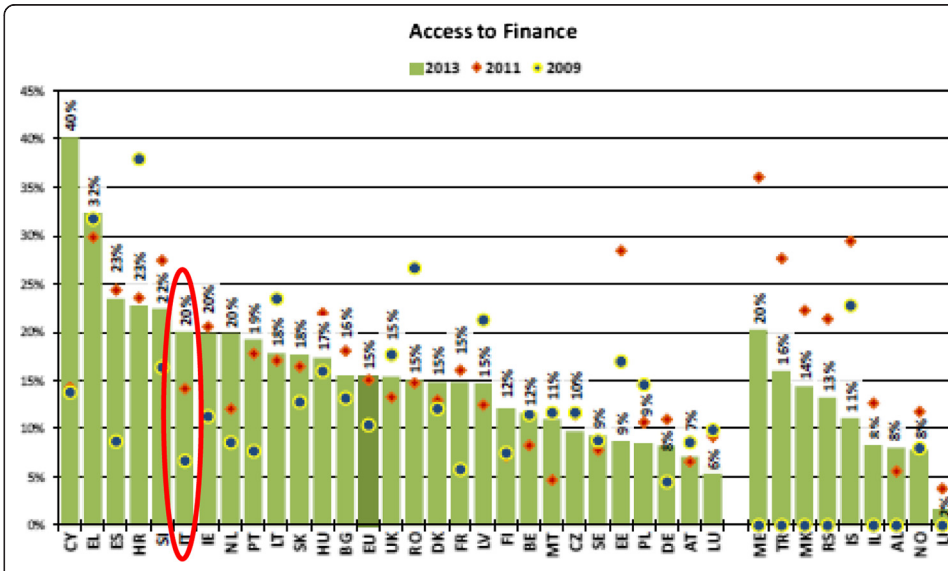

Fig. 5 Companies most pressing problem. Source: European Commission 2013c

Banks are less willing to provide loans to SMEs, and this indicates a drying up of private sector financial support (Formisano et al. 2012). In line with the long payment times for public authorities, total invoice payment times are still one of the longest in Europe (117 days), double the EU average (53 days) (European Commission 2013b (Fig. 6).

Problems continue in the wider interest rate spread between small and large loans and in the absence of private equity and venture capital investors, especially for early-stage investments. Despite the efforts made by the government to sustain new and traditional forms of financial instruments, Italian SMEs still suffer from a chronic and structurally difficult access to finance. The main problems are:

- The increased administrative rigidity of banks in providing loans
- The higher differential rates between large companies firms and small and medium companies

Methods

In agreement with the European Commission SME definition, this paper considers a sample of small and medium companies located in Italy. This sample has been extracted from AIDA, a database of Bureau van Dijk, which contains economic and financial information with up to 8 years of history of more than 200,000 Italian companies. Before this analysis, this paper analyses the main problem related to access to finance for Italian small and medium companies.

An analysis of the main weaknesses in financing Italian agro-food SMEs is the basis for the research. Data was obtained through a survey of business companies. The research was carried out with CFOs, responsible for capital budgeting decisions. In order to achieve this goal, a total of 153 entrepreneurs-managers were targeted as potential respondents. Due to the nature of research, the study focused primarily on CFOs and managers who are involved in the capital budgeting decisions.

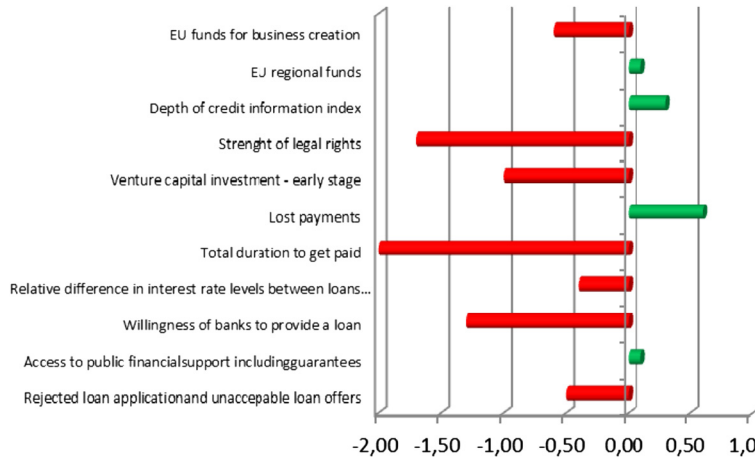

Fig. 6 Distance from the EU average (measured in standard deviation, EU average = 0). Source: European Commission 2013c

The aim of pilot testing was to check the relevance of the questions before interviewing. Out of the 153-targeted interviews, a total of 80 interviews were successfully conducted. They provided a response rate of about 52 %.

Results and discussion

The following section discusses the main findings and results of the survey on capital budgeting techniques used by Italian companies. The first classification refers to the size of the business and the sector of the companies involved. From the total of 80 respondents, 28.75 % qualified as medium enterprises, and the remaining 71.25 % were categorized as small businesses.

The objective of the survey was to find out whether there was any relationship between financial decision makers and their level of qualification. In fact, there is a different involvement of respondents to the survey. Figure 7 shows the formal educational qualifications of the decision makers of the respondents.

The research highlights that the decision makers that did have a high school diploma mainly used bank loans or overdrafts as compared to those that received formal training. However, an in-depth analysis revealed that the use of much more sophisticated financial instruments (factoring, leasing, etc.) was much more popular with those who received formal accounting-finance training. A closer look at the companies that used more than one source of finance indicates that the majority of them belonged to the post graduate category.

Another important step of the research was the analysis of the responses given per category of firms. The results confirm the theory that SMEs have a preference for financial sources: bank loans. In fact, about 70 % used bank loans or overdrafts, and as companies increase in size, they begin to use more financial sources.

External financial sources present an important cost: interests. In our interviews, we asked CFOs for the interest rates. This aspect is fundamental because this is a signal of entrepreneurial awareness in financial choices. The research highlights that the SMEs decision makers are not particularly aware of the interest rates on loans. They consider an interest rate as a fixed amount, but this is a crude approximation to reality.

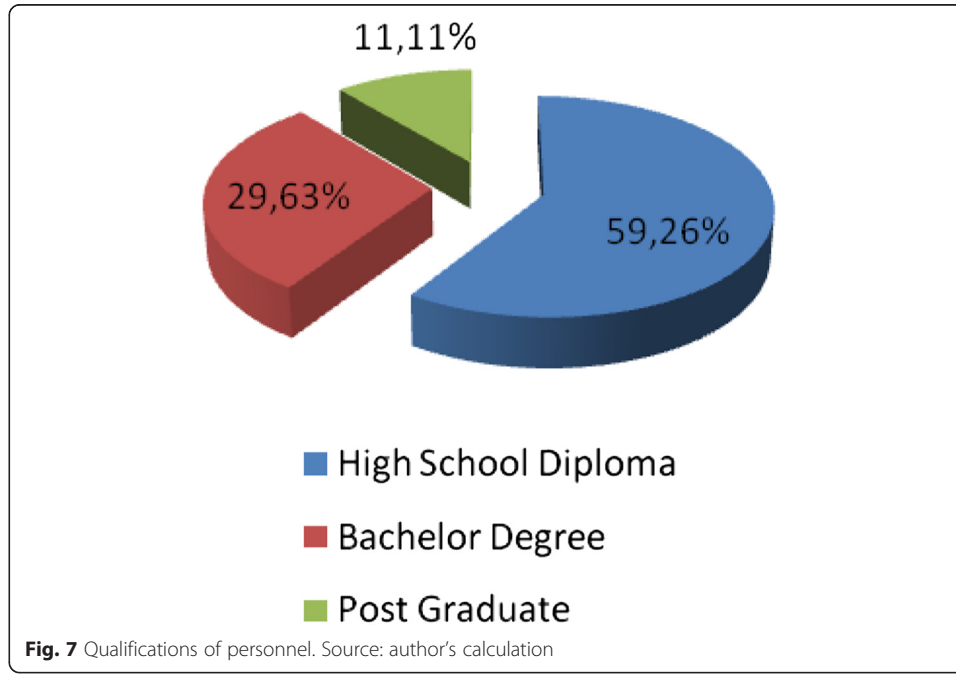

Fig. 7 Qualifications of personnel. Source: author's calculation

Decision makers play a key role in financial choices. Different organizations use different decision makers to make their financial choices. Table 5 shows that decision makers are responsible for the selection of better financial sources according to the size of the companies.

The results above show that about 75 % of the business owners are directly responsible for the choices of financial sources. Furthermore, the results suggest that different business level managers have limited influence on this decision-making process. However, the influence increases with the increase in the size of the company. It appears that, where present, the finance section had an important effect in all decisions making scenarios.

A similar view can be expressed with regard to the role played by teams. A possible explanation is linked to the nature of small businesses. The majority of the interviewees in small companies had limited operational structures, generally associated with larger corporations. This may be a reason why owners defined financial choices in small companies. However, the same reason cannot be attributed to larger enterprises. In fact, they have more formalized structures and large work forces.

Conclusions and research limitations

The research has combined primary data with secondary data to reach specific findings regarding the nature of choices of financial sources of agro-food Italian companies.

Table 5 Decision makers

Decision makers	Small (%)	Medium (%)
Owner	79	62
Chief financial officer	8	24
Team decision	13	14

Source: author's calculation

Particularly, in this research, two different variables were considered: the impact of the business size and the level of education of decision makers.

This research has proved that financial decisions are complex, but underestimated by SMEs. In fact, in these companies, owners are directly responsible. In most cases of the companies included in the sample, the decisions makers have taken choices without appropriate training (Rossi et al. 2012).

In terms of prescriptive conclusions, the obvious advice is to adopt proper strategic financial processes, especially for small companies. Beyond this and more constructively, research recommends greater attention towards growth and the achievement of proportional cost economies (scale and scope).

With regard to the choices of financial sources, the structural analysis of this research provides the low capital in companies and high financial exposure, generating a double negative effect: firstly, the high interest expenses erode the low operating revenue; and secondly, a vulnerability result of many local high-quality agro-food companies to acquisitions from larger international producers.

Research has also highlighted a deficiency regarding the degree and nature of investments. Specifically, the need for investment in tangible assets to be supported by investments in research and development was pinpointed: investments with the objective of product and process innovations; brand repositioning along a higher (consumer perceived) quality; and market and consumer knowledge towards development of ideas, creativity, originality and consumer-focused tactics.

The limitations of the paper are the result of its very nature: it is a largely conceptual paper. Empirical research is therefore needed to test and validate the essentially preliminary framework developed and the (well-based) assumptions made towards its development. Particularly, the most important limit is the definition of the company size that was based only on the number of employees. Other indicators of business size such as capital employed and turnover were not considered.

This research has an exploratory aim, and its findings are far from definite. On the contrary, they represent a starting point, a base for further research and analysis. For this reason, the empirical results should be interpreted in view of some limitations: the sample of companies is random and does not fully conform to the criteria of statistical representation; the sample of companies could be expanded numerically.

The above findings nonetheless, do require further research towards greater validation and refinement on the one hand (zoom in), and exploration of the wider perspectives presented on the other (zoom out). More specifically, it is recommended that research is undertaken to investigate more accurately and in greater depth, the various aspects of the agro-businesses; but also do so for specific sub-categories (by type, size, area, etc.). However, the complexity of the subjects, as well as the role of the human factor involved additionally calls for further research of a qualitative nature that will shed light on the less tangible, 'softer' aspects of agro-business management.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
The present paper is the result of the common reflection of all the authors; in the editing phase, the "Background", "Financing lifecycle: financial sources for companies", "Methods" and "Results and discussion" sections were written by Matteo Rossi; "The

Italian agro-firm structure" and "Access to finance for Italian SMEs" sections were written by Rosa Lombardi; "The Italian agro-food system" and "Land market and investments in the sector" sections were written by Dario Siggia; "The Italian agro-industrial system" section was written by Nadia Oliva; "Product of designated origin" was written by Matteo Rossi and Nadia Oliva; whereas "Conclusions and research limitations" section is the result of the common elaboration by the authors.

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Russia's experience of foresight implementation in global value chain research

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Abstract

The objective of this paper is to analyse the scope for improving empirical and methodological foundation of global value chain (GVC) research and for making relevant political decisions, primarily through application of foresight methodology based on the latest trend to combine the approaches of global value chain and national innovation system research. The authors choose Russia as an illustrative case of an economy in the changing geopolitical context to review major trends of global value chains' development, specific features of Russia's participation in them, and the necessary steps to increase the quality and efficiency of this participation. Special attention was paid to theoretical, methodological, and empirical tools of GVC research and of making relevant political decisions—which presently are far from being adequate: they need to be supplemented with the new ones to improve the forecasting potential and practical and strategic orientation of the GVC approach. To this end, approaches which would make it possible to research interconnection between global processes and trends with regional and national innovation-based development tendencies become of crucial importance. Application of foresight methodology may significantly contribute to researching the GVC phenomenon, being a major logical step towards creating advanced policy tools to mobilise available resources and coordinate stakeholders' actions to increase Russia's global competitiveness. The paper presents a number of case studies which describe practical application of various foresight methodology components to analyse Russian participation in various GVCs, by the examples of specific product and service groups (fresh fruit and vegetables, car parts, mobile phones, air transport, electronic payment systems). The authors conclude that both full-scale foresight studies and specific components thereof could be applied for the purposes of GVC analysis, strategic planning, and making political decisions.

Keywords: Global value-added chains (GVCs), Trade, Competition, Globalisation, Innovation, Foresight

JEL codes: O14, O25, O31

Background

Global value chains (GVCs) have become a key element of the world economy (OECD 2013a). Developed and developing countries alike participate in them, regardless of technological level and per capita income. This determines the global community's keen interest in understanding the structure of global trade in terms of value added

and value chains and identifying existing and potential opportunities for companies integrating into them, both on the national and industry-specific levels (Kaplinsky 2013).

Being a relatively new but increasingly common phenomenon, GVCs are subjected to in-depth analysis by leading international organisations including the OECD, the UNCTAD, the WTO, and the G20 to identify their potential positive and negative effects on the global economy and economies of particular countries.

At the same time, the work to advance the empirical and methodological foundations of GVC research is also under way (Lundvall et al. 2015; Morrison et al. 2008; Pietrobelli and Rabellotti 2011), which should contribute to increasing heuristic value and reliability of research results, practical importance of relevant R&D, and validity of prepared political recommendations.

The current trends in studies aimed at improving methodological approaches to GVC research include the following:

- Development of the so-called industrialist approach to GVCs, by analysing their effects on more local levels such as specific industries and clusters.
- Realising the need to take into account specific features of regional and national innovation systems (which ultimately became the decisive factor when we adopt the industrialist approach) allows to understand how and why participation in GVCs results (or does not result) in actual company-level changes in particular countries.
- Increasing the forecasting potential of GVC research to enable moving on to the strategic planning level and making political decisions relevant to participation in global value chains.

This paper is an attempt to combine all three current trends in GVC research. The objective is to analyse the scope for improving empirical and methodological foundation of GVC research and for making relevant political decisions, primarily through application of foresight methodology components to certain industries (specific product and service groups) and identifying their innovation aspects and the role of R&D.

To that end, it would be important to analyse the nature and major development trends of this global economy phenomenon, specific features and performance indicators of Russia's participation in GVCs, and the potential and limitations of theoretical, empirical, and methodological foundations of GVC research. The novelty of this work is due to the presented results of applying various foresight methodologies to conduct industry-specific analysis, through case studies of production, export, and marketing of several product and service groups, in advancement of the approach suggested in Kaplinsky (2004) based on the dynamic rent concept in the GVC framework.

Empirical evidence of Russia's participation in GVCs

GVCs are one of the most striking phenomena of the modern global economy, vividly demonstrating the pluses and minuses of increased interdependency between various countries' economies. At the same time, GVCs are, in a way, an answer to global challenges. In the framework of the present-day globalised economy, not just internationally traded end products are important from the job creation and development point of

view but also performance of companies participating in creation of these products. Accordingly, GVCs are frequently seen as an opportunity for developing countries to move up along the value-added "stairway", by creating favourable conditions for international businesses and attracting foreign investments (OECD et al. 2014, 2013).

In the most generalised way, Sturgeon (2001) defined GVCs as a mechanism for adding value during the end product creation process, which comprises various technological production stages, design, and marketing. In a specific global value chain, the OECD (2013b) distinguishes between *forward linkages in GVCs*, which reflect export of raw materials and services which are subsequently imported back as end products (linkages (companies) producing components and parts for more complex products), and *backward linkages in GVCs*, which reflect production and export of end products and services made using imported raw materials and services (advanced manufacturers assembling final products).

During 1995–2009, countries' participation in GVCs grew on average by 5–10 % (OECD 2013b) (Fig. 1). About 40 % of the OECD countries' exports is made up by foreign value added. Since 1995, the biggest increase of participation in global value chains showed South Korea, India, and China (growth of GVC participation index between 10 and 20 %).

The share of services value added embodied in manufacturing exports in the OECD and their partnering countries has on average also increased (OECD and WTO 2013) (Fig. 2). In recent decades, the biggest growth of this indicator demonstrated the EU countries (specifically Germany, the UK, and Italy), India, and the USA. Services value added embodied in manufacturing exports on average amount to 40–50 %. In Russia, the relevant figure remained practically unchanged, at about 30 %.

As previous experience shows (Gereffi and Kaplinsky 2001; Kaplinsky, 2013), in many developing countries, high growth rates are specifically linked with their integration into GVCs, using imported components and materials to develop own production and export.

According to international research, the service sector (intellectual property, logistics, marketing, etc.) creates the biggest share of value added, as opposed to the manufacturing sector (Kaplinsky 2013).

Figure 3 illustrates the typical structure of a common GVC in terms of what roles companies can play therein, how much value added do they create, and how ample is the economic profit they receive given that the higher the value added generated is the bigger the profit is. The highest profit rate shows companies which are the farthest-removed, in temporal terms, from the actual assembly of products, its design, and after-sales service. The most profitable GVC segments with the least number of players

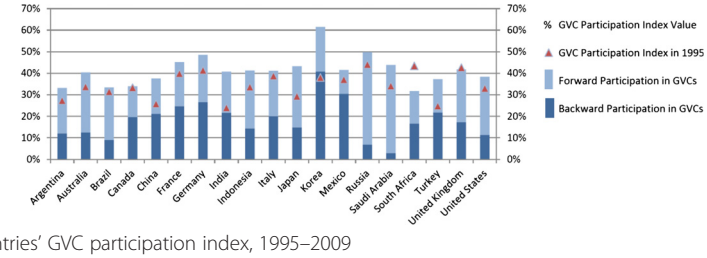

Fig. 1 Countries' GVC participation index, 1995–2009

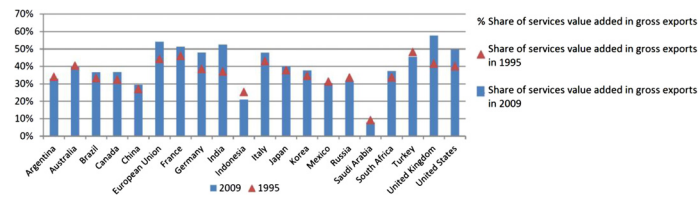

Fig. 2 Services value added embodied in manufacturing exports, across countries, 1995–2009

should be seen as strategic reference points by countries and companies willing to integrate into global value chains.

OECD/WTO TiVA database is closed-source. As of now, it presents calculations based on the 2011 data for a list of indicators showing global trade statistics through a "value-added" perspective. These indicators, for instance, include "foreign value added share of gross exports", "direct domestic value added content of exports", and "re-imported domestic value added content of exports".

Though the majority of trade economists has awarded it a critical acclaim stressing that value-added global trade statistics has a high heuristic value, the major drawback of such data is the lack of analytical capacity for any statistical speculations based on such data only need to be complemented by in-depth case study analysis.

Russia's GVC participation index (its most recent value is 51.8) (OECD and WTO 2013) shows that the country's overall involvement in GVCs is quite high (the 25th place out of 57) (OECD and WTO 2013) but the nature of its participation in global value chains remains very much limited to raw materials (Fig. 4).

Russia's participation in backward linkages in GVCs (exporting end products and services made with participation of foreign contractors and middlemen) is much lower than the OECD countries' (OECD 2013b). The relevant index value for 2009 was 6.9—the second lowest result (OECD and WTO 2013) after Saudi Arabia's.

A specific feature of Russia's participation in GVCs (see Fig. 5) is that this participation, especially in mining and metallurgy, chemical industry, wholesale and retail trade, transport, and telecommunications, is 86 % forward-oriented (i.e. other countries use Russian exports as raw materials or components for their own production) (OECD n.d.). The share of oil and gas in Russian exports reaches 70 % ("Commodity Composition of Russian Exports Into All Countries, January-December, 2014" 2015 (in

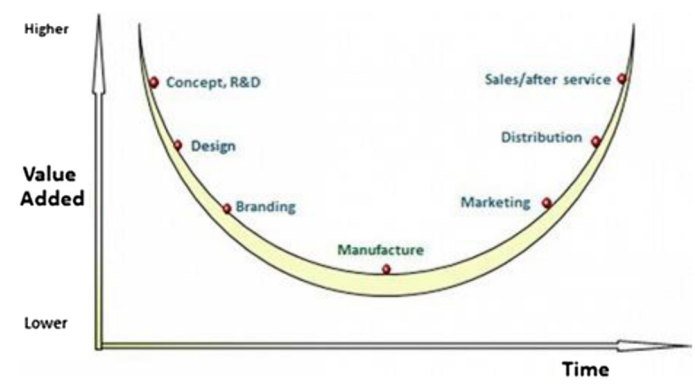

Fig. 3 Economic profit distribution across different business functions in GVC

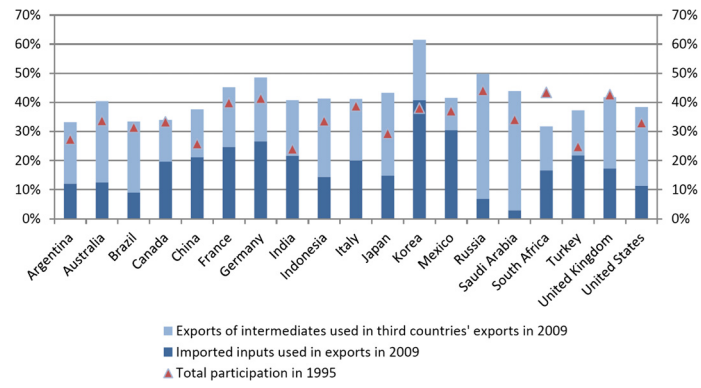

Fig. 4 Countries' GVC participation index and import/export ratio

Russian). This specialisation hinders creation of high value added in GVCs. The resources exported by Russian companies return into the Russian economy as imported end products with appropriate mark-up, which is further increased by the existing tariffs and non-tariff trade restrictions. At the same time, the share of Russian value added in these imported products is higher than the foreign-generated component.

Thus, Russia's current position in GVCs does not allow to gain all possible long-term benefits from this participation. At the same time, however difficult the current geopolitical situation may be, and however pessimistic Russian short-term economic development forecasts may look, it seems important to suggest certain steps which could potentially contribute to making better use of the country's existing competitive advantages and increasing efficiency of its participation in GVCs in terms of minimising possible risks and maximising the advantages of being a part of global value chains (for more on risks and benefits associated with Russia's participation in GVCs, see Meshkova and Moiseichev 2015 (in Russian)), including definition of "windows of opportunity"—the sectors where Russia can secure leading positions in backward linkages in a foreseeable future, and thus obtain the necessary competitive advantages.

Historical evolution of the GVC literature's methodology

Emphasising the heuristic value of GVC research in his "21 for 21" OECD transformation proposal (Gurría 2015), the OECD Secretary-General Angel Gurría has underscored that such research has allowed the OECD to "decode the trade genome" and such work should be continued with its results being put into real trade negotiations' practice.

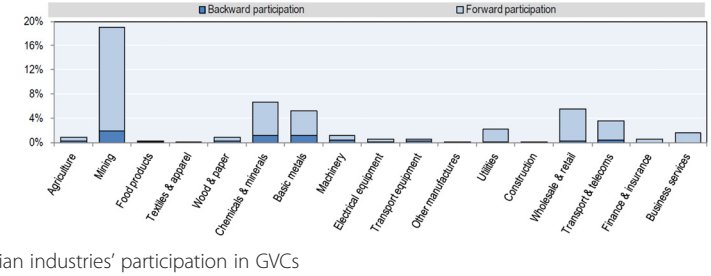

Fig. 5 Russian industries' participation in GVCs

The actual value-added chain concept was first proposed in the 1960s–1970s. Currently, there are two main distinct "schools" of thought (Morrison et al. 2008) regarding this subject area—*the internationalist* and *the industrialist.*

The first approach is represented by the US researchers and first of all by Gary Gereffi, professor of sociology and director of the Center on Globalization, Governance & Competitiveness at Duke University (Gereffi 1999; Gereffi and Kaplinsky 2001; Kaplinsky 2004), and also by several European scientists such as Raphael Kaplinsky, professor of international development at the Department of Policy and Practice at The Open University (Essex, UK) (Kaplinski 2002, 2004), and Peter Gibbon, researcher at the Danish Institute for International Studies (Gibbon 2001, 2003).

The industrialist approach is represented by researchers at the Institute of Development Studies of the University of Sussex (Humphrey et al. 2000; Humphrey and Schmitz 2002).

Internationalists conduct analysis mostly on the macro level (in the context of analysis units and the scale of proposed recommendations), while industrialists adhere to the micro level, analysing the more local experience of specific industries and clusters. However, this subdivision is quite notional since the presented approaches rather supplement each other—which among other things is confirmed by the emergence of a number of joint publications by representatives of both schools (Gereffi et al. 2001, 2005).

Empirical foundation of GVC research is provided by two international databases, Trade in Value-Added (TiVA) and World Input-Output Database (WIOD). TiVA was created jointly by the OECD and the WTO (OECD and WTO, 2013). It allows to look at the current international trade under a new perspective and move on from analysing export and import flows of products and services to a more holistic research of GVCs at the core of international goods and services flows. The current version of the TiVA database is its third edition (June 2015) which contains both the traditional external economic activity indicators and a whole range on innovation indicators describing national economies in terms of their participation in GVCs. TiVA contains data on 57 economies including all members of the OECD and Brazil, China, India, Indonesia, Russia, and South Africa, covering the period between 1995 and 2011 broken down into 18 sectors.

The system for forecasting countries' participation in global value chains is based on the WIOD designed at the University of Groningen (Timmer et al. 2012; WIOD Data n.d.). Its core elements are country-specific input-output tables (WIOD). The database includes data for 27 EU member states and the Union's 13 largest trade partners, for 1995–2011. The WIOD is made up of national and international inter-industrial tables and tables describing particular resources and their consumption.

Statistical measurement of trade based on value added and participation in GVCs certainly provides very useful data and allows to better understand the phenomenon of global value creation. However, so far, this data is not sufficiently reliable, detailed, or up-to-date to be applied in decision-making—e.g. development of trade or industrial policies. Also, value chains are global while the existing databases cannot yet be considered as such (i.e. also "global") since they almost completely lack coverage of certain regions, that is, the only CIS/EAEU country represented in the OECD/WTO TiVA database is Russia, and even for it the available data is just projected statistics from the last inter-industry balance for 1995 ("Inter-industry balance of production and distribution of products and services" n.d.; "Off to the database" 2010 (in Russian). It is a major

methodological flaw, especially keeping in mind that compared with 1995, we are currently living in a totally different domestic and international economic reality. Thus, we need further advancements in the methodology of GVC approach to complement the statistics available and reach out for the deeper insights.

From the methodology point of view, the approach suggested in Kaplinsky (2004) for studying industry-specific GVC aspects is the most suitable one to be complemented by a toolkit Foresight studies offer. It is based on the dynamic rent concept: production, export, and marketing of several product groups including fresh fruit and vegetables, canned fruit, footwear, and car parts were used as case studies.

For each of these products, the value chain segments were structured; major past, present, and future sources of economic rent were analysed; and the main consequences for production activities were estimated. Interestingly, this early model already includes a forecasting element—an attempt to project the structure of economic rent sources into the future.

The analysis yet was limited to specific product groups and did not cover the service sector. At the same time, as it was already noted, the service sector (financial, transportation, logistics, etc. services) ensures countries' most efficient participation in backward GVC linkages (Lundvall et al. 2015).

Another drawback of this early approach is the linear understanding of value-added creation. In reality, interactions within GVCs are usually network in nature (Lundvall et al. 2015). This is particularly obvious for the service sector.

Generally, excessive attention to specific case studies (not always supported by reliable empirical data) is often criticised, since it a priori introduces a significant element of subjectivity (Malerba and Nelson 2011; Milberg and Winkler 2011; Wood 2001). At the same time, it is the case study analysis that allows to operationalise research in this field to the maximum possible extent, at least while we lack up-to-date inter-industry data.

A serious concern about GVC research methodology applied by scientists specialising in innovation, innovation systems, and innovation-based economy theory (Ernst and Kim 2002; Pietrobelli and Rabellotti 2011) is insufficient attention to the local context of the clusters subjected to analysis and to specific features of national institutions and their activities aimed at improving companies' positions in GVCs.

The counter criticism by proponents of the GVC approach is insufficient attention to the nature of management, interaction, and power and influence distribution between various players inside a specific innovation system (Gereffi et al. 2005; Sturgeon 2001).

A number of researchers (Lundvall et al. 2015) are proposing to overcome the theoretical divide between the different schools of thought, to arrive to a compromise and join forces to come up with a radically new theoretical approach, free from known flaws of the existing theories and with a potential to obtain a deeper understanding of the GVC phenomenon. The existing methodological foundation of GVC research must be supplemented with advanced tools offering a better forecasting potential, more practically and strategically oriented. Approaches which allow to study interconnections between global processes and national-level innovation-based development trends, taking into account institutional specifics of the innovation systems, may be critically important for advancing GVC research and increasing its practical relevance.

Accordingly, application of Foresight methodology can become an important step towards implementation of these proposals and make a significant contribution to GVC

research being a major logical step to develop advanced national policy tools to mobilise available resources and coordinate stakeholders' actions to increase specific countries' global competitiveness.

For instance, one major idea Foresight researchers have managed to reveal in terms of GVC participation is that a country does not need to spend all efforts to penetrate present GVCs when it is possible to apply Foresight in order to create new markets and claim best positions there though a risky business it is (Chulok 2014). One can find such an example in a new ambitious strategy of Russia called National technology initiative ("National technology initiative of Russia" 2015).

Results

Agriculture: fresh fruit and vegetables

Description of the value chain and Russia's current position therein

GVCs in fresh fruit and vegetables trade include the following segments: seed farming, growing, processing and packaging of the crops, export, and retail. Nominally, Russia participates in all these segments, but in seed farming and export, the country's participation is much weaker than in other segments.

The most profitable segment of the global fresh fruit and vegetables production chain is seed farming: the volume of the global fruit and vegetable seeds market exceeds 6 billion USD. By 2018, it is expected to reach 13 billion USD, showing 28 % annual growth ("Russia seed industry outlook to 2018 - Cost-effective non-hybrid seeds to drive market growth," n.d.).

Global trends

Major global agricultural trends, including growing fresh fruit and vegetables, comprise increased international competition in seed farming; development of genetic engineering; more active international cooperation in food safety, dealing with famine and insufficient availability of food in the least developed countries; and consumer preferences in developed countries shifting in favour of environmentally safe, organic farm-grown food products.

Major challenges and threats

Though Russia is traditionally considered a country with developed agricultural sector, so far, it has been using the potential of the fresh fruit and vegetables GVC insufficiently, with practically no participation in selection, seed farming, and development of new products. And this sector of the economy is crucially important in the national security context. Barriers hindering the country's efficient participation in this GVC include (formal) shortage of free land for use as experimental and practice grounds and lack of necessary support to Russian R&D in the seed farming area, to small and medium agricultural producers, etc. If Russia implements appropriate "horizontal" and industrial regulation initiatives, it could make a radical breakthrough in relevant GVCs.

Windows of opportunity and the role of R&D

Moving on to better positions in "agrarian" GVCs is relevant for Russia from the import substitution point of view, to develop the potential of the domestic agricultural products market. The import limitations for agricultural products introduced by Russia in the summer of 2014 as a response became a driver of transformation of relevant

GVCs with Russian participation. Now, we are witnessing retailers' re-orientation towards domestic producers and suppliers form Latin America, Turkey, Iran, China, and Vietnam, instead of the EU and the USA. This will directly affect future prospects of the industry and the national economy as a whole. A practical government policy objective should be providing access to major markets to as many domestic and international producers as possible, to restore the market volume diminished by the exit of the Western partners, while maintaining high quality of agricultural products and affordability of the population prices. A long-term solution of this problem requires a viable and fair (from the distribution of economic rent point of view) value chain, open to participation of small and medium producers alongside big players.

The role of R&D in agriculture is connected with developing genetically modified products and fertilisers in line with environmental and food safety requirements. The main window of opportunity for Russia is to advance seed farming, enter international markets, and support import substitution by rebuilding the lost S&T basis.

Necessary political initiatives

The strategic goal of Russian industrial policy for the fresh fruit and vegetables sector should be supporting seed farming companies. Science and education policy initiatives are primarily required for that. Russian seed farming industry needs to rebuild the research and human resource basis which had been lost during the years of restructuring. Also, important are tools for improving business climate and attracting investments. Finally, it is important to implement high-precision industrial-level regulation mechanisms to help seed farmers access external and domestic markets.

Russia's possible prospective position in the value chain

In the future, it would be optimal for Russia to participate in these GVCs on the basis of having strong positions in seed farming and retail. Other links will not provide the same profit rate, but they also should be supported out of the national food security considerations.

Transportation services: air transport

Description of the value chain and Russia's current position therein

Aviation industry has a highly developed network of GVCs linked with both aircraft design and construction and with air transportation services.

The air transport GVC includes five major segments: the IT layer, retail (travel agencies), airlines, aircraft construction, and ground infrastructure (airports).

The latter are the most influential players in these GVCs, which for a long time attracted the attention of industrial organisation researchers (DiLorenzo 1996; Vasigh et al. 2014, 2013; Zhang and Round 2011).

Currently, Russia participates in all segments of the chain, but Russian aviation's integration into the global logistics is hindered by several problems: lack of market-based industry regulation mechanisms, which results in increased tariffs for air transportation; international logistical standards for electronic registration and tracking of air cargo shipments have not yet been adopted; etc.

Global trends

Aircraft construction and air transport are key industries for countries' economic development and their logistical systems. Aircraft construction is also a research-intensive industry—a donor of innovative technological solutions to other industries, creating a multiplication effect for the whole national economy.

Aviation GVCs are large-scale and complex. Relevant global trends include increasing international competition; growing passenger and freight traffic; and more active international cooperation through establishment of passenger and cargo transportation alliances. Another major global trend is rapid modernisation of aircraft fleets and "internetisation" of booking and tracking services. In most countries, the share of regional and local air transportation is growing.

Major challenges and threats

Key challenges to Russian participants of these GVCs are ticket prices' high dependency on fuel price and high price elasticity of demand. Another issue is shortage of aircraft crew personnel due to high costs of training pilots. In the current situation, this may result in losses for all participants of the value chain—which has actually happened in 2015 when the Russian Central Bank introduced floating rouble exchange rate. This led to the rouble losing more than half of its value (Gajdaev 2014 (in Russian)) so carriers' leasing costs exceeded the acceptable level resulting in mass bankruptcies of companies ("Nothing personal" 2015; "Russian Airlines Reducing Prices" 2015 (in Russian)).

Russian domestic air transport market is particularly difficult, with low profit margins ("Low-cost. Saga. Eclipse" 2015; "Nothing Personal" 2015; "Russian Airlines Reducing Prices" 2015). To ensure the citizens have freedom of movement, the government has to subsidise unprofitable flights to remote isolated Russian areas ("Constitution of the Russian Federation" 1993, sec. 27; "Flight of Subsidies" 2015 (in Russian)). International market provides higher returns, but the competition there is tougher.

Windows of opportunity and the role of R&D

Windows of opportunity for Russian participation in aviation GVCs are connected with making use of the country's competitive advantages in cargo transportation and with growing market for regional and local flights. Both these areas in Russia are not yet as popular as they are abroad, but the niches are gradually being filled (RBC.research 2015; "Russia's air transport companies to get ahead of RZD in passengers numbers" 2015; "Russia's cargo air transport market is growing" 2015).

The role of R&D inter alia includes optimising computer systems for booking tickets, introducing a unified cargo registration standard, personalisation of services, and upgrading aircrafts. Finally, innovations contributing to reducing airlines' (and the industry's as a whole) costs and increasing revenues are also important.

Necessary political initiatives

Russian companies' medium-term prospects in the air transportation services market (and first of all, the carriers') seem to be rather vague. In the next 5–10 years, they will be affected by such negative factors as volatile exchange rate and continuing international political instability. Probably, they will not be able to survive the next few years without government support.

In order to ensure such state support, the Government of Russia has put forward a plan of primary measures to maintain the economic and social stability in 2015 ("Plan of primary measures to maintain the economic and social stability in 2015" 2015), where one can find certain measures to support the air transport market. For instance, consecutive decline of VAT (up to 0 %) for inner air flights is planned, also an increase in subsidising transport organisations to preserve the network of flights to far and remote regions of Russia, development of a programme to support the aircraft's leasing for regional flights, and dissemination of practice to co-finance regional flights not only from local budgets but also from the budget of airport owners, airlines, and investors ("Minutes of the meeting of the Government Commission for Economic Development and Integration, chaired by First Deputy Prime Minister of the Russian Federation I.I. Shuvalov" 2015).

As to the ground infrastructure segment, its efficiency must be increased through traditional antimonopoly policies. For example, investment requirements to lessees, operators, and owners of fuel supply facilities (as members of an infrastructural monopoly) should be approved, and tender procedures for handing airports' ground infrastructure over to operators and investors should be developed. Methodology for government price (tariff) regulation should be adopted for storage and wing fuelling services in the scope of implementing investment programmes. Regarding trade policy, duty-free import of aviation fuel should be allowed for the next 5 years.

The aircraft construction segment also plays an important role. Russia has potential here, but the production model is vertically integrated and largely depends on exports—which makes it vulnerable to political and economic shocks (e.g. financial shocks, technological sanctions).

Thus, import substitution policy is also relevant in this industry. Own R&D and manufacturing potential must be developed (especially regarding critical technologies), and external partners should be diversified. In the long term, this would allow to partially move on to using Russian-made aircrafts, thus protecting lessees from currency-related shocks and contributing to accomplishing the national security objectives.

Finally, development of IT services and travel integrators would contribute to growth of air transportation services market. Russian R&D results in computer systems for optimising aircraft fleets, flight destinations, and ticket prices could become a factor of success, as well as IT designs for improving online booking systems and introducing a unified cargo registration standard.

Development of human capital should play an important role, including providing an adequate supply of pilots for the civil aviation based on forecasted volumes of passenger and cargo traffic; implementing a programme to subsidise retraining and upgrading of flight crews; and developing the system of official statistical monitoring of aviation personnel in line with the ICAO recommendations and experience of countries with the lowest accident rates.

Important industry-level measures among other things include adoption of international e-freight and e-cargo standards for electronic registration and tracking of cargos and harmonising freight services provided by different modes of transport.

Finally, Russia should actively and in a logical way participate in international transport institutions such as International Transport Forum (ITF) and the OECD/ITF Joint Transport Research Committee, Russia-EU Transport Dialogue, Northern Dimension Partnership in transport and logistics area, and International Civil Aviation Organisation.

Russia's possible prospective position in the value chain

To generate maximum possible rent in aviation GVCs, Russia needs an advanced system of modern airports, a competitive aircraft construction industry, and initiatives to promote regional and local air transportation services.

Electronics: mobile phones and smartphones

Description of the value chain and Russia's current position therein

For the mobile phones and smartphones market, the main GVC segments are product development (R&D) both in terms of hardware and software, production and assembling, packaging, export, and retail.

Globally, Russia's participation in these GVCs is weak. The production segment of this GVC is mainly located in East Asia, while research-intensive segments are controlled by Western and Japanese companies.

A new publication by Kaplinsky (2013) describes how value added is created in the course of an Apple iPhone production.

As Fig. 6 shows, the value added created by China is much lower than other countries'. Even the USA supply to China more components (in value terms) than the value added China creates by assembling the end product. Other countries' contribution to the final value added is much higher than the Chinese one. At the same time, Chinese export statistics count all previously created value added, so China's export would be much higher than other countries'. Meanwhile, the USA generates the highest profits from this GVC, by adding a retail mark-up of 64 %. The product retails at 500 USD while its actual production cost is just 179 USD.

Russian companies participate in such GVCs in a number of different ways: very few of them act as coordinators (the best example is Yota), while the vast majority buy standard ready-made "dummies" in Asia and concentrate on marketing and sales. There are also retailers who sell products made by foreign companies.

Global trends

Relevant major global trends include ubiquitous growth of production level and increased international competition, arrival of new players to the market, coupled with increased international cooperation in production, and relocation of production facilities into South-East Asian countries. An important trend is ever-changing consumer requirements and preferences (e.g. growing demand for smartphones), high rate of the industry products' moral obsolescence, and rapid transformation of end product markets due to technological and behavioural changes.

Major challenges and threats

Russia is barely present in most of the foreign markets, in effect limiting its interests to the CIS zone. Most of the Russian participants of these GVCs simply sell foreign-made products on the Russian market adding an appropriate mark-up. Russian companies' market share is insignificantly small compared with the global market.

The main challenge is rapid technological improvement of gadgets and their quick moral obsolescence. Another important issue is critically growing technological leadership of countries possessing key ("closing") technologies which will allow them to keep on improving their products and creating new technologies—thus closing such opportunities to countries who, because of various reasons (patent limitations, lack of

personnel, R&D potential and relevant infrastructure, technological sanctions, etc.), do not have access to such technologies.

Accordingly, Russia should concentrate its efforts on developing its S&T basis to be able to quickly follow any promising trend. And the political scope should be wide, not limited to any particular specialisation area.

Windows of opportunity and the role of R&D

The most profitable and promising for Russian players should be the design and R&D segments. On the CIS, Eastern European, and neighbouring countries' markets, Russian companies potentially could compete with foreign brands in the medium and high price ranges.

Obviously, the market for mobile phones, smartphones, and new communication devices which will replace the former in the coming decades will be developing extremely rapidly and with high profit margins. Therefore, Russian companies must start entering new markets now, securing strategic positions there.

Necessary political initiatives

Since the largest proportion of the economic rent in these GVCs is created in the R&D and marketing segments, making adequate use of the windows of opportunity first of all requires to have the right kind of personnel and pursue appropriate education, S&T, and innovation policies.

As regards education, engineering professions should be promoted, and young people are to be encouraged to acquire professions in IT, design, and engineering. Higher education organisations which train people in the above professions must receive government support including extra free places for students, efficient mechanisms to promote academic mobility of students and researchers, and recruiting recognised foreign experts to get access to cutting-edge technologies and the most advanced R&D results in the ICT area.

Creating adequate forward-oriented S&T results should become a major government policy priority. Particularly important is developing Russian designers' skills in automated component design, new multimedia technologies, etc. (Gokhberg L.M. (Ed.) 2014 (in Russian)).

Providing support to innovative industrial clusters through investment policy should also be seen as an important objective, since it would contribute to adopting a broad approach to ICT development (OECD Digital Economy Outlook 2015 2015).

No specialised or industry-specific measures are required in this area: if development of mobile telecommunication devices would be seen in the context of initiatives aimed at developing "digital" economy, after a while, the technological gap between Russian and foreign developers would diminish.

Russia's possible prospective position in the value chain

The high profitability of the above GVC segments with time will decrease, since existing technologies would gradually become more accessible. The main role will be played by the so-called disruptive innovations which create new markets and eliminate the existing ones. Therefore, no market forecast can yet be considered to be sufficiently reliable. However, long-term scientific future analysis, including through application of foresight methodology, and appropriate strategic planning are indeed required. Keeping in mind the available forward-oriented R&D results and the high level of human capital, Russia can increase its presence in research-intensive and highly profitable segments of these GVCs (design, R&D, sales).

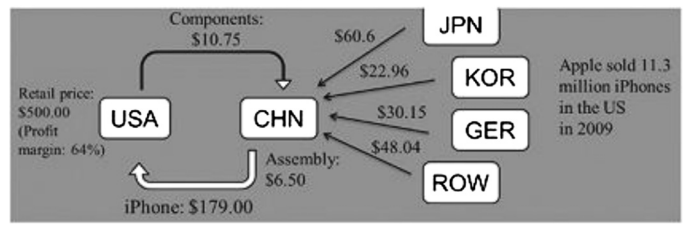

Fig. 6 The Apple iPhone GVC

Automobile production: car parts

Description of the value chain and Russia's current position therein

The main segments in the global car parts value chain are design, production, and sales. The production segment is a modular system (platform) for designing, manufacturing, and assembling. Factories performing the most technologically advanced operations (such as pressing, making engines, transmissions, and electronic components) are located closer to the company's headquarters, while assembly plants are positioned closer to the markets. Design and sales account for the biggest share of economic rent, while industrial production creates only a relatively small proportion of the value added. The design segment in Russia is practically undeveloped, while other segments are developing in the framework of the global transnational corporations.

Global trends

Globally, the design and sales segments are concentrated in the hands of a few international corporations who own major production facilities in developing countries. This market is becoming increasingly oligopolistic, with the number of independent car parts manufacturers getting ever smaller: they become dependent on the market giants, enter into joint ventures or strategic alliances with them, and some of the local producers become wholly owned subsidiaries of foreign corporations.

The same is happening in Russia: domestic producers are getting involved in international cooperation processes, integrating into large, successful GVCs and losing their independence in the process.

According to leading international experts, the car parts industry does not offer good opportunities for improving one's positions in GVCs (Gereffi et al. 2005; Humphrey and Schmitz 2002; Kaplinsky 2004).

Major challenges and threats

In the current situation, and in the foreseeable future, no Russian automobile manufacturer, all other conditions being equal, will be able to build a competitive global value chain. And that being so, the Russian automobile industry is doomed to lag behind, develop in a "catch-up" way, and suffer further reduction of profit margins.

Russian producers do have competencies in car parts manufacturing, but cannot match foreign companies in design and sales segments, which require significant intellectual resources and innovations. Russian labour is more expensive and less skilled than in the Asia-Pacific region.

Thus, Russian automobile industry has to integrate into the processes of industrial production cooperation with more powerful international partners, which will lead to further decline of the industry: Russian producers are given the role of assemblers, while the most profitable segments—design and sales—remain under control of the global giants, so the bulk of the profits goes abroad. In the future, it will continue to make Russian manufacturers increasingly worse off, making them ever more reliant on the global market situation and hindering their development.

A similar situation is noted in many developing countries; experts recommend them not to waste public resources supporting domestic producers in GVCs but invest in other industries offering opportunities to secure higher economic rent (Humphrey et al. 2000).

This recommendation is largely relevant to Russia too, but automobile production remains a strategic industry and requires maintaining and developing the S&T and manufacturing basis. This objective cannot be accomplished just by providing subsidies.

Windows of opportunity and the role of R&D

In the short to medium term, car parts production in Russia will follow the inertial development scenario, with foreign presence gradually growing and economic rent gradually diminishing. In 40–50 years' time, this scenario will lead to a dead end.

However, by the middle of the century (or sooner), new prospects will open for the Russian automobile industry. These are primarily connected with emergence of alternatives to the present-day internal combustion car (electric cars, fuel cell cars, compressed air cars, hydrogen cars, etc.).

The role of R&D is also linked to development of the "smart cities" concept. The approach which suggests abandoning personal cars altogether in favour of efficient, high-speed, environmentally neutral, safe, and cheap public transport in the megalopolises of the world is becoming increasingly popular ("Lecture by Michael Blinkin "Mobility of the future: the objective tendencies and naive delusion. Thinking about how people will move around the city and to the world in the middle of the XXI century"" n.d.), including appropriate modern tools and business models (car sharing, etc.).

Necessary political initiatives

There's a probability that by the middle of the current century, urban population will become much less enthusiastic about owning a personal car. This prospect looks quite attractive to Russia: when it comes to cargo and public transport, Russian producers can do better than those oriented towards the personal consumption segment.

Still, keeping in mind today's realities of Russian participation in "car" GVCs, employment policy and labour legislation seem to be important (trade unions, workers' rights), which could artificially increase the rent created in the assembly segment, though this would have a negative effect on the prices.

Generally, technologies and innovations must be developed, the future of the automobile industry "foreseen" through application of foresight methodology, and personnel trained—i.e. resources should be invested in what will replace the present-day car.

Development of public transport systems in large cities combined with diminishing role of the private car can serve as a reference point for government policy development.

Russia's possible prospective position in the value chain

Despite the possible prospects in remote future, we have to agree with Humphrey et al. (2000) and recognise that car parts manufacturing has no potential in terms of promoting Russian companies' integration into these GVCs, all other conditions being equal. Its reliance on subsidies will be growing, while the human potential will diminish. Only a radical transformation of the market and of consumer preferences may save the day, but this hardly seems likely in the foreseeable future.

Financial services: electronic payment systems

Description of the value chain and Russia's current position therein

GVCs in financial services cannot be presented as a common sequence of links, like in production. In this industry, value chains are rather based on the network principle, and certain operational phases are even completed automatically. An example of such network approach in banking—dividing banks' activities between specialised centres located in different countries—provides UniCredit ("UniCredit Group - Institutional website of the financial Group" n.d.): its offices in Ireland specialise in asset management, German ones—in investment banking services, Austrian ones—in mortgage credits, Turkish ones—in bank cards and related services, etc. (Backer and Miroudot 2014).

Russian financial services market has emerged comparatively recently, but it has a large potential. This market is very diverse, offering the same range of services as any developed foreign market does. Apart from international companies, Russian ones are also present, and their number is growing all the time. There is also a growth trend for cashless online payments: internet banking, e-money, and the nonbank credit organisations' segment are actively growing.

Global trends

The electronic payment systems (EPS) industry is among the fastest growing ones. The biggest payment systems are Visa, MasterCard, American Express, Diners Club, UnionPay (China), and JCB (Japan). The Chinese UnionPay shows the highest growth rate: since 2010, it remains the leader in terms of the number of issued cards, though its share of the Russian market is insignificant. Major global EPS trends include growing competition, development of non-banking financial services, and development of e-commerce.

Major challenges and threats

Risks and threats to development of the Russian EPS sector include the Russian banking sector's reliance on foreign payment systems; entry of new foreign payment systems in the Russian market; and the still insufficient competitiveness of the Russian financial services sector. The political component is also important. For example, the following large Russian banks were subjected to foreign sanctions: Gazprom Bank, VEB, Sberbank, VTB Bank, Moscow Bank, Rosselkhozbank, and Vnesheconombank ("EU sanctions against Russia over Ukraine crisis" n.d.; "Russia and Ukraine Sanctions, Department of the Treasury" n.d.). The sanctions limit the

banks' activities in a number of countries which hinders Russia's efficient participation in relevant GVCs.

Windows of opportunity and the role of R&D

At the same time, the sanctions gave an impulse to creation of the national payment card system (NPCS) to process transactions made with international payment systems' cards in Russia; the NPCS clearing centre was launched on 31 March 2015.

To increase the benefits of Russian participation in financial services GVCs, more attention should be paid to the e-commerce market and the NPCS: developing them opens a real window of opportunity to Russia since it will make the Russian economy more independent and potentially could lead to transforming the NPCS into an international payment system—like the Chinese UnionPay was transformed into one (among other things, it could be achieved by making use of the integration potential with the CIS and EEU countries).

Necessary political initiatives

Initiatives to improve Russia's positions in "financial" GVCs include further promotion of the NPCS, increasing its efficiency and reliability, and gradually upgrading it to the level of similar international payment systems; increasing efficiency of the government supervision and control systems (primarily the Central Bank's ones) over Russian banks' activities; and further implementation of policies aimed at strengthening the banking sector and improving the relevant legislation, among other things taking into account international standards and practices.

In the field of education, the Russian population's financial literacy should be improved.

Specific recommendations for the industry also include development of the legislation and human resources and stepping up R&D to promote development of information technologies for the sector and find the best ways to conduct transactions and protect data.

Also important is Russia's participation, jointly with partners, in the new international financial initiatives such as the New BRICS Development Bank, Asian Infrastructure Investment Bank, and the envisaged Shanghai Cooperation Organisation's Development Bank.

Russia's possible prospective position in the value chain

Prospective security of the Russian financial market must be ensured, by creating Russian equivalents of international EPS, making them internationally competitive, and taking leading positions in the new international financial organisations.

Discussion

Though only the basic Foresight elements were introduced into the analysis, they provide a much broader perspective in terms of hidden factors of influence and different policy areas to support the desired results of country's participation in the given GVCs.

For further advancement on the subject, a more in-depth analysis is needed as regards the influence of national innovation institutions on certain GVCs or clusters

with respect to what is happening to them in terms of technological transformations and their respective final goods' business cycles.

Despite the fact that it would take a lot of time and effort to carry out such analysis in respect of several industries, it would be more practical to concentrate solely on a certain cluster representing a single GVC, thus providing a bright example how the combined approach works. Given that a number of strategic initiatives are being realised nowadays in Russia, the time is short to support them with the novel approach and see whether it can be a success.

Conclusions

Despite the fact that the existing approaches of the GVC theory supplement each other, the classic theoretical foundation of GVC research cannot be described as faultless and is currently being developed, inter alia by the contributions of the innovation-based economy school representatives.

The empirical and methodological foundation of GVC research is being developed to increase the reliability of research results and their forecasting value, to propose more valid political recommendations, and to improve strategic planning.

The methodology applied represents early attempt to present evidence of how the approaches of GVCs and innovation systems research can be combined to reap the benefits of these theories while avoiding their inherent limitations.

The presented model takes into account the importance of national institutions for innovation in GVCs. The application of Foresight methodology expands the forecasting possibilities of the analysis and adds dynamism to this rather static model.

All this allows to increase the accuracy of the strategic planning of countries' participation in GVCs and improves the relevance of the policy advice produced compared to the existing models.

Methods

The analysis conducted was based on the model of dynamic allocation of rents originally demonstrated in Kaplinsky (2004), which was supplemented by elements of Foresight analysis to develop sectoral and horizontal policy recommendations to increase the effectiveness of participation of Russian companies in the corresponding GVCs. Thus, two product groups were selected for analysis as illustrative cases, also used in Kaplinsky's model to preserve the logic of the approach's evolution, that is, fresh fruit and vegetables and car parts. Additionally, the analysis covered the following product and service groups: mobile phones, air transport (transportation services), and electronic payment systems (financial services). The choice of these products/services was among other things determined by their direct connection with Russia's priority S&T areas (Gokhberg 2014; "Long-Term Russian S&T Foresight Until 2030" n.d. (in Russian): biotechnology (fresh fruit and vegetables), ICT (mobile phones, electronic payment systems), and air transport (transport and space systems).These cases partly coincide with the new markets, roadmaps for which are being constructed in the framework of NTI ("National technology initiative of Russia" 2015), including AeroNet, AutoNet, and FoodNet. The current and prospective (forecasted) GVC structure was identified for these case studies in relevant industries, together with Russia's current and prospective places in the value chains. Foresight methodology was applied to envisage possible

changes in the GVC structure within the planning horizon (10– 15 years, i.e. until 2025), with the accent on analytical tools enabling to determine the factors affecting changes in the structure of the value chain segments, sources and distribution of profits within them, and Russia's opportunities to secure more favourable positions. The basic model of Kaplinsky was extended by introducing therein the classical elements of Foresight methodology, that is, global and local technological and economic-social trends influencing the development of the given GVC; major challenges and threats affecting GVCs in specific industries; windows of opportunity to penetrate certain GVC segments that offer the biggest economic potential or to create new markets inside the emerging GVCs; and the role of R&D embodied in how it allows to accumulate new technological, marketing, and management designs and knowledge to support integration into GVCs and obtain the biggest possible benefits from participation in them. Finally, R. Kaplinsky's model was augmented with a set of political initiatives to be implemented, primarily by the government, to support the country's progress in global chain and secure the best possible rent. In addition, based on recommendations by international organisations (OECD et al. 2013; OECD, WTO, World Bank Group 2014), the so-called horizontal and industrial/sectoral initiatives were identified for each product and service group. Having analysed successful international experience of certain countries' participation in GVCs, the OECD and a number of other international institutions concluded that implementing the whole set of horizontal political initiatives (aimed at developing infrastructure and communications, improving business climate, financial sphere, R&D and innovations, and education and employment systems, increasing macroeconomic stability, etc.) is crucially important for ensuring success of GVC participation strategies. Implementing more specialised industry/sector-specific measures can serve as an important enhancement of horizontal initiatives but cannot replace them. Adopting purely sectoral approach (e.g. tariff-based and other trade restrictions, subsidies, requirements to export activities, and restrictions on foreign investments) at best can provide only a short-term positive effect for a specific industry (and more often, only for a limited number of companies) but cannot ensure a positive cumulative effect for the whole economy. Analysed among "horizontal" measures were the necessary steps the government should make to create adequate macroeconomic conditions; for public administration; for development of human capital (education and employment); for support of R&D and innovation; for trade policy; for investment policy and improvement of business climate; and for development of external economic relations and participation in international economic integration. Highlighting S&T and innovation policy among the "horizontal" initiatives allowed to take into account recommendations of the innovation-based economy school (Cooke 2001; Etzkowitz and Leydesdorff 2000; Lundvall et al. 2015; Pietrobelli and Rabellotti 2011) concerning the need to identify interconnections between participation in GVCs and specific features of national innovation systems. Studying international approaches to GVC participation, the authors attempted to apply certain elements of foresight methodology to conduct industry-specific analysis of several case studies in line with the approach previously used by R. Kaplinsky. Detailed results are presented in Appendix 1. Brief results in the text form are presented after this section.

Appendix 1

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis

Industry/sector Product/service group	Current state of the GVC		Factors affecting changes in the structure of the value chain's segments, sources and distribution of profits in the chain, and opportunities for Russia taking a more favourable position in the chains	Horizontal and industry-specific political initiatives required to promote Rus sia's position in the GVC	Prospective state of the GVC (planning horizon until 2025)	
	Value chain segments (top down) and Russia's current place in them	Current main source of economic rent			Prospective main source of economic rent	Value chain segments (top down) and Russia's prospective place in them
Agriculture Fresh fruit and vegetables	Seed farming Growing (ubiquitous)	Seed selection and new product development Coordinating GVC efficiency	Trends Increased international competition in seed farming Development of genetic engineering More active international cooperation in food safety, and dealing with insufficient availability of food in the least developed countries Consumer preferences in developed countries shifting in favour of environmentally safe, organic, farm-grown food (eco, bio, etc.) including fruit and vegetables	Horizontal measures Investment policy and improving business climate Promoting healthy competition Availability of affordable long-term loans Availability of land for agricultural use	Seed selection and new product development	Seed selection (Russia) Growing (ubiquitous)

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

Crop processing				
Export		Challenges and threats Further reduction of exporters', producers', and retail networks' profits Russia's growing reliance on imported seeds	Trade policy Among other things, countering illegal re-export of embargoed food products into Russia from neighbouring countries, through application of customs procedures, technological regulation, etc.	Crop processing Export
Retail (Russia)	Retail network	Global climate change Development of genetically modified products industry: profits vs. ethics Producers' growing reliance on subsidies, growing shortages on the domestic market (e.g. introduction of Russian counter sanctions on the EU agricultural products in 2014) Increased competition of retail networks and major producers for leadership in the GVC	Public administration Continuous implementa tion of the Food Security Doctrine approved by the presidential decree in 2010 and the National Programme for Develop ment of Agriculture and Regulation of Agricultural Products, Raw Materials, and Food Markets for 2013–2020 Systemic policy to support the agricultural sector	Retail

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

Radical change of Russia's agricultural trading partners	Development of a targeted programme to support small farmers; removal of administrative barriers hindering numerous small farmers' access to Russian and international markets
Need to replenish the domestic market niches which have appeared after the sanctions, while preventing inflation on the consumer market and preserving high food quality standards	
	Human capital development policy
Windows of opportunity	
Companies' integration into the seed selection and new product segments where economic rent is expected to grow	Availability of skilled personnel (according to agricultural businessmen, Russia desperately lacks skilled personnel capable of applying advanced technologies and introducing advanced business processes in the sector)
Development of Russian seed farming and seed engineering	Availability of rural infrastructure to provide at least a minimum level of comforts
Role of R&D	
Mainly connected with developing genetically modified products and fertilisers in line with environmental and food safety requirements	S&T and innovation policy
	Supporting initiatives in the agricultural sector, assisting with commercialisation of innovations

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

				Organisation of S&T events for young researchers and inventors Industry-specific initiatives: Maintaining healthy competition under the import substitution policy: providing broad market access to as many Russian and international agricultural producers as possible, including small and medium ones, to ensure adequate supply of agricultural products on the Russian market, and meet consumer demand and preferences Availability of land for agricultural use, simplifying administrative procedures for buying land for agricultural purposes, reducing land prices Availability of affordable long-term loans.		
Transportation services Air transport	Aircraft construction (weak Russian participation)	Leasing	Trends Increasing international competition, growing markets, growing passenger and freight traffic, especially in	Horizontal measures: Investment policy and improving business climate Introducing investment requirements to lessees,	Leasing Airport services (capital	Aircraft construction (Russia)

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

		developing countries	operators, and owners of fuel supply facilities (as members of an infrastructural monopoly). Development of tender procedures for handing airports' ground infrastructure over to operators and investors, and requirements to operators' investment programmes as grounds for establishing tariffs Approving methodology for government price (tariff) regulation for storage and wing fuelling services in the scope of implementing i nvestment programmes Russian trade policy Duty-free import of aviation fuel for the next 5 years Public administration Continuous implementation of the national programme "Development of the transport system" and the Russian Transport Strategy until 2030 Human capital development policyDevelopment of roadmap to provide adequate supply of flight crew	repairs, current maintenance) Advertising	
Airports (Russia)	Airport services (capital repairs, current maintenance)	More active international cooperation through establishment of passenger and cargo transportation alliances Decrease of real ticket costs Growing share of regional and local trafficVolatile economic rent Challenges and threats			Airports (Russia) Airlines (Russia) IT services (Russia) Travel integrators (Russia)
Airlines (Russia)		Ticket prices' high dependency on fuel price, susceptibility to risks of sharp price increases and reduced demand Currency-related, political, and other risks			
IT services (Russia)		Negative return on investments Shortage of pilots, high costs of pilots' training and upgrading Loss of air freight market share			

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

	Windows of opportunity	personnel for civil aviation, based on forecasted volumes of passenger and freight traffic
Travel integrators (Russia)	Development of Russian aircraft construction industry, application of competitive advantages in the air freight services segment	Implementing a programme to subsidise retraining and upgrading of flight crews
	Role of R&D	Developing the system of official statistical monitoring of aviation personnel numbers, to support forecasting their dynamics taking into account changes in the structure and size of the aircraft fleet
	Optimising computer systems for booking tickets, introducing a unified cargo registration standard, personalisation of services, upgrading aircrafts	Updating educational solutions for training flight crews, including length of training, in line with the ICAO recommendations and experience of countries with the lowest accident rates
		S&T and innovation policy
		Applying innovations which would help to reduce aviation companies' and the whole industry's costs and increase profits (e.g. activities of the Civil Aviation Innovation Centrehttp://www.c-ca.ru/ru/company.html)
		Approving methodology for assessing the state of airports'

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

		runway surfaces in line with the international ASTM standard Participation in international economic integrationMore active and logical Russian participation in international transport institutions such as International Transport Forum (ITF) and the OECD/ITF Joint Transport Research Committee, Russia-EU Transport Dialogue, Northern Dimension Partnership in transport and logistics area, the WTO, International Civil Aviation Organisation (ICAO), Inland Transport Committee of the United Nations Economic Commission for Europe, the EEU Industry-specific initiatives: Ratification of the Montreal Convention (MC-99), on changing the terms of carriers' liabilityAdoption of international e-Freight and e-Cargo standards for electronic registration and tracking of cargos, to make better use of Russia's transit potential and support the country's integration into the global transport system Adopting advanced airfreight registration

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

				standards for the entire logistical services market Joining forces to implement unified electronic cargo registration standards for all modes of transport Harmonising paperwork associated with freight services provided by different modes of transport Promoting independent suppliers and low-cost carriers		
Electronics Mobile phones	Product development (almost none)	Development of new technologies (operating systems, etc.)	Trends Increased international competition in the production segment due to technological development and arrival of new market players International cooperation in production, relocation of production facilities into South-East Asian countries	Horizontal measures: Human capital development policy Promoting engineering professions, encouraging young people to acquire professions in IT, design and engineering Providing government support to higher education organisations which train people in the above professions, including extra free places for students	Development of new technologies (operating systems, etc.)	Product development (Russia) Production Packaging
	Production		Growing demand for smartphones Challenges and threats Reduced profits of manufacturers due to increased competition			Export

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

Packaging (Russia)		Increased production costs due to growing wages Development of personnel and the R&D basis Competition between retailers and major brand-name manufacturers for market domination	Introducing efficient mechanisms to promote academic mobility of students and researchers while preventing "brain drain"; recruiting recognised foreign experts	Retail (Russia)
Export		Windows of opportunity Companies' integration into mobile phones production Selling R&D results to leading manufacturers	S&T and innovation policy Promoting Russian companies' activities to create and protect intellectual property Providing them comprehensive support in the licensing and patenting areas	
Retail (Russia)	Retail networks	Role of R&D Mainly connected with improving phones' properties, and the materials they are made of	Participation in international economic integration Development of international cooperation in the BRICS and EEU frameworks and with other emerging economies; gradual liberalisation of trade policy, simplification of customs and administrative procedures Industry-specific initiatives: Organisation of international	

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

				events, fairs, fora, conferences, etc. on relevant subjects, accompanied by appropriate PR activities		
Automobile production	Raw materials processing		Trends	Horizontal measures: Macroeconomic policy		Raw materials processing
Car parts	Design	Design	High level of production became common. Production is becoming increasingly global.	Further extension of the localisation programme to cover car parts manufacturers; development of cluster initiatives in line with the Russian Federation Automobile Industry Development Strategy Until 2020 (ON APPROVAL OF THE RUSSIAN FEDERATION AUTOMOBILE INDUSTRY DEVELOPMENT STRATEGY UNTIL 2020. Executive order of the RF Ministry of Industry and Trade of 23.04.10 319. Predprinimatelskoye Pravo, n.d. (in Russian))	Design	Design (Russia)
	Pressing	Harmonious functioning of the value chain	Rent is shifting to more protected segments of the chain. Gradual oligopolisation of the global market. Concentration of economic rent in intangible assets inside specific segments (design, application of new production technologies, brands, marketing).			Pressing
			Challenges and threats			
			Increased competition in the low-technology segments of the chain, negatively affecting market situation.			
	Assembly	Partially from pressing, partially from assembly				
			Windows of opportunity			
		Supplier's trademark	Changing consumption structure in the transport sector: reduced role of personal transport and growing importance of public transport	Investment policy and improving business climate Promoting investments into key segments of the		Assembly

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

	Role of R&D The role of S&T and innovation factor will grow due to increasing profit rate in the design segment	value chain such as R&D and design, by providing tax incentives Promoting joint R&D and design programmes Russian trade policy Stronger export orientation; promoting use of Russian raw materials through adoption of mechanisms limiting their import Human capital development policy Training high-technology professionals, implementing upgrading programmes based on on-the-job training at foreign companies S&T and innovation policy Orientation towards medium- and long-term demand: development of fuel supply technologies for multiphase injection Diesels, minimising toxic emissions, all-wheel-drive vehicles, alternative fuels, unmanned vehicles, etc. Industry-specific initiatives: Development of efficient		Export
Export (Car parts user) (Russia) Retail (Russia)			Supplier's trade mark	Retail (Russia)

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

				and competitive public transport systems for cities; application of advanced business models to reduce demand for personal cars		
Financial services Electronic payment systems	Establishing administrative centre	Banks' rent for using payment systems	Trends Growing international competition: payment systems previously limited to national markets are becoming international Development of e-commerce Development of non-banking financial services	Horizontal measures: Macroeconomic policy Deeper integration of the NPCS into the Russian economy. Improving political climate and Russia's positions in the world	Banks' rent for using payment systems	Establishing administrative centre (Russia)
	Establishing processing centre	Rent for conducting transactions	Challenges and threats Russian banking sector's reliance on foreign payment systems Entry of new foreign payment systems in the Russian market Reduced competitiveness of the Russian financial services sector	Investment policy and improving business climate Promoting investments to develop key segments of this chain Human capital development policy	Rent for conducting transactions	Establishing processing centre Establishing client base (issuing banks, equalising banks)
	Establishing client base (issuing banks, equalising banks)		Growing popularity of unofficial payment systems External shocks such as political sanctions and global volatility Windows of opportunity Creation of the national	Initiatives to improve financial literacy of the population S&T and innovation policy Further strengthening of the intellectual property		

Table 1 Dynamic distribution of GVC economic profits by product/service groups: current state and prognosis *(Continued)*

	payment system to make the industry more independent	system and relevant law enforcement practices in line with the relevant challenges; development of ICT	Transaction services (Russia)
Transaction services	Development of online transactions, generating more profits for companies	Participation in international economic integration	
	Development of the financial sector makes Russia more attractive to foreign investors	Participation, jointly with strategic partners, in the new international financial initiatives such as the New BRICS Development Bank, Asian Infrastructure Investment Bank, and the envisaged Shanghai Cooperation Organisation's Development Bank.	
	Transforming the NPCS into an international payment system		
	Role of R&D	Industry-specific initiatives:	
	Mainly connected with information technologies, to make transactions safer and improve data protection	Increasing efficiency of the government supervision and control systems (primarily the Central Bank's ones) over Russian banks' activities; further implementation of policies aimed at strengthening the banking sector and improving the relevant legislation, among other things taking into account international standards and practices Promoting development of information technologies	

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
TM made substantial contributions to the conception and design of the study, helped draft the manuscript and revised it critically for important intellectual content, and gave the final approval of the version to be published. EM made substantial contributions to the conception and design of the study, drafted the manuscript, and was accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Both authors read and approved the final manuscript.

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Innovation at country-level: association between economic development and patents

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Abstract

This study analyzes the role of economic indicators in country-level innovation, represented by patents in the technology sector. *Innovation* indicators include the ratio of patents owned by foreign residents and the number of patent applications in each industry in the technology sector. *Economic* indicators include GDP, gross national income, labor cost, R&D expenditure, real minimum wage, tax revenue, and education enrollment. The data for OECD countries collected from *stats.oecd.org* for 2000 to 2010 is analyzed using Cognos. Results show that countries with low GDP rely on foreign collaboration for innovation; education enrollment stimulates innovation; among the sectors, government and higher education have higher R&D expenditures than private and non-profit sectors. A significant contribution of our research lies in the dimension of internationalization and ownership of technology innovation. We suggest viable solutions for countries facing tax revenue losses arising from mobility of patents.

Keywords: Economic development, Patent, Industry, OECD, Education enrollment, Cognos, Business intelligence, Innovation

Background

Today, the world's societies face severe economic and social challenges. The economic downturn of 2008–2009 has led to reduced growth, rising unemployment, and soaring public debt. To recover, countries need to find new and sustainable sources of growth. Innovation—the introduction of a new or significantly improved product, process, or method—holds the key to boosting economic growth and productivity. Innovation has much broader implications than Research & Development and is influenced by a wider range of factors. Innovation can help accelerate economic recovery and put countries on a path to sustainable and greener growth. Innovation allows a country to discover opportunities that exist or are likely to emerge in time, to focus on existing business processes and practices that improve efficiency, to find potential customers, to minimize wastage, and to increase profits.

Innovation is a key driver of technology development and economic growth. It provides a means of satisfying the demands of the current market and the potential needs of future markets. Innovation is achieved through more effective products, processes, services, or technologies that are readily available to the current market. There is an

increased awareness and recognition among national policy makers about innovation as a key factor in economic growth. Many OECD (Organization for Economic Cooperation and Development)-member countries have enforced strategies and policies to enhance innovation and economic development.

Innovation has different implications for different economies such as developing, emerging, and developed. It is important that we develop tools to measure innovation across diverse economies. Various financial, industrial, economic, and social indicators are associated with trends in innovation.

Innovation is a crucial factor in national progress. The application of advanced technology along with entrepreneurship and innovation approaches in creation of goods and services results in translation of scientific and technological advances into productive economic activity. This contributes to economic growth when aided by environmental and regulatory structures. Policy makers look to regulatory framework as an instrument to promote innovation (Blind et al. 2004). The bridge between administrative or institutional regulations and innovation is through intellectual property rights (such as patents and copyrights). Policy makers can calibrate the strength of patent protection rights to have an influence on the country's innovation. As it stands now, research on innovation is fragmented. A general framework of analysis and greater coordination of research efforts will serve to offer a holistic view of the phenomenon, starting from its inputs to its economic and social impact. Innovation has become a multidimensional concept; it is not just about producing new products. It is also about services, technical standards, business models, and processes.

What are the key economic factors that determine the success of innovation at a country level? This study addresses the question by exploring the association between economic indicators and innovation (represented by patents) for OECD countries for the years 2000 to 2010. Though other studies have looked at economic growth and innovation, the uniqueness of our study lies in utilizing a large data set that spans a longitudinal period and in deploying a sophisticated analytic tool such as Cognos, in drilling down and identifying patterns and relationships in the data.

The remainder of this paper is organized as follows: Section "Research background" provides research background; Section "Methods" describes research methodology; Section "Results and discussion" contains the results and discussion of data analyses; Section "Scope and limitations" outlines the scope and limitations of the research; and Section "Conclusions" offers conclusions along with contributions and implications.

Research background

Innovation is an important element in the long-term growth and development of an economy. Over time, various definitions and characterizations of innovation have been offered, such as: innovation often arises from novel combinations of existing knowledge (Schumpeter 1934); centers on concepts of renewal, modernization, and change (King and Anderson 2002); and is something new and intended with an often uncertain, risky, and unpredictable outcome (Angle 2000). Innovation has been studied at the individual (Miron et al. 2004), the group

(Huelsheger et al. 2009), and the organizational level (Smith et al. 2008). Education and learning are some key factors for innovation (Leonard and Sensiper 1998).

Innovation and economic growth are intricately associated. Each drives the other, thus, innovation is a key component in a government's political agenda (Hsu et al. 2014). Economic indicators have an impact on innovation at various levels: firm, state, and country. In this study, we focus on country-level innovation—specifically, technological innovation represented by patents.

Over the last few years, there has been innovation in various industries, particularly in the technology sector. An important indicator of technological innovation is intellectual property (IP), an umbrella term for patents, copyrights, and other creative expressions. Studies have explored the association between stronger patent rights, innovation, and economic growth. The relationship of patents to economic growth arises out of the rationale that stronger patent rights positively influences innovation through cost-saving technologies and new product development, which in turn promote economic growth (Kanwar and Evenson 2003; Hudson and Minea 2013). Research in this arena has not always been consistent, however. Park and Ginarte (1997) used an index of patent rights compiled for 60 countries by Ginarte and Park (1997), to study the relationship between patent rights, economic growth, and R&D expenditure. While they found a positive association between strong patent rights and R&D expenditure for upper income OECD countries, they found no association for low- income countries. In addition, they found no relationship between patent rights and economic growth. On the other hand, Hudson and Minea (2013) found patent rights, along with GDP per capita, to positively influence economic growth. Park (2003) analyzed data for 18 manufacturing industries between the years 1980 and 1995 for 21 OECD countries and found a positive relationship of patents with labor productivity and R&D expenditure. However, for a larger sample of countries, they found that while R&D expenditure increased with patents, labor productivity did not. In an analysis of 32 countries between the years 1981 and 1990, Kanwar and Evenson (2003) found a positive relationship between patent rights and R&D intensity (ratio of R&D expenditure to GDP). Kim et al. (2008) found that patent rights for developed countries were associated with higher R&D intensity. Research is therefore varied and brimming with inconsistent results, which points to the need for more analysis and discoveries.

Where innovation is concerned education plays an important role in the economy. Research at universities and public research institutions contributes to innovation through publications that result in the creation of codified knowledge for potential technological innovations by businesses. Countries are investing their resources in academic research, doctoral education, and the knowledge transfer from these institutions. For example, United States legislation such as the Bayh-Dole Act of 1980 has allowed universities to have ownership of intellectual property (IP), which in turn enabled universities to form alliances with the private sector, venture capital industry, and foreign firms. These alliances have resulted in over 42,000 licensing deals and the formation of more than 4500 companies (Atun et al. 2007), contributing to major revenue for the economy. While national legislative frameworks such as the Bayh-Dole Act authenticate the legitimacy of academic patenting activities, they also signal the development of local IP management practices such as IP rights and IP

exploitation/incubation, with the objective of promoting economic growth (Weckowska et al. 2015). IP governance and regulation benefits economic growth by providing incentives for innovation without hindering transfer of knowledge (Atun et al. 2007). Note for example that countries with universities that support research commercialization show a higher rate of patents. Also, countries with a highly educated workforce can achieve higher economic wealth and available resources to invest in innovations (Rossberger and Krause 2015). It is therefore relevant to include education in the analysis of economic indicators of innovation in a country.

Methods

This study investigates the relationship between economic development and innovation at a country level for the OECD-member countries. Table 1 displays the research methodology.

The data source for the study is http://stats.oecd.org. Data on innovation and economic development for OECD-member countries was collected for the years 2000 to 2010. In this study, we use patents to represent innovation. This is appropriate since patents can be used to protect inventions by firms, institutions, or individuals (Granstrand 2005). The OECD's Directorate for Science, Technology and Industry maintains patent data by region and by technology. This study focuses on the patents by technology. Variables were selected at the country level for the longitudinal time period. Table 2 shows all the variables in the research.

The economic indicators include variables that cover financial, labor, research and development, and educational components of the economy. *GDP per capita* measures the total output of a country: it takes the gross domestic product and divides it by the population of the country. In studies involving country-level comparisons, this is very relevant because it reflects the relative performance. *GNI per capita* is the value of a country's total income in a year divided by its population, and indicates the average income per resident. *Labor cost index* is an important indicator that incorporates price changes as well as changes in the composition and characteristics of labor input. Since the direct and indirect costs of labor have the potential to vary by industry, it is important to consider the labor cost index as an indicator. Also, labor has an impact on the innovation level of an economy because it influences the production of goods or services. *R&D expenditure* includes creative work undertaken systematically to increase the stock of knowledge and the use of knowledge to devise new applications, all of which have the potential to influence innovation. *Real minimum wage* is the statutory minimum wage converted into a common hourly and annual pay

Table 1 Research methodology

Data collection and variable selection
Data source: http://stats.oecd.org/
Indicators: innovation, economic development
ETL
Extract: data extracted from OECD database in csv format;
Transform: data transformed and prepared for loading with framework manager;
Load: prepared data loaded into IBM's DB2 database and IBM's Cognos-8
Analytics platform/tools selection
DBMS: IBM DB2 | Analytics: IBM Cognos
Analysis: Cognos Analysis and Report Studio
Analytics implementation
Analysis and reports implementation using Cognos

Table 2 Variables in the research

Economic indicators	Description
Gross domestic product (GDP) per capita ($)	US $ current PPP, current prices
Gross national income (GNI) per capita ($)	US $ current PPP, current prices
Labor cost index (base year 2010=100)	Measures changes in average hourly labor cost, taking into account not only price changes but also changes in the composition and the characteristics of the labor input; Calculated by dividing the labor costs by the number of hours worked. Labor costs are made up of costs for wages and salaries, plus non-wage costs such as employer's social contributions. These do not include vocational training costs or other expenditures such as recruitment costs, and spending on working clothes.
Research & development (R&D) expenditure ($)	Money spent on creative work undertaken on a systematic basis to increase the stock of knowledge and the use of this knowledge to devise new applications in the sector
Real minimum wage ($)	Statutory minimum wages converted into a common hourly and annual pay period (in US$) for the OECD countries for which they are available.
Tax revenue as percentage of GDP (%)	Tax Revenue expressed as a percentage of GDP
Ratio of education enrollment to total population (enrollment in 3 levels of primary, secondary, tertiary)	Ratio of enrollment in primary, secondary, and tertiary education levels expressed with the total population
Innovation indicators	**Description**
PCT (Patent cooperation treaty) patent applications per 10,000 inhabitants	Number of patent applications in PCT per 10,000 inhabitants (reference date is application date)
Patents owned by foreign residents	Patents owned by foreign countries (drill down to 8 countries including EU)
Patent applications under PCT by technology sector	Number of patent applications by technology for different sectors (sectors include chemistry/metallurgy; electricity; human necessities; fixed construction; mechanical engineering, lighting, heating; performing operations/transportation; physics; textiles/paper)

period (in US$) in the OECD countries for which they are available. *Tax revenue as percentage of GDP* represents the percentage of revenues collected from taxes on income and profits, social security contributions, goods and services, payroll, and all other taxes. It reflects the degree to which the government controls an economy's resources. *Ratio of education enrollment to total population* represents the enrollment in primary, secondary, and tertiary education expressed as a ratio to the total population. This is another important economic indicator, with the potential to influence innovation at a country level.

Our *innovation indicators* include the patent statistics extracted from the patents by technology category. The Patent Cooperation Treaty (PCT) offers a unified procedure for filing patent applications with the objective of protecting the intellectual property in each of its contracting members. *PCT patent application per 10,000 inhabitants* represents the number of applications per 10,000 inhabitants filed under the PCT. *Patents owned by foreign residents* represent patents that are given for inventors who are not residents of the country in which the application is made. For a variety of economic reasons, inventors can apply for patents in a country outside of their country of residence. *Patent applications under PCT by technology* sector includes the number of patent applications for different sectors such as chemistry/metallurgy, electricity, human necessities, fixed construction, mechanical engineering/lighting/heating, performing operations/transportation, physics, and textiles/paper.

IBM Cognos was used as the analytics tool. The variables are granular with the drill down capability for details on country level development. The data was extracted, transformed, and loaded into an IBM DB2 database for processing. Cognos Framework Manager was used to transform the data into cubes. The cubes were published into a package that was then loaded into Cognos Query and Report Studios for analysis and reporting. The data set is comprehensive and longitudinal and allows in-depth analyses.

We based our research on the following premises:

- Patent applications are good indicators of the level of innovation (Granstrand 2005).
- Patent applications are only applied through Patent Cooperation Treaty (PCT).
- The International Patent Classification (IPC) for industries offers a sound basis for analyzing data.
- Patent application date is a good reference point and can be used like the application priority date.
- Every patent application has a reasonable success rate.

We analyzed the data to address our research question: What are the key economic factors that determine the success of innovation at a country level? The following section discusses the results of our analyses.

Results and discussion

Number of patent applications under PCT

We first analyzed the sample of OECD countries for the number of patent applications under PCT, to detect variations, if any. The analysis reflects a wide variation in the number of patent applications. Figure 1 shows the distribution for the countries for the year 2010.

Year: 2010
Patent Application under PCT: Descending order

Country	Year	Patent Application under PCT
United States	2010	87318.77
Japan	2010	63981.51
Germany	2010	34561.64
Korea	2010	18165.47
France	2010	14709.46
United Kingdom	2010	9059.07
Switzerland	2010	7806.77
Netherlands	2010	7703.20
Sweden	2010	6561.50
Italy	2010	5201.50
Canada	2010	4685.40
Finland	2010	4098.47
Spain	2010	3407.65
Australia	2010	3357.23
Israel	2010	2865.85
Austria	2010	2290.33
Denmark	2010	2224.83
Belgium	2010	2090.90
Norway	2010	1418.00
Ireland	2010	967.36

Fig. 1 Distribution of patent applications under PCT by country for 2010

As seen in Fig. 1, countries such as the USA, Japan, Germany, Korea, and France have a high number of patent applications under PCT (>10,000) indicating a significant level of innovation. Interestingly, even though there are only two Asian countries in the sample—Japan and Korea—both rank high in innovation. To get an idea of the sustainability of innovation over the years, we compared our 2010 ranking with Bloomberg's ranking of innovative countries by patents for the year 2015 (Bloomberg 2015). The top countries in our analyses were also among the top 10 in Bloomberg's list in terms of number patent applications, showing that the innovation level sustained over the 5 years following the research. For further meaningful comparisons, future analyses should consider weighting the patent applications for each country based on the population of the country.

We then explored the patents by industry to observe whether some industries were more innovative than others. Figure 2 displays the industry classifications and the number of patent applications for each classification for the year 2010.

Figure 2 displays the sector/industry ranking by number of patent applications. The lower-ranked industries (number of applications <5000) are highlighted in red and the higher-ranked (number of applications >10,000) in green. Industries—including textiles, paper, and fixed constructions—show a low number of patent applications compared to industries such as electricity and physics. Most countries tend to focus on the latter type of industries, referred to as sunrise industries because they show more potential for innovation. Breakthrough innovations in electricity and physics, such as electromagnetism or nuclear physics, have led to transformational developments in modern television, computers, and household appliances, and so it is inevitable that associated industries should introduce a high level of innovation. The number of patent applications for performing operations and transporting is also high. Human necessities, an industry category with a high number of patents, include the industries of agriculture, personal or domestic health articles, foodstuffs, and amusement. Countries looking to stimulate innovation should focus on industries that show potential for development and entrepreneurship.

R&D expenditure per capita

In order to understand the level of economic development in these countries, we looked at Research & Development (R&D) expenditure per capita for a single year,

Year: 2010 AND NOT Patent by Technology: Total Patents

Patent Application under PCT: Descending order

Patent by Technology	Year	Patent Application under PCT
Electricity	2010	31500.51
Physics	2010	26506.75
Human Necessities	2010	26406.39
Chemistry; Metallurgy	2010	20153.22
Performing Operations; Transporting	2010	20125.11
Mechanical Engineering; Lighting; Heating; Weapons; Blasting	2010	13132.01
Fixed Constructions	2010	4237.75
Textiles; Paper	2010	1459.54
Summary		**143521.29**

Fig. 2 Distribution of the number of patent applications by industry for 2010

2010 (Fig. 3). The R&D expenditure per capita was calculated using the GPD per capita and expenditure/GDP, as shown.

Figure 3 shows that, for 2010, Finland ranks first with the highest R&D expenditure per capita, followed by Sweden, Denmark, and Austria. The large R&D expenditure in Finland can be attributed in part to its headquartering Nokia, the multinational ICT (information and communication technology) company that pioneers innovative technology. These findings are consistent with Bloomberg's 2015 global innovation ranking of countries based on R&D expenditure (Bloomberg 2015). Sweden and Finland also were among the top five innovative countries in Bloomberg's ranking. On the other hand, Germany, which is sixth in our ranking, does not figure among the top six in Bloomberg's 2015 ranking. It may come as a surprise that, in terms of R&D expenditure, the USA does not figure among the top countries in either our analysis or in Bloomberg's.

We expected countries that rank high in R&D expenditure to also be the most innovative. However, Finland, Sweden, Denmark and Austria, which are the top ranked countries for R&D as shown in Fig. 3, do not rank among the top innovative countries shown in Fig. 1. An explanation for this could be the fact that while some countries innovate by increasing their investment in R&D, others do so by utilizing the know-how already generated by other countries (Guloglu and Tekin 2012). Furthermore, R&D is only one of the indicators for innovation; others include institutional and social regulations, education of the workforce, and technical skills of the workforce. Therefore, it is possible to innovate by way of measures other than R&D expenditure.

Tax revenue as a percentage of GDP and patents owned by foreign residents

At a country level, tax revenue is an important indicator of economic development. We felt it is important to analyze whether a country's tax revenue as a percentage of GDP

Continent: Europe AND Year: 2010

GDP per capita (US$) * Expenditure/GDP: Descending order

Continent	Year	Country	GDP per capita (US$)	Expenditure/GDP	GDP per capita (US$) * Expenditure/GDP
Europe	2010	Finland	181,535	0.0781	14177.88
Europe	2010	Sweden	196,727.95	0.0678	13338.16
Europe	2010	Denmark	200,949.4	0.0614	12338.29
Europe	2010	Austria	200,324.2	0.0558	11178.09
Europe	2010	Luxembourg	345,077.4	0.0296	10214.29
Europe	2010	Germany	149,720.36	0.056	8384.34
Europe	2010	Norway	229,037.8	0.0336	7695.67
Europe	2010	France	171,281.35	0.0447	7656.28
Europe	2010	Belgium	188,639.2	0.0401	7564.43
Europe	2010	United Kingdom	178,434	0.036	6423.62
Europe	2010	Netherlands	168,782.28	0.0371	6261.82
Europe	2010	Slovenia	134,705	0.0418	5630.67
Europe	2010	Ireland	161,912.52	0.0341	5521.22
Europe	2010	Spain	159,519	0.0278	4434.63
Europe	2010	Portugal	127,221.45	0.0317	4032.92
Europe	2010	Italy	159,555.5	0.0252	4020.80
Europe	2010	Czech Republic	126,289.2	0.031	3914.97
Europe	2010	Estonia	101,966.45	0.0326	3324.11
Europe	2010	Hungary	82,222.44	0.0232	1907.56
Europe	2010	Slovak Republic	116,318.2	0.0126	1465.61

Fig. 3 R&D expenditure per capita for 2010

has any association with innovation in terms of patents owned by foreign residents (Fig. 4).

As shown in Fig. 4, we calculated an index using the ratio of patents owned by foreign residents and the tax revenue as a percentage of GDP, in order to obtain a comparative assessment for each country. We show benchmarks for the variables. For the ratio of patents owned by foreign residents, values under 10 are highlighted in red to indicate poor performance, and values over 20, in green to indicate high performance. For tax revenue as percentage of GDP, values above 200 are highlighted in yellow to denote good performance. For the index, values under 0.12 are highlighted in red to indicate poor performance while values over 0.12 are highlighted in green to indicate good performance. Figure 4 shows that countries such as Sweden, France, Finland, and Austria have high tax revenues as percentage of GDP but show a low ratio of patents owned by foreign residents. On the other hand, countries such as Luxembourg and Iceland with low tax revenue as a percentage of GDP have a higher ratio of patents owned by foreign residents. There seems to be an inverse association between tax revenue (as a percentage of GDP) and patents owned by foreign residents. Countries with high foreign ownership of patents experience a decrease in tax revenues. This is a relevant finding on patents/IP and it has important implications that will be discussed in the "Conclusions" section.

Real minimum wage and PCT patent applications per 10,000 inhabitants

We looked to see whether real minimum wages (as an economic indicator) has any relationship with innovation indicated by PCT patent applications per 10,000 inhabitants (Fig. 5). Real hourly and annual minimum wages are statutory minimum wages converted into a common hourly and annual pay period (in US$) for the OECD countries

Year: 2005

Tax revenue as percentage of GDP: Descending order

Country	Year	Ratio of patents owned Foreign residents	Tax revenue as percentage of GDP	(Ratio of patents owned Foreign residents) / Tax revenue as percentage of GDP
Denmark	2005	10.0162	254.15	0.039
Sweden	2005	5.5053	244.35	0.023
Belgium	2005	19.3308	222.35	0.087
France	2005	9.2681	220.5	0.042
Finland	2005	3.4884	219.55	0.016
Norway	2005	18.0851	216	0.084
Austria	2005	3.6293	210.55	0.017
Iceland	2005	8.8889	203.45	0.044
Italy	2005	7.4958	202.95	0.037
Slovenia	2005	2.0202	193.1	0.010
Netherlands	2005	6.7639	192.1	0.035
Luxembourg	2005	23.1884	187.9	0.123
Hungary	2005	8.5107	186.55	0.046
New Zealand	2005	16.1138	181.75	0.089
Czech Republic	2005	10.9678	180.5	0.061
Spain	2005	8.2052	180.2	0.046
Israel	2005	23.9719	178.4	0.134
United Kingdom	2005	19.1934	177.15	0.108
Germany	2005	5.7859	175.15	0.033
Poland	2005	13.986	165	0.085

Fig. 4 Tax revenue as a percentage of GDP and patents owned by foreign residents

Real Min Wage: Descending order

Year	Country	Real Min Wage	PCT patents applications per 10,000 inhabitants
2008	Netherlands	27,374.46	2.17
2008	Belgium	26,510.56	1.02
2008	Ireland	25,857.88	0.97
2008	France	24,350.08	1.11
2008	United Kingdom	23,999.89	0.98
2008	Canada	17,273.34	0.78
2008	Japan	13,633.05	1.99
2008	United States	13,582.12	1.43
2008	Spain	13,174.55	0.36
2008	Greece	13,099.21	0.1
2008	Slovenia	10,767.05	0.7
2008	Korea	10,351.71	1.46
2008	Portugal	9,442.18	0.13
2008	Poland	6,443.7	0.05
2008	Czech Republic	6,025.01	0.2
2008	Hungary	5,815.24	0.22
2008	Estonia	5,484.9	0.34
2008	Slovak Republic	5,066.27	0.06
2008	Chile	3,763.74	0.03
2008	Mexico	1,409.54	0.02
Summary		**263,424.48**	**14.12**

Fig. 5 Real minimum wage and PCT patent applications

for which they are available. The numbers are deflated by the national Consumer Price Indices (CPI).

Figure 5 lists the countries in descending order of real minimum wages (in US$). The values of PCT patent applications per 10,000 inhabitants that are above 1.0 are highlighted. The countries of Netherlands, Belgium, and Ireland have the highest real minimum wages. These countries also have an elevated number of patent applications per 10,000 inhabitants. Countries like Mexico, Chile, Estonia, and the Slovak Republic have low real minimum wages and a correspondingly low number of PCT patent applications per 10,000 inhabitants. There is a positive association between real minimum wages and the number of patent applications, in that the higher the real minimum wages, the higher the level of innovation reflected by patent applications. Thus, countries that foster higher standards of living and better work conditions (through higher minimum wages) also foster more innovation and growth. Korea is an exception in that it has a high level of patent applications despite an average minimum wage. This phenomenon can be attributed to it being the headquarters for Samsung, the multinational telecommunication giant. In terms of patents, our rankings are consistent with the 2015 ranking of Bloomberg's innovative countries (Bloomberg 2015) thereby demonstrating that these countries have sustained their innovation over the years 2010 to 2015.

Labor cost in different industry categories

To identify any significant patterns, we analyzed labor costs by industry for all European countries in our sample (Fig. 6). The labor cost for an industry encompasses direct and indirect costs including employee wages, employee benefits, and payroll taxes of employers.

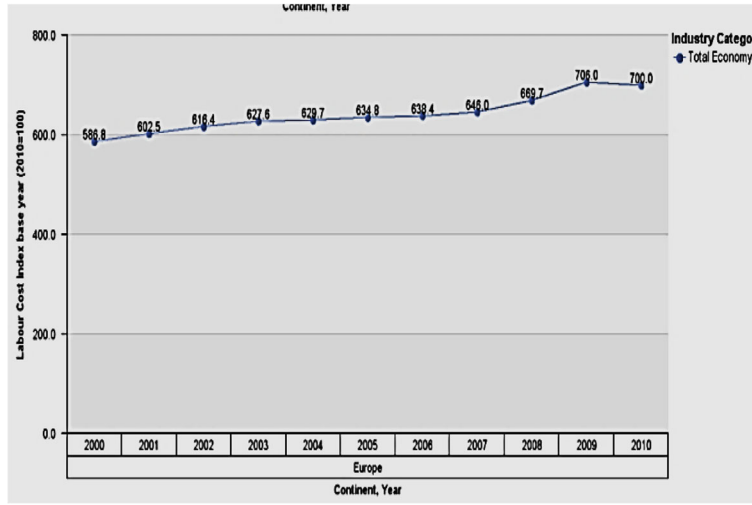


Fig. 6 Distribution of labor cost by industry for countries in Europe

It is important to analyze this component as the costs vary depending on the nature of the industry. For example, costs for manufacturing vary from that for service industries due to the nature of tasks and activities.

Figure 6 shows a 9.3% increase in overall labor cost for the European countries between the years 2000 and 2010. With the exception of a small decrease in total cost between the years 2009 and 2010, the general trend in labor cost is upward. To ascertain which industries contributed most to cost increases, we broke down costs by industry (Fig. 7).

Figure 7 shows that of all the industries construction has a significant contribution to the increase in labor cost over time. From our earlier analysis on the number of patent applications by industry (shown in Fig. 2), construction showed a less-than-average number of patent applications per 10,000 inhabitants. It appears that there is a negative association between labor cost and number of patent applications. The higher the labor cost, the lower the number of patent applications, suggesting that countries should contain the cost of labor in order to stimulate innovation and growth.

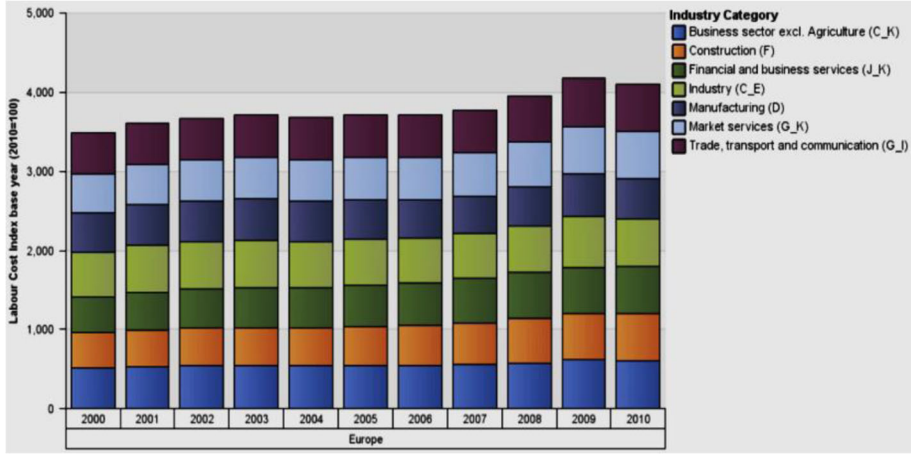


Fig. 7 Labor cost by industry for countries in Europe

Ratio of education enrollment to total population

Because education is an important indicator for any economy, we chose to investigate whether education plays a role in country level innovation. In order to draw meaningful comparisons on the state of education enrollment, we calculated a ratio of education enrollment to total population for each country. The ratio is shown for the countries in the continents of Asia, Europe, North America, and South America (Fig. 8). From these continents, we selected Europe to show the annual variation in the ratio of enrollment to population and used a line chart to depict our findings (Fig. 8).

As seen in Fig. 8, for all the continents, the ratio of education enrollment is highest at the elementary level followed by that at the secondary level. Enrollment at the tertiary level is highest in North America, where it is almost equal to the enrollment at the secondary level. We see, looking at the trend line for the ratios for the years 2000 to 2010, that enrollment at the secondary and tertiary levels are increasing without a corresponding increase at the elementary level. One possible explanation for this trend is that more adults are returning to school to complete their secondary and tertiary education. In terms of institutions and facilities, access to higher-level education has increased across Europe over the years. The education sector, in general, has expanded to include diverse options relative to content, pedagogy, and methodologies. This expansion has opened up a vista of alternatives to traditional college education, including online/hybrid courses as well as vocational and technical certification programs. As a result, young people today may achieve a higher education level than prior generations. According to the 2012 Survey of Adult Skills, about 32% of 25- to 34-year-olds show upward mobility. That is, they have a higher level of education than their parents (OECD 2014).

Was there an association between education enrollment and the innovation (number of patent applications) at country level for the years 2000 to 2010? We investigated this question next.

Figure 9 shows a table of the countries with the highest number of patent applications and a line chart depicting countries with the highest ratios of education enrollment to total population. The top three innovative countries (with the most patent applications) for the years 2009 and 2010 are USA, Japan, and Germany. However, out of these countries, we see that only the USA has a high ratio of education enrollment

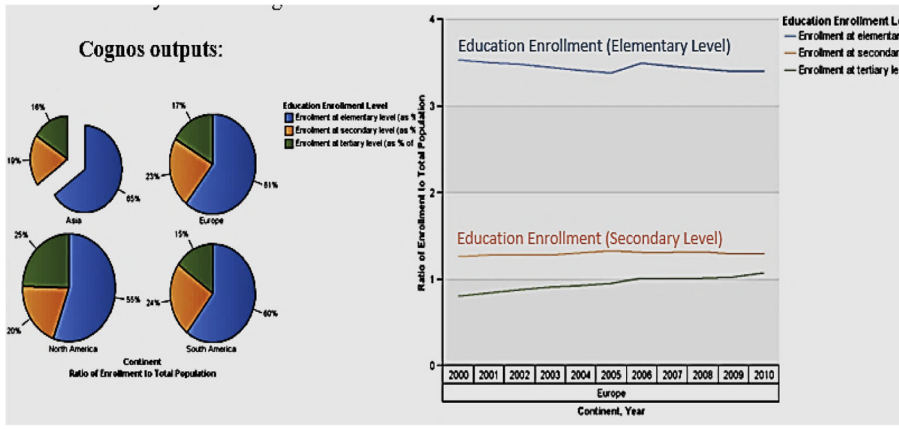
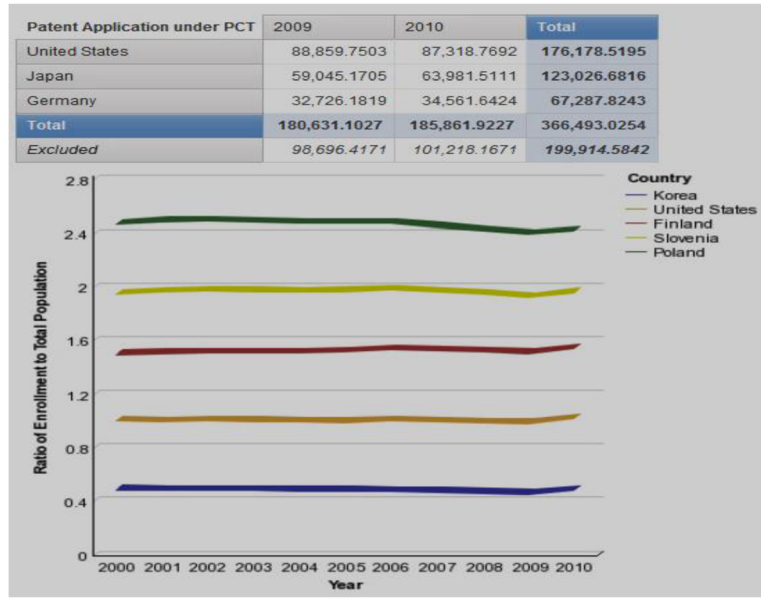


Fig. 8 Ratio of education enrollment to total population



Patent Application under PCT	2009	2010	Total
United States	88,859.7503	87,318.7692	176,178.5195
Japan	59,045.1705	63,981.5111	123,026.6816
Germany	32,726.1819	34,561.6424	67,287.8243
Total	180,631.1027	185,861.9227	366,493.0254
Excluded	*98,696.4171*	*101,218.1671*	*199,914.5842*

Fig. 9 Ratio of education enrollment and number of patent applications under PCT

to total population (as seen in the line chart). Poland and Slovenia have high education enrollment but do not figure among the top innovative countries. It appears that there is no direct association between education enrollment and innovation.

High education enrollment does not necessarily indicate high innovation. Even though education, learning, and knowledge are integral for creative thinking and innovation, transforming creative ideas into innovation is contingent upon environmenal components (Fagerberg and Srholec, 2008) as well as the way in which education is fostered (Sawa 2016). Some innate skills required for innovation include the ability to think, make judgments, and express oneself. To facilitate innovative tendencies, education systems need to instill in students critical thinking and communication skills. In some countries such as the USA, the undergraduate curriculum in universities is designed with an emphasis on liberal arts education which teaches students to synthesize disparate ideas into creative, unified solutions. This type of education offers a good foundational framework for innovation. While the liberal arts undergraduate curriculum focuses on empowering basic skills, a graduate curriculum delivers specialized skills that directly relate to future jobs. In other countries like Japan, the undergraduate curriculum does not emphasize the critical thinking skills, focusing instead on quantitative skills (Sawa 2016; Shin and Zhou 2007). Quantitative skills are important of course, but they need to be balanced with the liberal arts skills of thinking and communicating. Thus, the quality of education is important.

We examined education enrollment at the tertiary level in Europe to study possible associations with innovation (number of patent applications). Figure 10 shows the association for the continent of Europe.

Figure 10 shows that, for Europe, as the enrollment in tertiary level increases, the number of patents (innovation) also increases (except between the years 2007 and 2008). It appears that, in Europe, higher (tertiary) education stimulates innovation by endowing citizens with the requisite skills sets that are required. Also, in Europe, more resources are allocated to higher (tertiary) education, thus enabling the population to

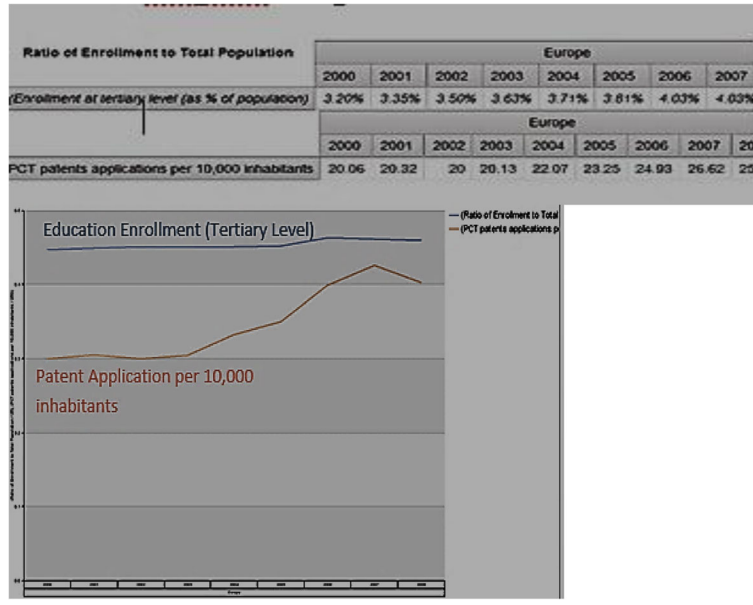


Fig. 10 Education enrollment at tertiary level and PCT patent applications per 10,000 inhabitants

explore innovative endeavors. These findings suggest that governments looking to promote innovation can invest more in higher education, allocating more resources and facilities that encourage the pursuit of high-level studies. Our analysis, however is limited to Europe; future studies may analyze the differences between continents in terms of the relationship between tertiary or secondary education and innovation.

Patents owned by foreign and domestic residents

We analyzed the proportion of patents owned by foreign versus domestic residents for countries in Europe for the year 2005 (Fig. 11).

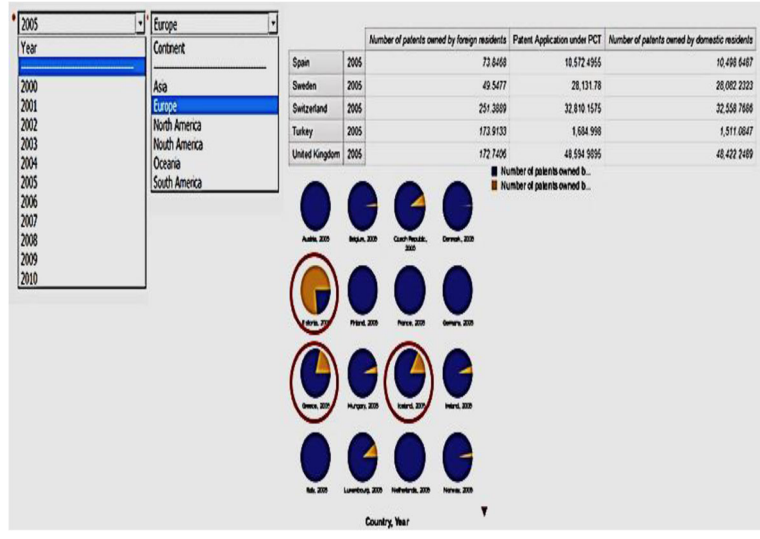


Fig. 11 Comparison of patents owned by foreign residents vs. domestic residents in Europe for 2005

Figure 11 shows the proportion of patents owned by foreign residents and that owned by domestic residents for each country in Europe for one year, 2005. From the pie charts, we see that Estonia, Greece, and Iceland have more patents held by foreign residents (these are circled).

To encourage and stimulate more innovation by local residents, countries like these should put in place the appropriate policies and resources to do so. In addition, these countries should focus on improving their educational systems so that they offer the relevant skills and knowledge to foster innovation and growth. The findings on patent holdings by foreign versus domestic residents hold implications for policies on taxation and ownership of patents. These findings are discussed in detail in the "Conclusions" section.

Average of economic indicators (GDP/GNI/real minimum wages) and patents owned by foreign residents

We analyzed the association between the average of economic indicators (GDP, GNI, and real minimum wages) and percentage of patents owned by foreign residents. We expected that the more developed an economy (higher average of GDP, GNI, and real minimum wages), the lower the percentage of patents owned by foreign residents (Fig. 12).

Figure 12 shows that countries with a low average of economic indicators have a high percentage of patents owned by foreign residents. These countries rely on foreign collaboration to strengthen their resources and facilities for innovations. These cross-border collaborations often result in patent ownership by foreign residents instead of locals. On the other hand, countries that have a developed economy—characterized by high GDP, GNI, and real minimum wages—have more local resources and talent, and therefore do not rely on foreign collaboration. This leads to a high proportion of patents owned domestically and a low proportion of patents owned by foreigners.

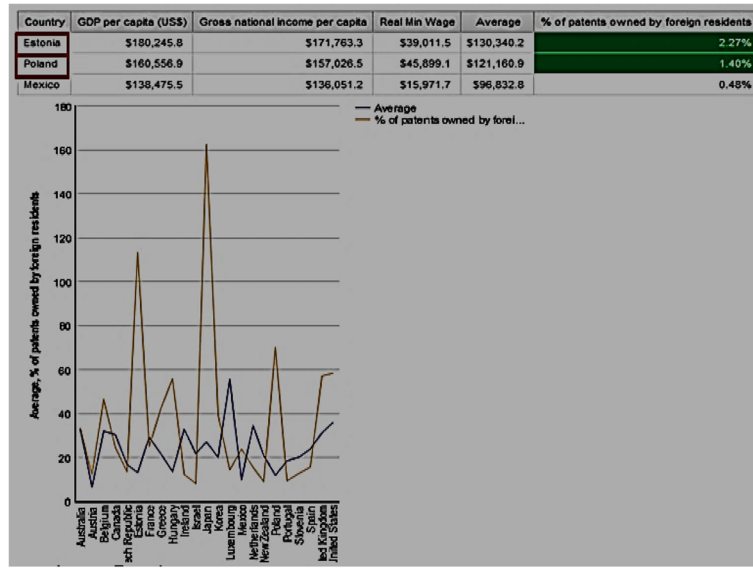


Fig. 12 Economic indicators and patents owned by foreign residents

For the countries Estonia, Iceland, and Greece, which show the highest percentage of foreign-owned patents as illustrated in Fig. 11, we analyzed the number of patents under PCT by industry (Fig. 13). We were curious to see whether there is a pattern showing that certain industries dominate the category of patent ownerships by foreign residents. We selected 2003 for analysis.

Figure 13 shows that for Greece, Iceland, and Estonia, the industry with the most foreign owned patent applications is performing/operations/transporting followed by mechanical engineering. This finding indicates that local talent in these sectors is insufficient, creating a dependency by the economy on foreign talent. One solution to this dependence would be to enhance education that specifically addresses requirements in these sectors. More local residents should be able to acquire knowledge and skills that encourage innovation internally. In addition, the government in these countries should introduce measures to promote innovations in these sectors.

R&D expenditure by sector and patent applications

We had analyzed overall R&D expenditure per capita (Fig. 3) for all the countries. To identify significant patterns within particular sectors, we then explored the R&D expenditure by sector (government, business, higher education, and private and non-profit sector) for the continent of Europe (Fig. 14).

Figure 14 shows that government and higher education sectors in Europe have higher R&D expenditures than private and non-profit sectors. To reverse this trend, European

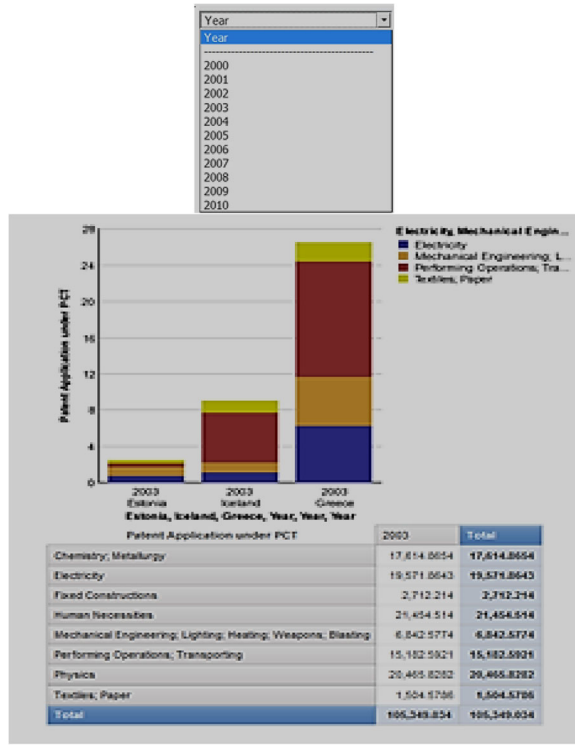


Fig. 13 Patents under PCT by industry for countries with high percentage of patents owned by foreign residents

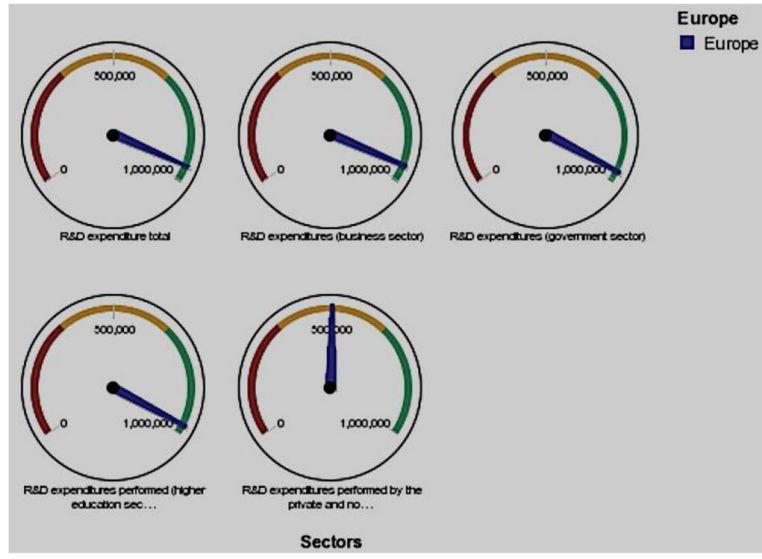


Fig. 14 Number of patent applications and R&D expenditure by sector

countries in this sample should advocate policies that encourage more innovation in the private and non-profit sectors.

Scope and limitations

There are some limitations to our study. First, although we cover a reasonable time span of 10 years, future studies can cover a longer span thereby increasing the possibility of highlighting more trends and patterns. Second, using analytics, our study looks at associations but does not investigate causality in the relationship between economic and innovation indicators. Third, we only consider a small segment of economic and innovation indicators. Obviously, other and more variables could be considered and included for future research. Our data is from a secondary data source (OECD), which is an aggregated set from multiple models and sources and therefore subject to limitations. Finally, we deploy a health analytics approach to investigate the relationship between economic indicators and innovation. Other studies could explore alternate approaches, theories, and models.

Conclusions

Despite its limitations, our study makes several important contributions to literature on innovation and economic growth at a national level. Whereas most studies on innovation focus on firm-level or enterprise-level innovation, our study analyzes country-level innovation. In addition, it incorporates a comprehensive and large data set from OECD that allows for longitudinal analyses.

We also contribute in terms of the methodology of analytics used in the research. This emerging technique offers potential in various domains including innovation. We demonstrate how data-driven analytics can help make informed decisions on innovation and economic growth. The research adds to the empirical studies literature on innovation that deploy an analytic approach.

By identifying a portfolio of economic factors that influence innovation, we offer insights policy makers may call upon to design effective policies targeted toward promoting and encouraging innovation. Our analysis of industries with the most potential for innovation offers benchmarks for effective resource allocation or incentive assignment in fecund industries. Incentives can take the form of subsidies, tax breaks, grants, or business incubation services that facilitate innovation. In addition, our results offer benchmarks for efficient resource allocation among industries.

The relationship between R&D expenditure and innovative efforts of a country has been emphasized by endogenous growth models (Romer 1994; Zachariadis 2003). In this regard, we show that while R&D is an important indicator for innovation, only some OECD countries innovate by increasing their investment in R&D. Others promote their innovation through technology spillovers from other OECD countries (Acemoglu and Linn 2004; Wang 2010). These countries utilize the know-how that is generated by other countries (Guloglu and Tekin 2012). This finding does not mean that R&D is not important for long-term growth. Instead, it implies that the measure of R&D cannot be interpreted as a complete measure of innovation: other factors must be considered (Aghion and Howitt 1998).

On a socio-economic level, our findings on the association between the standard of living (real minimum wages, labor cost) and innovation suggests that to improve innovation and economic growth, countries need to focus on improving the standard of living in terms of high minimum wages, low labor cost, and better work conditions.

A notable contribution of our research lies in the dimension of internationalization and ownership of technology innovation (patents). We show that countries with high foreign ownership of patents have low tax revenues as a percentage of GDP. An exploration of the concept of income from intellectual property (IP) is helpful in interpreting this association further. In general, income from IP is mobile because it has no associated trade costs (Griffith et al. 2014). Thus, patent ownership may be found in locations other than the country in which they were created. Multinational companies, a big source for patents, typically exploit this mobility by locating their intellectual property in low-tax countries (referred to as tax havens) thereby decreasing their tax burden (Lipsey 2010). It's no wonder that countries that see a high proportion of patents owned by foreign residents have grown increasingly concerned about the tax revenue losses arising from such relocation schemes. To address this, some countries have introduced patent boxes to reduce the tax rate on income derived from patents. Belgium, for example, introduced a patent box in 2007, reducing the tax rate from 34 to 6.8%. The Netherlands reduced the tax rate from 31.5 to 10%. In 2008, Luxembourg reduced the rate from 30.4 to 5.9%; and in 2013, the UK introduced a patent box at the rate of 10% reducing the tax rate from 30 to 24% (Griffith et al. 2014). We suggest that countries should address the ownership of patents and encourage more ownership by local residents and less by foreign residents, in order to increase innovation and boost tax revenues that result in economic growth.

In terms of education in influencing innovation, we highlight the importance of having an integrated curriculum that offers students the liberal arts skills (analytical, evaluative, critical and creative thinking, and written and oral communication) as well as quantitative and technical skills needed for the workplace. Most employers want

employees to have the ability to learn and synthesize new ideas, be reflective and articulate, and have excellent organization and time-management skills. We reinforce the need for governmental policies to focus on enhancing the quality of education to facilitate the knowledge transfer needed for country-level innovation. Proposing a regulatory framework to promote innovation is a challenging task because, in addition to economic growth, this framework has to address social and environmental goals. More theoretical and empirical research is needed. Another important direction for future work is analysis of the impact of other forms of intellectual property-copyrights and trademarks in addition to patents- on economic growth and innovation.

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Dialectic evolution through the social innovation process: from microcredit to microfinance

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Abstract

Microfinance is the provision of financial services to the financially excluded, usually the poor. We use literature reviews and descriptive research to present different aspects of the relationship of the microfinancial services to microenterprise. The first thrust in this field had been from microcredit and group lending to encourage business initiatives among the poor. The hope that these services would lift them out of poverty had largely built the brand image of the sector. However, the spread of consumer microcredit and uncontrolled growth of microfinance led to over-lending without adequate checks and balances, leading to over-indebtedness and associated stress, and critique of microcredit. To restore balance, other financial products, such as microequity, microsavings, microinsurance, microguarantees, and microremittances, have been suggested. We place these developments in a social innovation process perspective by showing that microfinance, through its wide range of innovatively distributed products, can be a key factor to foster entrepreneurship.

JEL: L26, O16, O17, O30

Keywords: Entrepreneurship; Microcredit; Microequity; Microinsurance; Microsavings; Microremittances; Microguarantee; Innovation

Background

Addressing poverty is a complex issue. Different researchers and professionals have focused on different tools. For example, De Soto (2000) stresses that the absence of property rights keeps countries from developing, Prahalad (2006) feels that the least of the poor should be targeted as consumers and included into the market, Karnani (2007) feels that there is no fortune at the bottom of the pyramid and the poor need public sector jobs, and Ashta (2013b) feels the need for raising minimum wages for those who already have jobs. Sachs (2005) feels that the very poor are so incapacitated that only donations would help, and Yunus (2003) recommends microcredit. There are many other issues involved such as health and education. All these researchers and practitioners realize that the tool they are focusing on is just one in a bag of tools required to increase the capital of the poor: Since the governments of these countries are poor and cannot provide the basic services such as property rights, adequate public works, or even high-enough minimum wages, one possible solution advocated is self-help: for the poor to rise from poverty requires them to become microentrepreneurs and take charge of their own fate. The free market has not solved the problem because entrepreneurship requires financial capital, social capital, and human capital.

A social innovation is therefore required because existing public and private institutions cannot solve the problem. Schumpeter (1935) considers innovation as the production of a new good, the introduction of a new method of production, the opening of a new market, the conquest of a new source of raw material, and the creation of a new organization. Social innovation means that new forms of social relations are required in order to overcome the financial and social exclusion and create empowerment (Moulaert et al. 2013b). Evidently, this requires overcoming conservative forces which would prefer to perpetuate the existing system or try to take over any new system to its own advantage and, thus, either perpetuate the exclusion or find new ways to exploit (Moulaert et al. 2013a). This agency paradox needs to be overcome by institutional entrepreneurs, aiming at creating, maintaining, and disrupting institutions (Lawrence et al. 2009). They do this by influencing public policy and legislation.

Microcredit is one example of a social innovation because it is an initiative taken by actors in order to provide new answers to social problems (social and financial exclusion, poverty) and a device capable of providing services to enable construction of a society with high levels of quality of life. Hence, it is also a social innovation (Assogba 2007; Couchoro 2001) in the sense of focus on being a response to social needs (Cloutier 2003). It may also impact the environment because it is focused on a local development. It has developed new social relations in different ways (Ashta et al. 2013) that have included getting conservative local actors to work towards inclusion (Marti and Mair 2009). However, there are a multitude of conservative actors who are nonlocal and would like to use the microcredit movement to suit their own ends instead of developing entrepreneurship. We therefore need to provide other solutions to mitigate the misuse of microcredit. One such solution is to provide other financial products and go from microcredit to microfinance. In this paper, we focus on microfinance and whether the new financial products can develop entrepreneurship.

Microfinance is the provision of financial services to the poor and the financially excluded. These financial services include credit, savings, insurance, remittances, and guarantees, among others. As a result, an associated vocabulary includes microcredit, microsavings, microinsurance, microremittances, and microguarantees. A relatively new focus has been on providing microequity.

The major common problem of providing all these services to the poor is that the transaction size is very small. As a result, any processing cost, or transaction cost, becomes a high percentage of the transaction amount. This makes the product very expensive for commercial banks and formal financial institutions to provide these services to the poor, who therefore remain excluded. A second common problem is that the poor not only lack financial capital but are also often socially excluded and lack bridges to rich people. A third common problem is that they are often uneducated, even illiterate, and excluded from technological innovations.

To solve these problems, microfinance institutions (MFIs) have created social innovations which permit them to offer financial products which were otherwise not viable commercially (Armendàriz and Morduch 2010). Seeing the success of MFIs, hitherto conservative commercial financial institutions are also downscaling to profit from the vast market at the bottom of the pyramid. All of these are trying to use advanced technologies such as management information systems, mobile banking, and online financing to increase their outreach (Ashta et al. 2011). The question is whether their own

ideological heritage will permit conservative institutions to foster entrepreneurship or to turn the system to their advantage.

Research methodology

Our research methodology is to use literature reviews and descriptive research based on empirical data from secondary sources. Such research is a good starting point to take inventory as well as to find patterns based on which future analytical research can find explanations.

> Descriptive research on industry dynamics has identified a dominant pattern where prices fall, output rises, and the number of firms rises and then falls over time. Several models have been advanced to explain these patterns (Lenox et al. 2007).

> The descriptive research on compliance costs emphasizes the burden of compliance costs, with little attention to measuring any benefits from tax planning. In contrast, the analytical research in tax evasion suggests an incremental benefit of compliance costs in reducing taxes (Mills 1996).

In fact, there is a growing field which considers that too many papers unnecessarily develop theoretical models rather than simply presenting their findings (Leung 2011; Hambrick 2007).

Results and discussion

We will start with the relationship of entrepreneurship to microcredit because it is the most developed product in microfinance. But today, it is being increasingly realized that other complimentary financial products are necessary for the poor, and the relationship of these to entrepreneurship will be discussed in the next part.

Microcredit and entrepreneurship

What is microcredit?

In underdeveloped countries, the vast majority of the population has no access to the banking system, whether in rural or in urban areas. The absence of appropriate formal financial services had long led the people to the informal financial sector. At best, they use Rotating Savings and Credit Associations (ROSCAs), a traditional practice of mobilizing savings, brilliant but sometimes very risky (and reserved for the middle class, the one having the capacity to save) and at worst they are entrenched with the usurious moneylender, with very prohibitive interest rates, for example, 300% in Ethiopia (Belwal et al. 2012). In the 1990s, it was estimated that 90% of adult African population was excluded from financial services compared to 85% for Brazil (Gentil and Servet 2002). Data available from Microcredit Summit shows that by 2010, 11% of the poor in Africa and Middle East, 32% in Latin America, and 69% in Asia and the Pacific were being covered by microcredit (Maes and Reed 2012). To the extent that a dent has been made in the exclusion problem, we can say that in this respect (outcome), microcredit is a social innovation.

To understand the other aspects of this social innovation, it is important to understand the problems it addressed. Essentially, lending to the poor suffered from three

major problems: default risk, transaction costs, and lack of complementary inputs (Armendàriz and Morduch 2005; Ashta 2009; Wydick 2002). The first, default risk, arose from asymmetric information as well as a lack of physical collateral with the poor borrowers. The asymmetric problem arose from the lack of information on the borrower's ability and willingness to repay the loans and thus an inability to separate safe borrowers from risky types. The lack of enforcement capacity owing to voids in legal enforcement systems created other threats for reinforcing moral hazard. The second, high transaction costs, arose from the small, or micro, size of the loan being attributed. Any fixed cost of processing the loan application as well as servicing the loan to take back reimbursement becomes high in relation to the small amount of the loan. Finally, even if the poor could be provided financial capital, it was felt that they would not be able to be entrepreneurial since they did not have the necessary complimentary social and human capital. This reinforced the moral hazard. For richer borrowers, banks solve the risk problem by asking for collateral, but the poor do not have either collateral or the legal documents for the property they may have acquired (Belwal et al. 2012; De Soto 2000).

Microcredit aims towards a minimal equality in the access to credit by allowing people excluded from the traditional financial system to take loans for creating their own jobs. It can be defined as any loan initiative intended to create income-generating activities, focused on microentrepreneurs with no access to traditional bank lending. It aims to fight against poverty. The Microfinance Information eXchange (MIX) 2010 statistics show that gross loans portfolio and the average loan are different from one region to another (Table 1).

Owing to low transaction sizes and because of the relatively high processing costs, MFIs apply an interest rate generally higher than that of the banking sector. Regulators do try in some countries to control this, but the ceiling varies over time. For example, in the particular case of countries of the West African Monetary Zone (Couchoro 2011), laws on usury for all financial institutions operating in the area impose 'an usury ceiling' not exceeding twice the discount rate of the central bank (i.e., 17% per year). The MFIs have since obtained a waiver; the central bank has revised the law on usury. Today there are two ceilings: one for commercial banks (18%) and the other for MFIs (27%). Therefore, we can see that microcredit has been able to influence public policy to enhance its institutional work.

Evolution of microcredit

Microcredit is a new form of lending to the poor, hailed as a social innovation of the 1970s, resulting in loans to about 200 million people (Maes and Reed 2012; Reed 2013) and impacting about a billion people (taking a family size of five). Figure 1 illustrates

Table 1 Microcredit institutions' loan statistics

Regions	Gross loan portfolio (US$)	Average loan size (US$)
Africa	4.6 billion	371.9
Latin America and the Caribbean	22.9 billion	1,024.4
South Asia	8.4 billion	144.0
East Asia and Pacific	21.2 billion	305.6
Eastern Europe and Central Asia	8.3 billion	1,687.8

Source: The Microfinance Information eXchange (MIX) 2010.

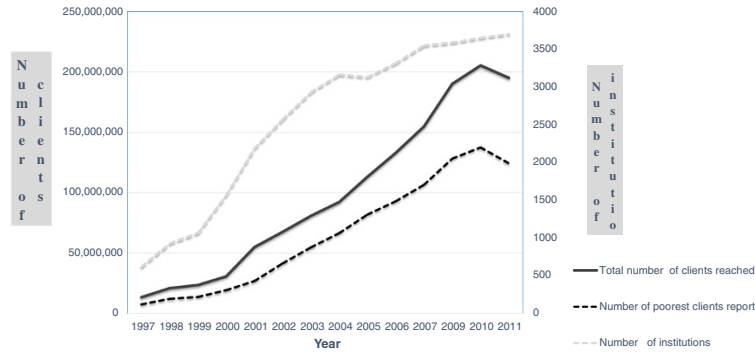

Figure 1 Evolution of microfinance. Base on data from Microcredit Summit report (Maes and Reed 2012; Reed 2013).

the evolution of microcredit: the top curve uses the secondary axis and indicates that today, 3,703 MFIs report to the Microcredit Summit Conference, indicating that they have reached 195 million clients out of which 124 million are very poor.

Microcredit is staged today as a global movement and part of a globalization process, and is considered as an excellent indicator of economic, social, and cultural opportunities, 'an important lever for change, contributing to local development …' (Gentil and Servet 2002).

The number of customers has more than doubled from 2003 to 2011 (Table 2). Table 3 provides the geographical distribution of microfinance.

Microcredit model

Microcredit consists generally of short-term loans with repayments that occur as soon as the loan is disbursed. Repayment is either weekly or monthly.

The social innovation that microcredit was typically associated with was the use of an innovative mechanism in the financial world in order to reduce default risk and to avoid excluding candidates to credit: creating groups of borrowers for lending to the poor, staggered lending, progressive lending, frequent repayments, local management, compulsory savings, and training in the management of income-generating activities. While these methodologies are often associated with the Nobel Peace Prize winning Grameen Bank of Bangladesh, similar models started at around the same time in Brazil and Bolivia and even existed decades earlier in the informal sector, such as tontines or Rotating Savings and Credit Associations. Professor Muhammad Yunus, the founder of Grameen Bank, was able to create a faster social diffusion of his particular, and this helped him get, conjointly with his bank, the Nobel Prize. In this group lending model, money is lent first to two women in a group of five, and they are told that another two

Table 2 Number of people served by microcredit

	Minimum number of MFIs reporting	Customers served (millions)	Number of poorest in first loan (millions)	Numbers of women among the poorest (millions)	Percentage of women among the poorest
31 December 2003	2,931	81	55	45	82.5
31 December 2009	3,589	190	128	105	81.7
31 December 2010	3,652	205	138	113	81.9
31 December 2011	3,703	195	124		

Source: State of the Microcredit Summit Campaign Report 2004, 2011, and 2012 (Daley-Harris 2004, 2011; Maes and Reed 2012; Reed 2013).

Table 3 Number of active borrowers of microcredit

	Number of microcredit institutions	Actives borrowers (millions)
Regions		
Sub-Saharan Africa	1,009	12.7
Asia and the Pacific	1,746	169.1
Latin America and the Caribbean	647	13.8
Middle East and North Africa	91	4.3
Eastern Europe and Central Asia	73	5.2
North America and Western Europe	86	0.2
Total	3,652	205.3

Source: State of the Microcredit Summit Campaign Report 2012 (Maes and Reed 2012).

will get a loan only if the first two repay. Thereafter, if all four repay, the fifth would also get a loan. This simple mechanism coupled with some others overcame some of the problems outlined above. The use of social information available to the groups helps them seek similar kinds of members (safer ones) to overcome adverse selection. Constant monitoring of each other as well as pressure to repay helps them overcome moral hazard. The group would also provide help (advice, network) to each other so that the other members succeed and others would get a loan. The group lending consists also of granting credit to a group whose members are chosen freely and are jointly or severally liable for the repayment of all the loans to the group. If one member fails, the others are required to force her to honor the commitment, otherwise they will be the ones who will pay back in her place. Reimbursements were also more likely if the loans were collected frequently: weekly rather than quarterly. The joint liability of the group enabled social collateral to fill the absence of physical collateral. To reduce transaction costs, repayments were made by all the groups of the village at the same time, enabling the credit agent to come to a village, take the money, and then proceed to the next village. Often, loans were made to women since they were considered safer to lend to. An ancillary benefit has been the empowerment of women if this has led to them participating in society. Lending is most of the time progressive and consists of providing credit in tranches whose amount increases as the reimbursement is effective. Future loans are provided only if the previous period has been repaid.

Microcredit has been confronted with many problems and has responded by innovating: providing individual credit (once the group-based lending has permitted information gathering), nonstandard sums, providing credit to men also, and many other innovations. Moreover, since credit is only one financial service and produces stress, new innovations included the development of microsavings, microinsurance, microguarantees, microremittances, and micropayments. All of these have fueled the growth of microfinance.

The rapid growth of the microfinance sector has been accompanied by high profitability for a vast percentage of MFIs. Based on voluntarily submitted data from Microfinance Information eXchange by over 1,000 MFIs, we find that the median return on equity (ROE) is 8%, and from Figure 2, we can see that a good three-fourths (below the top curve) is profitable (ROE > 0), about half have a ROE greater than 10% (between the top two curves), and about one-tenth of all MFIs manage to obtain a return on equity higher than 40% (below the bottom curve).

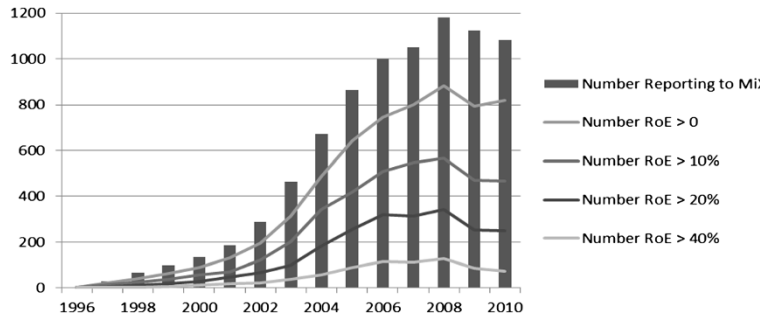

Figure 2 Return on equity of microfinance institutions. Based on MIX data downloaded on June 12, 2012.

How is lending to the poor so profitable? Part of the answer lies in high interest rates charged to offset high operating costs. Using yield as a proxy for interest rate, according to our data from the MIX, the median MFI charges 28% per annum, as shown in Figure 3, about one-fourth charge more than 40% per year, and about a tenth of MFIs charge more than 60% per year. A few outliers charge more than 80%, yielding to a lot of public and academic debate on the ethics of MFIs (Ashta and Bush 2009; Rhyne and Guimon 2007; Rosenberg 2007). At the same time, these interest rates are much lower than those of moneylenders (Eversole 2003; Armendàriz and Morduch 2005).

It is believed that interest rates in microfinance will reduce only with a reduction in operational costs owing either to competition-induced better governance (Rosenberg et al. 2009) or due to the use of innovative technologies such as cloud computing information systems, mobile banking, and online financing of microfinance institutions (Ashta 2011). Together with these technological innovations, it is believed that institutional innovations are required in public governance as well as corporate governance.

Despite this impressive growth, it is recognized that only 11% of African poor have access to microcredit, and large tracts of Latin America are also not covered (Maes and Reed 2012). According to Epstein and Yuthas (2010), it is possible that MFIs avoid areas where they believe that there are either cultures of non-repayment or because the poor lack the necessary entrepreneurial abilities. These cultures of non-repayment may be owing to factors such as individualistic (as opposed to collectivist) characteristics, attitudes towards the debt and the wealthy, and mistrust of institutions and prior

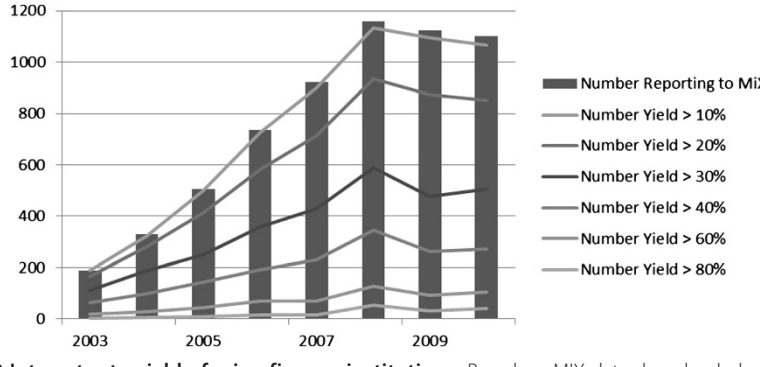

Figure 3 Interest rate yield of microfinance institutions. Based on MIX data downloaded on June 12, 2012.

governmental and nongovernmental organization (NGO) interventions involving debt forgiveness. They suggest the use of smaller groups and strengthening ties between members by encouraging them to help each other's business, thus building trust between the members, and a more personalized and closer interaction between the MFIs and the borrowers with business and capacity building activities and transparency to build trust with the MFI, thus distinguishing it from other institutions with whom the borrower may have dealt in the past.

Microcredit and entrepreneurial opportunities

Microcredit is believed to finance survival enterprises rather than entrepreneurial enterprises which are larger and better capitalized (Epstein and Yuthas 2010). Development actors want to show the potential of poor people to take entrepreneurial initiatives. Through microcredit, they want to highlight the ability of the poor to create their own business, doing their own jobs, if they are freed from the constraint of self-financing their projects. Microcredit is for the masses excluded from the conventional financial system, sometimes subject to the whims of suppliers and the dependence on moneylenders, with a hope to enable them to develop a wide range of productive activities, thus generating income, and in turn, improve their living conditions and social status.

Microcredit is characterized by a strategy based primarily on a participatory process. This process requires the active involvement of all actors in society, especially the borrowers, towards the objectives of fighting against poverty. Through this approach, the poor will find the opportunity to influence policies that are supposed to affect their lives. The philosophy of microcredit is that the beneficiaries should not be passive actors in the fight against poverty (which makes them assisted), but rather active actors, responsible for improving their living conditions. Undoubtedly, it has the characteristics of participation and empowerment that are radically different from assistantship.

However, the scope of microcredit is limited to the ability of beneficiaries to enhance the resources that are available to them. Microcredit should not give the impression that everyone is able to create, edit, manage, and develop her own business.

An evaluation of microcredit for entrepreneurship

An interesting framework for the evaluation of microcredit was provided by Zeller and Meyer (2002) who argue that successful microfinance institutions have to balance the triangle of outreach, sustainability, and impact. Outreach is often divided into breadth (number of poor people reached) and depth (vulnerability of poor people reached). As we can see, the triangle is essentially consisting of problems inherent in any double bottom line or hybrid entity: how to balance the need for high breadth of outreach and economic profitability with the need to reach the most vulnerable and have an impact in getting them out of poverty by helping them develop their enterprises.

In recent years, microcredit has come under increasing attacks from virulent academics and media. These critiques can be grouped into two major categories: the first one is mission drift and the second one is related to its lack of proven impact. We will discuss both of these as they relate to entrepreneurship.

The mission drift

The mission drift critiques are usually on diversion into consumer credit, larger loan sizes, and high interest rates. Thus, according to them, microfinance starts to resemble the existing conservative actors (banks, consumer finance, moneylenders) who perpetuate poverty by redirecting microfinance from entrepreneurship which would solve the poverty problem. The first critique of mission drift is essentially that microcredit is increasingly being used for consumer credit rather than entrepreneurial finance. This is not to say that consumer credit is bad: it may lead to positive outcomes such as consumption smoothening, food consumption, economic self-sufficiency, and some aspects of mental health and outlook, with some finding negative effects on other aspects of mental health (depression and stress) (Karlan and Zinman 2010). And of course, the dividing line between consumer finance and entrepreneurial finance is often blurred: for example, how would you place education loans or loans for professional training? An innovative method for combining education and microfinance is provided by Tooley (2007) who suggests that private education-dispensing enterprises should be formed (since public schools do not deliver) and financed by microloans.

A second critique is that even when it is being used for entrepreneurial finance, we are using it for giving loans to the near poor rather than the poorest. For example, Copestake et al. (2001) studied PULSE in Zambia and found that it targets clients who are better off than the poor. This is usually reflected in larger loan sizes. Larger loan sizes are usually applied for by those who are educated, males, those with access to bank credit, and those having assets for collateral; and MFIs grant larger loans at higher interest rates to those who have more assets, higher valued collaterals, minimal equity, effective loans, and more experience (Dutta and Magableh 2006). Often, it is not possible to expect the ultra-poor to become entrepreneurs without first giving them subsidies aimed at building their minimal capacity to enterprise (Tavanti 2013). The critique needs to be nuanced in the wake of the Microcredit Summit data indicating that 124 million of the 195 million microcredits are in fact going to the very poor. Another part of this critique is that the institutions posing as MFIs are actually financing small enterprises managed by not-at-all-poor entrepreneurs (Pisani and Yoskowitz 2004).

A third critique is that profitability motivation has led to a focus on high interest rates which siphon off the profits from the microentrepreneur to the microfinance institution, creating a feeling of deceit among the borrowers (Eversole 2003). A wave of critiques in the media and in academics took off with the successful IPO in 2007 of the microfinance MFI Compartamos which was reported charging interest rates as high as 99% per year (including VAT) (Ashta and Bush 2009; Ashta and Hudon 2012; Lewis 2008; Smith and Epstein 2007). A second much publicized IPO that attracted critiques was by SKS in 2010 in India which led to accusations that the microcredit is causing borrower stress and even suicides (Ashta et al. 2011). This led to the collapse of microfinance in Andhra Pradesh in India. The size of this state's microfinance is so important that it may largely explain the reduction in global microfinance from 205 million clients to 195 million clients (Reed 2013).

The impact of microcredit

Studies on the impact of microcredit have shown mixed results. Some show positive impact on enterprise, households as well as the community (Woller 2002; Pitt et al. 2006),

while others show no impact or mixed results. For example, Wydick (2002) finds some initial positive impact on enterprise growth in terms of revenue and employment generation from taking microcredit but stagnation in the number of employees thereafter, and those women entrepreneurs taking microcredit gain more than male entrepreneurs in terms of staying in the program as well as employment generation. Afrin et al. (2010) find that the positive impacts on successful women entrepreneurs come from microfinance institutions providing them complimentary human and human capital by teaching them financial skills and providing them a group identity. The financial skills could also have been imparted to the families of women if they were in business. Belwal et al. (2012) find that income and savings of women entrepreneurs increased after taking microcredit, but they conclude that this did not have any positive impact on their lives after loan repayment and interest. Studies on the lack of impact of microcredit focus usually on either statistical results or reasons of overfocusing on microcredit to deliver anything.

The first group consist of experimental as well as qualitative studies indicating that microcredit has no impact, no statistically significant positive impact, or that any impact which is proven is not robust from one study to another or on one indicator across geographies. For example, one study indicates that those entrepreneurs who take a second loan have usually gained in terms of profits, household income, and diversification, but those who drop out after one loan have usually suffered (Copestake et al. 2001).

The second group of studies focuses on the impossibility of credit alone to alleviate poverty. They usually focus either on the need for providing complementary capital to financial capital or on financial services other than microcredit. For example, Gomez and Santor (2001) show that the success of microfinanced enterprises is significantly determined by social capital of the entrepreneur and the neighborhood environment. Similarly, Burand (2012) would like to complement microcredit with ready-to-go microfranchise packets of desirable goods that the poor can market in their villages and communities through networks. Thus, we see the importance of social capital in marketing the products financed by microcredit, as well as the human capital of the people who designed the microfranchise packet.

Other microfinance products and entrepreneurship

To overcome the criticisms of microcredit, which could be viewed as conservative actors taking over the work of social innovators and institutional entrepreneurs to suit their own ends, it is evident that new avenues need to be explored. One response has been to indicate that for microcredit to be useful, the poor need a range of other financial products. Social entrepreneurs are therefore trying to provide these additional financial services. Evidently, if ways of diffusing other financial products to the masses can be found through social innovation, then conservative actors too could take over these innovations to suit their own ends. These new financial products include guarantees, insurance, savings remittances, and equity, as shown in Figure 4. In this part, we look at the relatively smaller literature on these aspects to see if these financial products would foster entrepreneurship and, through this, an end to poverty or whether it would merely impact consumption.

Microguarantees and entrepreneurship

Evidently, if microcredit is placing stress on microentrepreneurs, it is because MFIs do not guarantee their returns and they themselves are under pressure. This is evident as

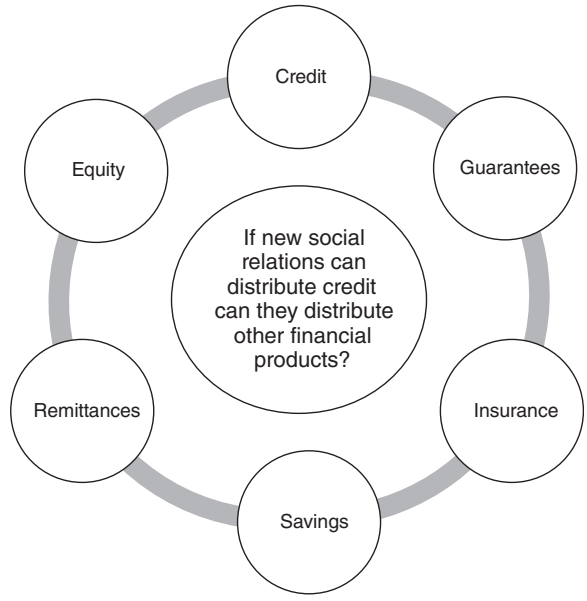

Figure 4 A range of financial products for the microentrepreneur.

the business model moves from group credit, with its inherent social guarantees, to individual lending. Thus, individual guarantees would be the first solution to the new social problem of stress in the system.

In developed countries, mutual guarantee associations or government-backed public institutions guarantee part of the banks' loans to entrepreneurs (De Gobbi 2003). This reassures the bank because often entrepreneurs are able to pay back a large part of the loan, even if they are not successful in total reimbursement. The European Association of Mutual Guarantee Societies has 34 members providing guarantees for 1.9 million small and medium enterprises (Source aecm.org 2009 statistics). This is the case for example in France of the social cohesion fund, established by the Planning Act for Social Cohesion on 18 January 2005 (Lecomte 2008). The fund has over 5 years of 73 million euros. It brings guarantee for microenterprises created by disadvantaged populations or individuals who are victims of banking exclusion. However, although such guaranteeing institutions are cropping up in developing countries, they do not have the required outreach among the poor.

Guarantees are closely related to microcredit. Part of the reason microentrepreneurs, especially poor ones, are not able to get loans is that they do not have collateral. Microfinance has used social solidarity guarantees to overcome this problem: if one of the borrowers cannot pay, someone else from the group would not get a loan or someone else from the group must pay (De Gobbi 2003).

Of course, microentrepreneurs can also get guarantees from people who do have collateral. But very often, poor people lack the bridging social capital to meet richer people who would be willing to put their assets at risk for helping out the poor. Today, thanks to technology, we see the development of websites such as UnitedProsperity.org which take cash from someone in a rich country which then serves as cash collateral for a

bank loan to a MFI and from the MFI to a poor entrepreneur, thus extending the ability of the MFI to give loans to poor people.

Microinsurance and entrepreneurship

The difficulty in mobilizing guarantees from rich people in favor of microentrepreneurs led to a search for insurance to cover the risk of default. As it became evident that business default came not only from business risk but also from personal risks of the microentrepreneur not being able to work, for example for health reasons, personal microinsurance was also desired. Insurance for the poor as mutual protection was the foundation of many insurance countries in the nineteenth century (Churchill 2007). The importance of microinsurance emanates from the limitations of conventional loan-based microcredit programs in protecting the poor from all sorts of vulnerabilities. Although microcredit has been shown to generate various beneficial outcomes, there is also evidence that not all sectors of the poor can benefit. One such group is those who experience severe health shocks, which reduce work capacity and investment and require a redirection of resources to the consumption of healthcare (Hamid et al. 2011). Due to increased evidence that microcredit does not help the poorest of the poor, welfarists stress the value of adding auxiliary services to improve the effectiveness of the programs (Hamid et al. 2011; Bhatt and Tang 2001; Woller et al. 1999; Woller and Woodworth 2001). Insurance can protect vulnerable people from risks and shocks when existing coping strategies fail.

The first noted search for microinsurance is a paper by Dror and Jacquier (1999). A notable publication is an edited publication by Churchill (2006).

Microinsurance is a program which provides insurance services to low-income populations and small businesses in developing countries. It is typically characterized as a financial arrangement to protect low-income people against specific perils in exchange for regular premium payments proportionate to the likelihood and cost of the risk involved (Biener and Eling 2011; Churchill 2007). As this definition implies, microinsurance serves the low-income population based on the same fundamentals as regular insurance (Biener and Eling 2011). A wide range of risks is covered, and products comparable to those in regular insurance markets are provided. Common types of risks covered are life, health, disability, and property (especially agricultural insurance). The particularity is that microinsurance is characterized by low premiums and low caps.

Most MFIs admit that many clients use loans to pay for medical expenses, funerals, or to smooth household cash flow. Even if they do not have an immediate emergency, some customers only invest a portion of the loan in their businesses and save the rest so that they will have a cushion to fall back on if they experience repayment problems (Churchill 2002). These assertions support the argument that in the absence of significant assets and other risk mitigation mechanisms, the poor lack the capacity to withstand the consequences of many shocks (Cohen et al. 2005). A study in Tanzania, Uganda, and Kenya shows that for the poor, the impact of a shock follows a two-step process: the immediate impact of the loss of assets and/or income and need of money, and the impact in the medium and long term that requires strategic choices coming from households, particularly in terms of resource reallocation (Barlet 2000). Thus, a shock that would prove mild to upper- and middle-income households can, in the case of a poor household, dramatically reduce assets (including stocks of physical and

human capital), reduce or eliminate income sources, lead to reduced consumption, and ultimately put present and future generations of the poor deeper into poverty. The vulnerability is directly related to the ability of households to manage risk (Barlet 2000). To cope with shocks, poor households use many different risk management strategies, including informal group-based and self-insurance mechanisms, such as borrowing, saving, and drawing down productive and nonproductive assets. A relatively new option for the working poor to manage risk is microinsurance. Indeed, for a low-income person, usually the beneficiaries of microcredit for the implementation of microprojects, microinsurance paves the way for better risk management and helps reduce vulnerabilities to shocks.

The poor are more vulnerable to risks than the rest of the population (Churchill 2007), and they are the least able to cope in case of occurrence of the crisis. Furthermore, poverty and vulnerability reinforce each other in an escalating downward spiral. The occurrence of a crisis puts particularly financial pressure on low-income persons who, moreover, suffer from the uncertainty about whether and when a loss might occur. Because of the precarious world of the poor, a shock such as illness, death of a loved one, fire, or theft can rapidly erase hard-won gains and make the escape from poverty harder to achieve (Cohen and Sebstad 2005). Based on this apprehension, the poor are less likely to take advantage of income-generating opportunities that might reduce poverty (Churchill 2007). The link between vulnerability and entrepreneurship is no longer subject to doubt. A shock plunges a person or a low-income household in a state of inactivity and therefore in poverty by the loss of labor force or by massive absorption of household resources.

Microinsurance may be either directly related to entrepreneurship or indirectly related. Examples of direct relationship with entrepreneurship include property risks such as crop insurance, cattle/livestock insurance, theft/fire insurance, and insurance for natural disasters. The reasoning is that when a farmer has insurance against downside risk, he is inclined to be more risk seeking which can pull him out of poverty. For example, if he is insured against crop failure, he can use innovative cropping strategies which may have higher yields.

Examples of indirect relationship with entrepreneurship include health and accident insurance (illness, injury, disabilities). Often, if a poor entrepreneur falls ill, he is unable to work and repay loans. As a result, his business collapses. If health insurance kicks in, he is able to survive during this critical period and continue repaying his loans. Research suggests that households that are insured against hospitalization and accidental death have less diversified income portfolios (Kwon 2010). This focus on a core business may improve profits.

No centralized agency maintains public-access documents for microinsurance. A survey in Africa (Matul et al. 2009) estimated that there were 14.7 million poor people insured in Africa, 56% of which is in South Africa. The most used insurance product was credit life insurance, i.e., an insurance which repays the debt if the insured dies.

Microinsurance may be delivered directly by insurance companies but is often packaged in ways by which it can be delivered by microfinance institutions, which are directly in contact with microborrowers. Some microinsurance programs are community-based mutualization of risk but suffer from low coverage. Two preconditions for commercial microinsurance firms to successfully sell directly to the poor is to understand how the

poor are different and have different needs and to educate the poor on the use of insurance (Churchill 2007).

A study of 600 MFIs indicated that MFIs' willingness to offer microinsurance is positively correlated to a rise in the financial expense ratio, loan repayments in arrears, years of operation, number of borrowers, woman borrower ratio, life insurance penetration ratio, and family size. In contrast, the willingness to offer microinsurance is negatively correlated with their loan asset ratio, bad loan write-off ratio or average loan size in comparison to GNI per capita (Kwon 2010).

In conclusion, improved health status may lead to higher productivity, higher labor supply, fewer workdays lost, and reduced healthcare expenditure (Hamid et al. 2011). In addition, if households are insured against health risk, they may invest in high-return riskier assets because they do not need to retain cash or to hold highly liquid assets for precautionary purposes. Microinsurance is therefore an innovation for fostering entrepreneurship.

Microsavings and entrepreneurship

One problem with insurance is that the microentrepreneur has to pay premiums, which he may not be able to afford, especially if the risk is shared only by local entrepreneurs. A cheaper alternative would be for the entrepreneurs to save money and use it when required. Savings can be useful for transactional reasons (consumption smoothening), precautionary reasons (risk mitigation) as well as speculative reasons (windfalls/opportunities). 'Saving is where financial services begin and end' (Rutherford 2001). Microsavings are the small amounts of money saved by poor people with financial institutions, mostly MFIs. They provide a source of lump sum cash in case of future events, i.e., emergencies, start-up business capital, and major life cycle events, and they support daily consumption needs of the poor people (Mersland and Eggen 2007).

MFIs have the development objective of employment creation to facilitate growth of enterprises along with poverty reduction. As financial service providers, MFIs on one hand provide loans to accelerate growth of existing enterprises and facilitate creation of new enterprises while, on the other hand, gives the entrepreneurs access to secure places for savings. With majority of the MFI clients being women, researchers inferred that credit and saving services have contributed partially towards incomes and savings of women entrepreneurs (Belwal et al. 2012). Among the poorest of the poor, the most important element of microfinance is not lending but providing savings opportunities (Collins et al. 2010). Such savings can be quite useful in the lives of the poor people as once a large amount is accumulated together, this can finance acquisition of assets, construction of houses, and more importantly, starting up community-based enterprises.

Rutherford (1999) describes three basic ways people can covert a flow of savings into a lump sum: 'saving up,' 'saving down,' and 'saving through'. Saving up is mentioned as the small accumulation of money until it reaches a lump sum; saving down refers to loans, where people save in the form of making the repayments of the loans; and saving through is either through insurance or some other group-based system where the poor people may get access to a lump sum at the time it is needed through a series of small savings. All three systems are important to promote entrepreneurial activities as financing the entrepreneurship needs of poor clients is on top of the list of financial service-providing MFIs, and this smoothens the client's income, thus helping build a sustainable livelihood (Tavanti 2010).

Empirical evidence also suggests that poor people use saving products more than they use credit. The Opportunity International Bank of Malawi has 45,000 borrowers and 250,000 savers, the Equity Bank in Kenya has 715,000 borrowers and four million depositors, and the Grameen Bank has over US$1.4 billion in deposits, which is 145% of its outstanding loan portfolio of US$965 million (Maes and Reed 2012). In a study in Bangladesh, it is found that there are 27.8 million depositors and about 20.6 million borrowers in a sample of 28 MFIs and that 26 of these 28 Bangladeshi MFIs have more depositors than borrowers (Khan and Ashta 2012). Another study has shown that only 24.5% of the services of the microfinance institutions go towards the extremely poor (Rahman 1998). Extremely poor people generally tend to exclude themselves from traditional microcredit programs, either through self-exclusion or through a process of peer screening. Self-exclusion refers to the poor people's fear of not being able to repay the loans due to different social and/or religious barriers; thus, they are not willing to borrow (Hashemi 1997). Many of the poor people are also excluded by the peer members of the traditional group methodology, where they are regarded as risky and unreliable as social collateral (Hulme and Mosley 1997). While the poor people do have their own ways of coping with vulnerability, they do so by accessing savings schemes and emergency loans to enable themselves to cover short-term crises (Hasan and Iglebaek 2004). In this process, they develop a social relationship with the microfinance institutions, where they demand to be served individually through carefully designed savings products. *Safe*Save in Bangladesh has demonstrated such relationship with its clients through the introduction of a daily collection system and service delivery at the doorstep of the clients. The basic philosophy of *Safe*Save's financial service to its clients is to give them the opportunity to save, without any mandatory requirement to borrow, unlike the traditional Grameen approach, where progressive borrowing is a precondition to access such service.

However, there are many informal sector microsavings institutions on which very little data is available. For example in Ethiopia, there are community-based organizations such as Ekub, a system of forced saving, with finance secured through traders, friends, and relatives; and Iddir, informal associations where members save for funeral costs (Belwal et al. 2012). Similarly, there are susu schemes in West Africa (Adusei and Appiah 2012). In addition, there are microfinance institutions which may require compulsory deposits as a prerequisite to providing loans.

Adusei and Appiah (2012) studied the impact of the susu scheme on entrepreneurs. Essentially, these schemes collect a small amount of savings on a daily or weekly basis and return the money at the end of the month after taking a fee. During the period, the collected sum can also be lent out with interest, but no interest is paid on the deposits. These savings then help the entrepreneur discharge his end-of-the month working capital responsibilities. Ninety-six percent of the depositors find that the susu system helps them in their business. The perceived impact of this system of microsavings on business is more for married entrepreneurs as well as for male entrepreneurs, suggesting that women use their money for their families. Moreover, the impact on business is higher the longer the people stay in the system and the more they deposit.

Entrepreneurship can generate a much stronger concentration of wealth (Quadrini 2009). In many developing countries, among many economically active poor people, technical knowledge and skills are limited, as are money management skills and access

to capital. Because of financial constraints, entrepreneurial investment depends on wealth. From this, the incentive of entrepreneurs to accumulate wealth to overcome the borrowing constraints is derived (Quadrini 2009). The propensity to save and to form solidarity groups to facilitate access to microsavings, which also gives security of the small amount of money the entrepreneurial poor accumulate over time, and combined with money management skill delivery, access to small amounts of capital for investment, links to financial institutions, business skills training, and various life skill enhancements resulted in the rapid growth of small-scale enterprises both at rural and urban settings. Again, enterprising households can have significant concentration of wealth, which could result from the high savings rates of the entrepreneurs (Quadrini 1999). Gentry and Hubbard (2004) quantified that entrepreneurial households own a substantial share of household wealth and income, and this share increases throughout the wealth distribution and the income distribution.

At all stage of business development, capital pumped in by the entrepreneur plays a key role (Chamlee-Wright 2002). The main source of finance for microentrepreneurs is personal savings (Gunu 2010). Small traders largely depend on their own savings to provide for the start-up capital, and at a later stage, they try to access alternative sources of fund to expand the business. MFIs, ROSCAs, Accumulated Savings and Credit Associations (ASCAs), and many other informal mechanisms are present globally to facilitate such access to varying financial services. Another key area of funding is remittances from migrant workers accumulated as savings. This accumulated savings and the technical skills the returning migrants gather during their stay abroad may provide the basis for entrepreneurial activities, which contribute to the economic development of their country of origin (Lianos and Pseiridis 2009). After the Vietnam War, Asian immigrants have successfully established numerous small business enterprises in US communities with the help of having access to capital through informal financial market (ROSCAs) and business counseling services (Chotigeat et al. 1991).

Although microsavings can be developed by banks, in many countries (for example, India), social innovator actors in the form of NGOs are not allowed to collect savings as this was reserved for banks. Now, in the wake of the Andhra Pradesh crisis, it is recognized that microfinance institutions need savings, and very small savings are being allowed by the central bank in the name of encouraging thrift. Thus, public policy is being used to permit social actors to get local finance to provide credit.

Microremittances and entrepreneurship

If the microentrepreneur has difficulty saving his own money, his next step for funding would be to turn towards love money from friends and family. This transfer or remittances often comes from relatives who have migrated. Human beings have migrated since the beginning of civilization. People migrate for food and security, searching better employment opportunities and income security. Today, migration does not take place only to change the destiny of migrating people but also to improve the livelihood conditions of families staying back in their home countries. This is done through remittances, which channel the migrants' income. Even when the migrants return to their home country, they bring in with them the benefits related to the skills acquired abroad and to the savings brought home by returnees with the purpose of undertaking entrepreneurial activities (Lianos and Pseiridis 2009). In 2005, the worldwide officially

recorded remittances were US$232 billion. Of this, developing countries received US $167 billion, which was more than twice the level of development aid from all sources (World Bank 2006).

Remittance is the surplus portion of earnings sent back by the expatriate community from the country of employment to the home country. Over the years, remittance has emerged as an important source of external development finance (Hasan 2006). Remittance has significant impact at the household level. This impact of remittances partially depends on the characteristics of the migrants and the recipients, i.e., whether they constitute the rural poor or the more educated sectors of the population generally residing in urban areas (Hasan 2006).

The remittances from migrants are an important source of funding for the economies of developing countries and recipient populations. There are broad segments of society who would live in extreme poverty without these resources. It is considered that these transfers have a significant impact on poverty reduction, funding for housing, education, other basic needs, and even on investment and entrepreneurship. Woodruff and Zenteno (in Amuedo-Dorantes and Pozo (2006)) estimate that 27% of microenterprises located in urban areas in Mexico rely on remittances from abroad.

In 2005, the worldwide officially recorded remittances were US$232 billion. Of this, developing countries received US$167 billion, which was more than twice the level of development aid from all sources (World Bank 2006). Total remittances have increased steadily and were US$440 billion worldwide, and of this, US$325 billion went to developing countries in 2010.

Even in a situation of economic and financial crisis in the migrants' country of residence, monetary flows tend to remain stable, unlike economic development assistance and investment. Remittances from migrants to their families in sub-Saharan Africa were US$ 21.5 billion in 2010, despite a slight decline in 2009 due to the global financial crisis, according to the *Migration and Remittances Factbook 2011* (Collection Statistics 2011 World Bank on migration and remittances). Of this, Nigeria received as much as US$10 billion, followed by Sudan (US$3.2 billion), Kenya (US$1.8 billion), Senegal (US$1.2 billion), South Africa (US$1 billion), Uganda (US$800 million), Lesotho (US$500 million), Ethiopia (US$387 million), Mali (US$385 million), and Togo (US$385 million). In terms of percentage of gross domestic product, the largest recipients in 2009 were Lesotho (25% of GDP), Togo (10.3%), Cape Verde (9.1%), Guinea-Bissau (9.1%), Senegal (9.1%), Gambia (7.9%), Liberia (6.2%), Sudan (5.6%), Nigeria (5.6%), and Kenya (5.4%).

It should be emphasized that the figures on which to base these reports do not include informal channels used by millions of migrants. These figures are therefore below the actual amounts. It is therefore essential to facilitate remittances and lower the transaction costs. It is estimated that sending funds to Africa costs on average 10% of the amount sent.

Remittances are cited as making up around 60% to 70% of recipient poor households' total income (De Bruyn and Kuddus 2005). Investment in health and education is valuable for long-term economic growth and poverty reduction. Studies have found that migrant families invested more in these areas (Murshid et al. 2002). While such investment works as an indirect contributor towards developing entrepreneurial skill, remittance acts as an enabler to develop human capital as well as direct investment in enterprise. Inflow of remittances is directly associated with a larger volume of own finance, which in turn affects the total financial size of the start-up project as well (Korosteleva and Mickiewicz 2011).

The money sent by migrants to their families facilitates investment in both productive and consumption goods, which otherwise would not have been possible due the nature of large cash involvement in such initiatives (Yang 2008). Yang (2008) also identified that when developed countries facilitate employment opportunities for workers from overseas, this contributes in stimulating human capital investment and entrepreneurship at the household levels of developing countries.

Some key elements to promote entrepreneurship could be diverse source of capital, enabling environment, policy framework, and supportive infrastructure (Pages and Markley 2004). Running a profitable business also depends largely on the skill, capacity, knowledge, and training of the entrepreneur. Application of such knowledge and skill, often, could be facilitated through accumulation of large sum of money coming in the form of foreign remittance. While much of the incoming remittances are used by recipient household for consumption, any residual after consumption may be converted into savings to be used not only for future consumption but also for investment purposes (Rivera and Reyes 2011).

Microequity and entrepreneurship

Obviously a missing ingredient to microcredit, to provide relief to the over-indebted borrower, is equity. Therefore, we should immediately see the need for supplementing the equity of the borrower through founder's equity from savings, love money from remittances, and angel investors. However, very poor people have very little savings and their social network is often too poor to provide them with love money. It is evident that they need to go to business angels, but business angels are rarely interested in projects which are as tiny as a few hundred dollars or even a few thousand dollars.

There is therefore a need for microangels. This would be a new breed of investors who would provide small amounts of capital for different motivations. Some may want profit; some may want to do good to help poor people survive. We comment briefly on four such movements: the local investment movement in France (CIGALES), slow money, socially responsible investment and impact investment, and crowdfunding.

In France, since 1983, there are investment clubs such as CIGALES (Nouvel 2004; Taupin and Glemain 2006; Russo 2007) which regroup investors who want to make alternative use of their solidarity savings in local projects. At the end of 2012, the movement has grown to 220 clubs with almost 3,000 members (an average of 13 members per club). Thus, again we see the use of groups as a social innovation, made possible through the possibility of using a legal form (indivision) which is specific to France. The average contribution of each member is 25 euros a month or 300 euros a year. For 13 members, this makes a pooled investment possibility of 3,900 euros. This money is then invested in a microenterprise. While 95% of business angels are male, it is found that more than a third of these microangels are women, 72% have a university degree, and 72% are actively employed (Estapé-Dubreuil et al. 2012). The select projects are based on social and solidarity aspects, economic aspects, as well as environmental aspects. However, the ranking of these factors may vary from region to region: for example, in Brittany there are many investment clubs financing windmills. The selection criteria for the investments also take into account entrepreneurial characteristics, of which the three most important are entrepreneur's motivation, level of understanding shown by the team presenting the project, and social and solidarity motivations (Estapé-Dubreuil et al. 2012). The movement grows especially in

times of crisis when local solidarity needs are felt more. However, ideological, motivational, institutional, and communication difficulties have kept the movement from growing further (Ashta and Hudon 2012).

One way of overcoming the high costs of diffusion of information is to use the internet. The slow money movement in the USA is regrouping investment funds which want to invest in local projects, often linked to slow food and artisans (Tasch 2009). These investments are usually patient, agricultural-related, local, and small. Thus, the objective enshrined in the CIGALES movement is being diffused today in the USA (Ashta and Bratu 2013). However, the investment funds are much larger and investing in socially and environmentally desirable projects of a larger size (Ashta 2013a). This would then be using a technological innovation (the internet) and transposing a social movement (slow food) to create a parallel innovation.

In fact, the funds registered on the slow money movement resemble largely the funds in impact investment which could be considered as related to socially responsible investments. Recognizing that there are a lot of investors who want to get an impact bang out of their investment buck, a whole new asset class of impact investments is being made to encourage investments in entrepreneurial projects which would lead to high impact all over the world (Freireich and Fulton 2009). Examples include Aavishkaar, Acumen Fund, and Root Capital. As opposed to socially responsible investments which seek near-market returns but filter out undesirable sectors, impact investors tend to be social investors seeking to get their money back with a low return to cover inflation. However, most of these impact investments are too large to finance small entrepreneurs directly and are financing instead the microfinance institutions. They are therefore close to dedicated microfinance investment vehicles, such as ResponsAbility funds or Blue Orchard which also finance microfinance institutions. Thus, innovation is more one of targeting people with noneconomic motivations to invest in socially desirable sectors.

Can technology go further than mere diffusion of information and break this barrier and allow for wider investment possibilities directly into microentrepreneur projects? Crowdfunding websites are emerging to allow small investors to participate in financing microentrepreneurial projects. Today, there are over 300 such websites with a new one being started every other day. There are 24 such websites in France alone according to the Association Financement Participatif France. While many of the crowdfunding sites are

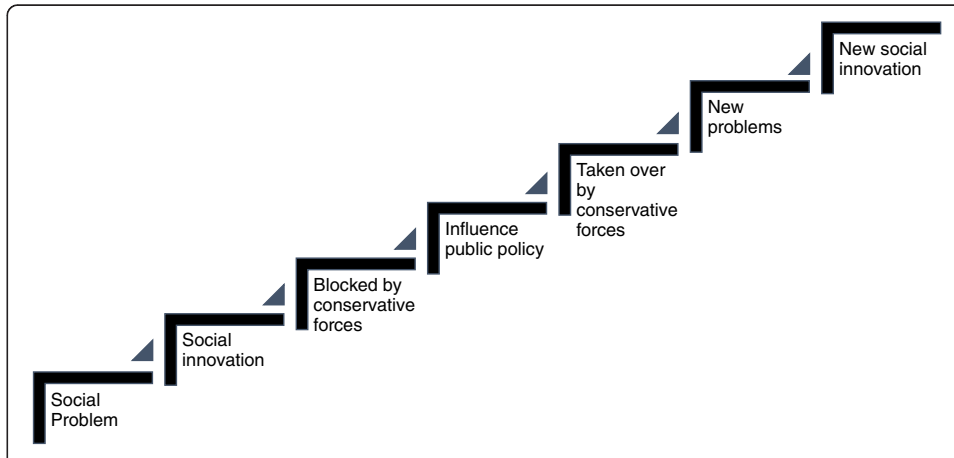

Figure 5 Dialectics in the social innovation process.

still offering only possibilities to donate (Kickstarter in the USA and MyMajorCompany in France) or lend (Kiva in the USA and Babyloan in France), some are offering possibilities to offer equity (WISEED in France). The legality of such equity offerings is not clear, but ingenious means are being taken to circumvent laws which do not allow a small entrepreneur to ask the public for equity funds without the permission of the regulatory watchdog, which wants to protect the small depositors. Clearly this is a radical innovation, specifically one of creating an ecosystem.

Conclusions

Microfinance has come out with a number of financial products to satisfy an unserved market through innovative distribution. The market was unserved because the size of the products was too large, entailing high costs and high risks for financial institutions. By reducing the size of the product and by distributing it through new channels, microfinance has effectively created an innovation. Moreover, microfinance has shown the entrepreneurial potential of the poor and their ability to create their own jobs. It is therefore an innovation that fosters entrepreneurship which allows recipients to develop a wide range of productive activities that generate revenues.

Microfinance is evolving both as a social institution as well as in utilizing new technologies such as cloud computing information systems, mobile banking, and online financing of microfinance institutions for the development of its outreach (Ashta et al. 2011). Many of the financial services being targeted to the poor, including microsavings, microinsurance, remittances, and government-to-poor payments, are based on innovative institutional creation. All of these represent areas for future research.

Our paper has presented an application to illustrate the dialectics in the social innovation process as presented in Figure 5. The entrepreneur lacked financing since the banker did not trust him. This social problem was solved by social innovations presented in microcredit. These social innovations were blocked by conservative forces at a local level. To influence public policy, the social entrepreneur therefore needs to attract public policy support, including donors and regulators. Once social innovation is proved successful, banks and other for-profits can take over the microcredit movement. However, their use of this leads to new forms of stress for the microenterpreneur. This in turn requires new social innovations to provide services such as microguarantees, microinsurance, microsavings, microremittances, and microequity.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
AA drafted the microcredit and microequity sections, MC drafted the microinsurance and microguarantee sections, ASMM drafted the microsaving and microremittances section. All authors reviewed and added to each others' sections and participated in the full paper.

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Women-owned family businesses in transitional economies: key influences on firm innovativeness and sustainability

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Abstract

This research presents an examination of familial influence on strategic entrepreneurial behaviors within a transitional economic context. Utilizing a large sample of women-led family businesses, the study investigates the relationships between risk-taking propensity, entrepreneurial intensity, and opportunity recognition of the entrepreneur and the innovative orientation of the firm and sustainability. A model of the influences on innovativeness and sustainability in family firms is developed, and the potential contribution of the present study is the identification of constructs that facilitate these strategic outcomes and behaviors that drive growth. The degree to which family firms can create new products, services, and processes that add value to their marketplace can strongly influence their sustainability, especially in an emerging economy.

Keywords: Family business; Women entrepreneurs; Innovation; Sustainability; Emerging economy; Opportunity recognition

Background

Research conducted within the transitional economies of Central and Eastern Europe has shown that models of entrepreneurship have high transferability to these cultures (Gibb 1993; Gundry and Ben-Yoseph 1998; Kickul et al. 2010). Entrepreneurial firms are at the forefront of economic development in emerging economies (Neace 1999); as such, the influences on the growth and sustainability of these enterprises are of research and public policy interest. Numerous studies identifying the success factors of small and medium-sized enterprises (SMEs) have been conducted in developed countries (Anna et al. 2000; Chaganti and Parasuraman 1997; Lerner and Almor 2002). However, more research utilizing rigorous scientific approaches is needed (Tkachev and Kolvereid 1999).

The study on women entrepreneurs and women in family firms can trace their start to the mid-1980s (Carsrud and Olm 1986; Hagan et al. 1989; Chrisman et al. 1990). Since that time, there has been an increasing interest in women entrepreneurs and the challenges they faced in developed economies (Marlow 1997; Carter and Allen 1997; Baker et al. 1997; Berg 1997; Cole 1997). The presence of women leading small and entrepreneurial organizations has had a powerful impact on the global business landscape and employment (Minnitti et al. 2005; Diana Project 2005). However, research

on women entrepreneurs in transitional economies is less developed (Tkachev and Kolvereid 1999), and the positive impact of female entrepreneurs is not always recognized to the same degree by countries in transition (Welter and Smallbone 2010). Scholars have acknowledged that with regard to gender and entrepreneurship, policymakers and financial experts in any particular country should not uncritically rely on research results from other countries (Eriksson et al. 2009; Welter 2011). Bruton et al. (2008) pointed out a need to develop a deeper understanding of entrepreneurship in emerging economies. Furthermore, the lack of information on successful female entrepreneurs, especially running family firms, is especially apparent.

The study extends previous work by using a large sample of women-led family businesses in order to examine familial influence on strategic entrepreneurial behaviors, including opportunity recognition and innovativeness. This study examines whether family influence affects the relationships between risk-taking propensity, entrepreneurial intensity, and opportunity recognition of the entrepreneur and the innovative orientation of the firm and sustainability. The degree to which family firms can create new products, services, and processes that add value to their marketplace can strongly influence their sustainability, especially in an emerging economy.

This paper is structured as follows: first, we discuss family firms in entrepreneurship research and the usage of family and gender as explanatory variables. Next, family business research within transitional economies is discussed, with focus on the Russian context. The theoretical constructs employed in this research are summarized, and the research model is presented. The 'Methods' section with description of the sample, research instrument, and operationalization of the constructs is followed by results of the analysis and discussion, and implications for future scholarship and practice in this area.

Family firms and entrepreneurial research

The academic study on family business is usually tied to the founding of *Family Business Review* in 1987 (Carsrud and Brännback 2012). The characteristics, capabilities, and resources of family firms can influence entrepreneurial orientation, including innovation and risk-taking behaviors (Zahra 2005), making family firms an excellent context in which to examine entrepreneurial processes (Zahra et al. 2004; Dyer 2006; Naldi et al. 2007; Nordqvist et al. 2008). Furthermore, as noted by Naldi et al. (2007), more research is needed on the relationship between entrepreneurial orientation and firm outcomes within family firms.

Research on family firms also has tended to focus on male founders and successors (Hall et al. 2001; Steier 2001), while many other topics have been largely ignored (Carsrud and Brännback 2012). Perricone et al. (2001) have shown that most successors are first-born males. However, the empirical study on leadership in family firms remains largely understudied (Renko et al. 2012). Family business research continues to lack unified theories (Carsrud and Brännback 2012) but is still identified by a few key themes such as succession, intergenerational conflict, growth, and corporate and family governance (Miller and Le Breton-Miller 2003; Sonfield and Lussier 2004; Carsrud and Brännback 2012). The field of family business cannot even agree on a definition of what constitutes a family business or even a family (Carsrud et al. 1996;

Chrisman et al. 1996; Chua et al. 1999; Carsrud 2006; Carsrud and Brännback 2012). If the study on women entrepreneurs and women in family businesses is to advance, more empirical research needs to be done based on both existing research and well-tested theories that can work across genders and using objective and measurable operational definitions of concepts.

Using family and gender as explanatory variables

To understand *family* as an explanatory factor in entrepreneurial family firms in transitional economies requires looking at the relationship between two systems (*family* and *firm*). Here is where the concept of *family influence* (Habbershon et al. 2003) can provide both a theoretical basis and research evidence. This concept can be of use in understanding women-led family firms and the attractiveness of such firms in terms of social, human, and financial capital (Carter and Rosa 1998). While such an approach has its merits, it still suffers from the attempt to turn essentially a loosely defined demographic variable (family) into a causal factor. Is family really a unitary concept or is it in fact a multi-faceted term that serves as a quick reference for a variety of factors such as generations, values, religion, ethnicity, culture, etc.? In other words, when one uses the term family, one is subsuming a number of factors within that term. Is the impact of family or family influence due to values, cultural background, organizational structure, the number of family members in the firm, who leads it, or the number of generations involved (Carsrud and Brännback 2012)? To advance social science, one needs to add precision to the definition of family influence and family as they are most likely multi-dimensional variables for purposes of research studies. The current study is limited to the definition provided by the subjects' self-reports. While this may limit the generalizations and explanations available from the current study, if individuals self-identify as a family firm, then one can assume they perceive family to be an important influence, or identity, in the firm.

Family context may have a special importance for women entrepreneurs. Recent literature suggests that for women, work-life balance is a more complex and demanding task, involving family embeddedness as the main issue (Brush et al. 2009). Jennings and McDougal (2007) suggested the term 'motherhood' as a metaphor representing the household/family context. Brush et al. (2009) argued that motherhood or family/household contexts might have a larger impact on women than men, while Welter and Smallbone (2010) illustrated that this context might be very different depending on the country of operation. For example, in a recent study of entrepreneurial intentions in two developed and two developing countries, it was found that the highest barrier for starting a business is indeed risk related (Iakovleva et al. 2013). However, that was not the case for developing countries, where risk barrier was ranked second or third. It was concluded that in more turbulent environments, people generally rely less on government or existing jobs. Thus, risk relating to owning and running a business is perceived lower in comparison with developed countries, where being an employee provides far more benefits and security. In their study of Russian and Ukrainian women entrepreneurs, (Iakovleva et al., unpublished work) found that developing countries often do not provide the same institutional conditions for working women during their maternity leave. This reduces the benefits of being employed in relation to running a

business, which provides more flexibility. This might have direct implications for the models explain behavior of family-owned firms as well, where it is often suggested that such firms are less risk oriented based on the results of empirical findings from developed countries. Thus, in the present study, we suggest using gender as a lens to explore behavior of female entrepreneurs in family-owned firms.

Family business research in transitional economies

The generalization of existing entrepreneurship research findings outside developed nations (Carsrud 1992) remains lacking despite the impact of the Global Entrepreneurship Monitor (GEM) Project (Minnitti et al. 2005). The current study bridges this gap by including women-headed organizations self-classified as either family or non-family businesses in the rural parts of a country in transition to a market economy - Russia. Research in Central and Eastern Europe show current models of entrepreneurship, and new venture creation strategies may be transferable to these transitional economies if a holistic approach is used to facilitate learning and development (Gundry and Ben-Yoseph 1998). While Chrisman et al. (2002) and Carsrud et al. (2007) suggest that the family may have a strong influence on perceptions and performance of the firms they own and manage, questions remain (Carsrud and Brännback 2012). To what extent does this family influence translate into differences in entrepreneurial orientation, including risk taking, entrepreneurial intensity, opportunity recognition, and innovation strategies deployed by the business? How do these in turn impact sustainability of the firm, and are these different in transitional economies? These are the key questions to be examined in the present study.

Entrepreneurship in the Russian context

Entrepreneurs in a transitioning economy may face continuing challenges and obstacles, including unpredictable and often hostile external environments, and resource scarcity, especially financial resources (Smallbone and Welter 2001). Research on entrepreneurship in transition economies over the last two decades has included research on start-ups in Poland (Erutku and Vallée 1997), venture capital in Hungary, Poland, and Slovakia (Karsai et al. 1998), as well as studies on the growth of women-owned firms in Turkey (Esim 2000; Hisrich and Ozturk 1999) and entrepreneurs in India (Mitra 2002).

In comparison to other transition economies such as India and China, the development of the small business sector in Russia has been somewhat slower (Verkhovskaya et al. 2007). For example, the number of SMEs per 10,000 inhabitants is 6.0 in Russia (Zhuplev 2009). By comparison, in the EU, there are approximately 30 registered SMEs per 10,000 inhabitants.

In part, this is explained by the operating environment for entrepreneurs and small businesses that can involve extensive bureaucracy, corruption, weakly developed financial markets, and poor governmental support mechanisms for beginning entrepreneurs (Karhunen et al. 2008; Verkhovskaya et al. 2007). In addition, poor management, a lack of knowledge and experience, and the culture of market relations hinder the development of entrepreneurship (Kickul et al. 2010; Iakovleva et al., unpublished work). Russia's transition from a centrally planned to a market economy began in the early 1990s (Ogloblin 1999). Twenty-plus years later, SMEs in Russia are a key part of the country's sustainable

economic development. SMEs constitute 20-25% share in GSP with high growth potential forecasted (European Investment Bank, 2013).

During the past decade, positive changes in relation to entrepreneurship support systems and funding opportunities have been observed in Russia. In recent Russian banking history, there were two periods when banks targeted SMEs and entrepreneurs. The first period was in the late 1990s, when the European Bank for Reconstruction and Development mostly granted credit to micro and small businesses. However, in 2000 this program was closed. Nearly 10 years later a new wave targeting small business began, and today banks offer a wide range of services, including loans, for the SME sector. However, the interest rate for loans is quite high, and many start-ups chose to use other, informal, sources of funding (Iakovleva et al. 2013). Although few in number, there are programs to support entrepreneurs with venture capital, mortgages, or business incubation. One example is non-repayable subsidies of 300,000 RUB (approximately equivalent to 7,000 euros) to start a business. For SMEs at the development stage, there is, for example, a special program to cover the first lease payment or leasing interest for those who need equipment. To support innovation, there are programs covering patent payments, certification, or R&D costs. There are also programs at the federal level intended to promote a positive image of entrepreneurship. For a country with no tradition of entrepreneurship, it is important that people understand that business owners create work places, attract investment, and pay tax. However, there is an absence of any programs or initiatives to promote women entrepreneurs in Russia. Also, when it comes to funding availability, banks do not differentiate on gender; rather, the payment history and general business conditions are estimated (Iakovleva et al. 2013).

Most Russian entrepreneurs are between 30 to 50 years of age (Wells et al. 2003; Turen 1993); 70% to 80% have higher levels of education (Babaeva 1998; Wells et al. 2003). Women entrepreneurs in Russia have yet to follow worldwide trends similar to those found in other national studies on women entrepreneurs. By various estimates, the enterprises managed by women provide 50% to 52% of the national GDP in Germany and in the USA, 52% to 55% in Japan, and 57% to 60% in Italy (Gorbulina 2006), suggesting that women in these countries are fairly well integrated in economic development. However, in Russia it is estimated that women entrepreneurs only represent 30% to 40% of the total. According to Ylinenpää and Chechurina (2000), societal limitations in other fields may ultimately serve as factors propelling women to enter the entrepreneurial sector, where starting new ventures serves the dual purpose of generating additional family income and increasing self-fulfillment. However, it is clear that they have yet to achieve the percentages found in more developed economies.

In the current market economy, those women entrepreneurs have adapted and sought to acquire knowledge and information rapidly. As noted above, Russian women generally have a high level of education and many possess more than one degree from institutions of higher education. This characteristic, along with the ability to establish relationships, leads to steadier levels of employment and higher income generation in women-owned companies (Gorbulina, 2006). First-generation Russian women entrepreneurs succeeded in a highly dynamic environment in the transition to the market economy. As economic conditions stabilize, new opportunities are emerging for women (Kickul et al, 2010).

Since entrepreneurial businesses first emerged following the fall of the Soviet Union, first-generation Russian women entrepreneurs have succeeded in a highly dynamic

environment in the transition to the market economy. As economic conditions stabilize and new opportunities emerge for these entrepreneurs, the ability of firms to survive and grow requires an entrepreneurial orientation. The present study expands previous work to propose a theoretically driven model exploring the role of entrepreneurial orientation in the innovation and sustainability of women-led family firms in a transitional economy.

Entrepreneurial orientation in family firms: the roles of risk taking, entrepreneurial intensity, and recognizing new opportunities for innovation

Organizations that exhibit an entrepreneurial orientation tend to engage in risk-taking behavior, including incurring debt and making large resource commitments with the expectation of high return (Lumpkin and Dess 1996). Casillas and Moreno (2010) studied the influence of family involvement on entrepreneurial orientation and growth, and results showed that family involvement increases the influence of innovativeness on growth and, at the same time, decreases the influence of risk taking on growth. In the family business context, researchers have found that family firms are less inclined to undertake risk, perhaps because the survival of the firm is of utmost importance; this seems to be especially true in emerging and underdeveloped economies (Zahra 2005; Gomez-Mejia et al. 2007).

While entrepreneurs are likely to be committed to their entrepreneurial endeavor, some entrepreneurs can be characterized as having a single-minded focus to work towards the growth of the venture, often at the expense of other worthy and important goals - known as entrepreneurial intensity. In a study on entrepreneurs in high- and low-growth firms, intensity was found to discriminate among entrepreneurs on the basis of actual growth rates: high-growth entrepreneurs were significantly more motivated to do whatever it takes to grow their enterprises and ensure new venture success (Gundry and Welsch 2001).

Opportunity recognition in the context of family firms

The motivation of the entrepreneur has been shown as an important factor associated with superior firm performance (Carsrud et al. 1989; Carsrud and Brännback 2011); static personality characteristics and other individual traits have not been proven less effective at predicting performance (Sandberg and Hofer 1987). The ability to identify opportunities is very valuable for entrepreneurs as they are able to recognize and develop market opportunities, strengthening the competitive advantage of their firms (Chandler and Hanks 1994; Carsrud and Brannback 2007). Opportunity identification involves identifying new market opportunities for products and services, discovering new ways of improving existing products, and forecasting customers' unmet needs (De Noble et al. 1999). Opportunity recognition is a process of perceiving a possibility to create a new business or to significantly improve the position of an existing business, and in both cases, new profit potential emerges (Christensen et al. 1994).

Similarly, innovativeness is perceived as a highly relevant component of entrepreneurial orientation in the family firm context (Nordqvist et al. 2008; Zellweger and Sieger 2012). Innovation can be defined as the effective application of new products and processes designed to benefit the organization and its stakeholders (West and Anderson 1996;

Wong et al. 2009). According to Damanpour (1996), innovation is a means of transforming an organization in response to changes in the external environment or, proactively, to influence the environment. Based on a multidisciplinary analysis, scholars recently proposed an integrative definition of innovation as a multistage process in which firms transform ideas into new or improved products, services, or processes to compete and differentiate themselves in the marketplace (Baregheh et al. 2009).

Researchers have postulated that family firms tend to have a longer-term orientation and, thus, may have well-developed entrepreneurial strategies for innovation, especially if the entrepreneur has a strong orientation towards innovativeness and can make decisions more rapidly given the structure of the family firm (James 1999; Mustakallio and Autio 2002; Zahra et al. 2004; Casillas and Moreno 2010). Entrepreneurial innovativeness can be directed towards achieving specific firm outcomes, including sustainability. Given the general long-term orientation of family firms, it is of research interest to investigate the influences of entrepreneurial orientation and firm innovativeness on the sustainability of a family-led organization.

Sustainability

Sustainability is often described as a measure of an organization's ability to fulfill its mission and serve its stakeholders over a longer period of time and to have a recognizable and measurable impact. Improved sustainability can lead to broader sources of funding and enhances the firm's ability to provide value over an extended period of time (Bryson 2004; Carsrud and Brännback 2010). The process of achieving sustainability is designed to achieve specific, identifiable goals toward a specific impact and not an end into itself. Sustainability involves all the elements and functions of an organization and every major decision made within the organization (Chen and Singh 1995; Bryson 2004; Carsrud and Brännback 2010). Sustainability has been characterized by capacity and adaptability (York 2012). There are four components of a sustainable firm: (1) the adaptive capacity to monitor, assess, and respond to both internal and external changes; (2) the leadership capacity to make decisions and to provide the direction necessary to achieve the organization's goals; (3) the management capacity to employ resources efficiently and, typically, in a resource-constrained environment, and (4) the technical capacity (skills, experience, and knowledge) needed to implement the programmatic, organizational, and community strategies (Bryson 2004; Carsrud and Brännback 2010; York 2012).

A firm's focus on sustainability leads to a greater emphasis on long-term viability and impact, and it relies on an approach to innovation that effectively applies new processes in ways that benefit the stakeholders of the organization (West and Anderson 1996; Wong et al. 2009). By introducing innovative processes and practices, sustainable organizations are able to adapt to challenging scenarios and can operate in resource-constrained environments (Carsrud and Brännback 2010).

Research model

The present study focuses on a large sample ($N = 310$) of Russian female entrepreneurs heading family firms. Previous research indicates that Russian women often attribute their entrance into entrepreneurship to 'push' factors, such as the need to generate

family income and create an arena for self-fulfillment (Minnitti et al. 2005; Reynolds and White 1997), and they are able to identify growth opportunities (Iakovleva and Kickul 2007). Although some of the findings in the literature discussed above regarding growth orientation and innovativeness of family firms are sometimes contradictory, we suggest that the turbulent environment of the Russian economy provides stimulus for women entrepreneurs to perform opportunity-oriented behavior. Previous research has shown that risk taking, among other proactive behaviors, and innovativeness influence growth in family firms (Casillas and Moreno 2010). Based on the above discussion, risk-taking propensity and entrepreneurial intensity leading to opportunity recognition are important antecedents of innovativeness which in turn is seen as key to obtaining firm sustainability. The following research model is proposed (Figure 1).

A potential contribution of the present study is the identification of constructs that facilitate innovativeness and firm sustainability in these family businesses. These are depicted in the model below. This approach may help practitioners and policy makers formulate and implement new strategies and programs supporting women entrepreneurs. These findings are especially important to the discovery of ways to support female-led family businesses within turbulent transition economies as they innovate and achieve sustainable business performance.

Results

Descriptive statistics and intercorrelations among the study variables are provided in Table 1. As mentioned, the model was tested using SEM. The fit statistics for our proposed model suggested an adequate fit to the data (χ^2 (5) = 33.50, goodness of fit index (GFI) = .96, comparative fit index (CFI) = .90, incremental fit index (IFI) = .90).

Table 2 presents the total, direct, and indirect effects of risk-taking propensity and entrepreneurial intensity on the endogenous variables in the model. The total effects match the standardized regression coefficients derived from regressing an endogenous variable on risk taking and entrepreneurial intensity. As displayed in Table 2, the significant risk taking and entrepreneurial intensity total effects were completely indirect based on our model as they were transmitted through opportunity recognition and innovation. Mediation would be supported if the fit of the model would not be improved by the addition of direct paths from risk-taking propensity and entrepreneurial intensity to sustainability. The addition of these paths did not improve the model fit. This indicates that personal characteristics such as risk taking and intensity are factors

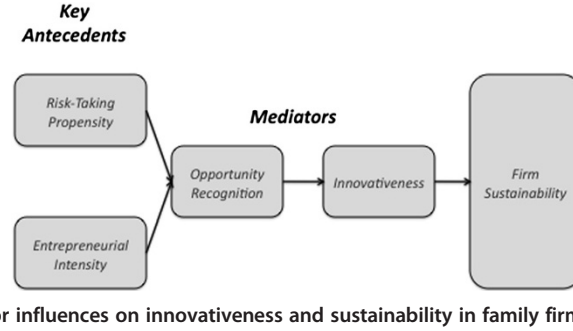

Figure 1 Model for influences on innovativeness and sustainability in family firms.

Table 1 Means, standard deviations, zero-order correlations, and reliabilities of measures

Variable	Mean	SD	1	2	3	4	5
1. Risk-taking propensity	4.46	2.21	(.89)				
2. Entrepreneurial intensity	6.26	1.83	.13*	(.88)			
3. Opportunity recognition	7.65	2.36	.32**	.36**	(.63)		
4. Innovation	4.27	1.91	.29**	.15*	.37**	(.77)	
5. Sustainability	(—)	(—)	.16*	.16*	.39**	.49**	(.95)

Firm sustainability measure was standardized. *$p < .05$; **$p < .01$. Dashes indicate data are not applicable.

only as they impact opportunity recognition and innovation. To illustrate, with a model that includes direct paths from risk taking and entrepreneurial intensity to sustainability, the chi-square dropped by only 2.88 (2 degrees of freedom), and the other fit statistics (e.g., GFI, CFI, IFI) were virtually unchanged. Mediation was therefore supported - the effects of risk taking and entrepreneurial intensity on sustainability were mediated by opportunity recognition and innovation. This notion that 'personality and motivational factors' operate via other behaviors to impact firm performance has been found previously (Carsrud et al. 1989; Carsrud and Brännback 2011).

Unlike much previous research on family firms which typically show reduced levels of risk taking, the current findings revealed that Russian female entrepreneurs within family firms exhibited both risk-taking attitudes and an entrepreneurial intensity. These then led them to seek and find new opportunities and implement these opportunities and innovations for the marketplace. It is possible that the current research is reflecting the early stage of these ventures, but it does challenge the notion that family firms are less risk oriented. The findings revealed that both opportunity recognition and innovativeness fully mediated the relationship between risk taking and entrepreneurial intensity and firm sustainability, that is, these key antecedents leading to venture sustainability of a venture were consistently structured, valued, and in place for these women-led family firms.

Discussion

While this study clearly needs to be replicated with other samples of female entrepreneurs running family-owned firms within emerging economies, this study has allowed a

Table 2 Direct, indirect, and total effects

	Effect		
	Total	Direct	Indirect
Risk-taking propensity			
Opportunity recognition	.30**	.30**	
Innovation	.09		.09
Sustainability	.14		.14
Entrepreneurial intensity			
Opportunity recognition	.42**	.42**	
Innovation	.13		.13
Sustainability	.19		.19

*$p < .05$; **$p < .01$. The effects are controlling for the other effects in the models.

view into what drives sustainability and growth in new family firms run by women in an emerging economy. It is certainly possible that the cultural context in this study, Russia, does have an impact on the risk taking being displayed and subsequent impact on opportunity recognition and innovation. For example, a culture that does not prize innovation may therefore not see this as important behaviors to exhibit even if it is important to subsequent entrepreneurial performance and firm sustainability. The Russian culture has certainly prized education and scientific innovation; therefore, one would expect that risk-taking attitudes would be found to impact firms via innovation, given the cultural support for such behaviors.

It is interesting to explore the extent to which our results correlate with findings from other research. Although Hofstede's measures of uncertainty avoidance are quite high for Russia with a value of 95 compared to the average of 50 for developed countries (Hofstede 2001), other research asserts that Iakovleva this general measure does not indeed reflect risk in relation to establishing or operating a business. In fact, it was found that start-up intentions are higher in developing countries (Iakovleva et al. 2011) and that risk is perceived as a higher barrier in developed countries (Iakovleva et al., unpublished work)). Thus, although Russia is relatively low with regard to the measurement of total entrepreneurial activity[a] (TEA = 4.6) in comparison to an average of 14.1 for factor-driven economies (Bosma et al. 2011), risk is perceived as a less important barrier in comparison to financing (Iakovleva et al., unpublished work). Our findings from the present research confirm positive propensity toward risk taking among Russian family businesses.

This paper adds to the literature on the impact of cognitive/psychological factors of entrepreneurs. It shows that the impact is not direct as many early researchers proposed and yet were unable to demonstrate (Sandberg and Hofer 1987), but in fact operate as indirect influences on firm performance as proposed by Carsrud et al. (1989) and Carsrud and Brännback (2011). This shows that risk taking and intensity are critical to subsequent opportunity recognition and innovation. Those factors in turn are critical to firm sustainability. The implications of this research suggest that entrepreneurs can be encouraged to undertake appropriate risks, even in environments where obstacles exist, as a means to embrace opportunities in the marketplace. If they do so effectively, they contribute to the sustainability of their organizations. More work is needed here to promote the development of entrepreneurial instruction and support programmes towards this goal, helping entrepreneurs identify and pursue objectives critical to sustainability of their ventures.

This paper adds to both our understanding on family-owned firms and family firms owned and managed by women. It is clear that in the Russian context of the early twenty-first century, such firms' sustainability is impacted by the risk-taking attitudes and entrepreneurial intensity of their women leaders. This may be due to the nature of that particular emerging economy, as these findings support the recent comparison between developing and developed countries (Bosma et al. 2011; Iakovleva et al. 2011). However, our findings also suggest that in newer family firms run by women, opportunity recognition and innovation are critical to survival and growth. A recent study on Russian female entrepreneurs suggests that they often need to be very competitive and make bold decisions, and the challenge of being women in a turbulent environment adds to the necessity for taking calculated risks (Iakovleva et al. 2013). The present

study shows that Russian women are very capable of exhibiting those behaviors in order to sustain their self-identified family firms. The traditional myth of risk aversion often seen in more established economies and firms may not hold in emerging economies, with family firms headed by women. This is an example of the kinds of myths and assumptions that family business researchers need to challenge and which can only be done by looking beyond the traditional samples in Western developed economies with large established family firms (Carsrud and Brännback 2012).

Conclusions

Examining the influences on innovative behavior in family firms can contribute to our understanding on how these businesses strategically prepare for, and implement, new innovations for sustainability. Without overstating our results, and underscoring that additional research needs to be conducted to further the work in this field, the , inclusion of a large sample of female-led family businesses adds to the growing body of literature on the role and contribution of women business owners to the global economy, and to their families and communities in particular, something long called for by academics (Hagan et al. 1989). If entrepreneurship and family firms are critical to all economies - both established and emerging, then more research like this which examines variables that impact those firms must be done, especially in emerging economies not only in Eastern Europe and Russia, but also in Africa.

The ever evolving competitive environments in transitional economies render seemingly sustainable strategic advantages obsolete. Instead, competitive advantages arise from a family firm's capability to constantly redeploy, reconfigure, rejuvenate, and innovate their capabilities in responding to the changing environmental conditions.

Methods

Participants were entrepreneurs of 310 Russian women-led family firms. The data were obtained from the Russian Women's Micro-financial Network (RWMN). The mission of the RWMN is to support the development of sustainable women-focused, locally managed microfinance institutions (MFIs) throughout Russia by creating an effective financial and technical structure that provides high-quality services to partner MFIs over the long term. RWMN operates in six regions in Russia: Kostroma, Tver, Kaluga, Belgorod, Vidnoe, and Tula, with the head office in Moscow. Each division is an independent local organization that provides micro loans for clients, with no less than 51% of clients being women.

The survey was pretested with the assistance of seven native-speaking Russian women entrepreneurs who commented on each question. Data were collected by the workers of local divisions during face-to-face interviews with respondents. Descriptive statistics are presented in Table 3. The sample mainly consists of sole proprietorships with 94% of businesses having no more than ten employees (and 60% having just two employees), being woman-led and woman-owned (95%), operating mainly in the service industry (80%), with 56% of the enterprises self-reporting as being family businesses. This profile differs from the typical Russian SME profile with regard to gender, educational background, industry structure, legal form, number of employees, and family

Table 3 Participant characteristics

Variables	Number	Percent
Respondents		
Average respondent age	40 years	
Higher education - yes	252	49
Entrepreneurial experience of relatives - yes	76	14
Enterprises		
Independent business - yes	24	96
Family business - yes	310	56
Average firm age	8	
Average number of employees	4	
Industry		
Manufacturing	28	5
Trade and catering consumption	442	80
Service	81	15

business issues (Iakovleva 2005; Bezgodov 1999). One might consider these as early-stage, small family firms.

Firm sustainability was based on measures by Chandler and Hanks (1994) and Westhead et al. (2005). Respondents were asked to indicate the degree of importance their enterprise attached to the following items over the past 3 years: sales level, sales growth, turnover, profitability, net profit, gross profit, and the ability to fund enterprise growth from profits. Then they were asked how satisfied they were with the same indicators over the past 3 years. The questions are those slightly modified versions used by Iakovleva (2005) based on those from Chandler and Hanks (1994) and Westhead et al. (2005). The questions were transformed after consulting with Russian entrepreneurs to assure clarity of the meaning of the questions. Based on these 14 questions, a composite firm sustainability index was constructed following the principle used in expectancy theory and later in the theory of planned behavior (Ajzen 1991). Questions about importance were rescaled from a 7-point Likert scale (1 to 7) to a –3-to-3 scale, and then satisfaction and importance scores were multiplied. A principal component analysis was then done, which resulted in one factor which we called firm sustainability (please see Table 4 for additional analyses).

Risk-taking propensity was assessed by taking two items taken from Miller and Friesen (1982). The items were rescaled to a 7-point one-sided Likert scale to be in the same format as the other questions: 'owing to the nature of the environment, bold, wide-ranging acts are viewed as useful and common practice', and 'we have a strong proclivity for profitable, but risky, projects.'

Entrepreneurial intensity is the degree to which entrepreneurs are willing to exert maximum motivation and effort towards the success of their venture. The Entrepreneurial Intensity scale was adapted from the Entrepreneurial Profile Questionnaire, successfully implemented in a variety of research sites in the USA, Mexico, Russia, Poland, Romania, and Hungary (Pistrui et al. 1998; Welsch and Pistrui 1993 ; Welsch and Roberts 1994). A sample item measuring this construct is 'my business is the most important activity in my life' (Gundry and Welsch 2001).

For *opportunity recognition*, six items were taken from De Noble et al. (1999): ability to see new market opportunities for new products, ability to discover new ways to

Table 4 PCA for composite sustainability

Variables	Factor loadings	Communality
Composite sustainability		
Sales level satisfaction × importance	0.87	0.76
Sales growth satisfaction × importance	0.89	0.80
Turnover satisfaction × importance	0.87	0.75
Profitability satisfaction × importance	0.90	0.81
Net profit satisfaction × importance	0.88	0.78
Gross profit satisfaction × importance	0.88	0.78
Ability to fund business from the profit satisfaction × importance	0.80	0.64
Eigenvalue	5.31	
Percent variance explained	75.85	
Cronbach's alpha	0.95	

Factor loadings 0.3 or smaller are suppressed. KMO = 0.925, Bartletts's test of sphericity App. chi-square 3392.079; df = 21, sig. 000.

improve existing products, ability to design products that solve current problems, ability to create products that fulfill customers' unmet needs, ability to identify new areas for potential growth, and ability to bring a product concept to the market in a timely manner. These items were measured according to the recommendations by Bandura (2001). The respondents were asked to indicate their degree of confidence in performing the tasks successfully. The scale ranged from 0 = 'no confidence at all', to 5 = 'some confidence', to 10 = 'complete confidence'. Finally, *innovativeness* was assessed using three items from Chandler and Hanks (1994): 'we strive to be the first to have new products available', 'we stress new product development', and 'we engage in novel and innovative marketing techniques'.

Structural equation modeling (SEM) was used to test a sequence of models that examined the mediating effects of opportunity recognition and innovativeness on the relationships (paths) between risk-taking propensity, entrepreneurial intensity, and firm sustainability (Joreskog and Sorbom 1993). We used SEM as it effectively estimates model parameters. Lisrel 8.7 (Joreskog and Sorbom 1993) was used. SEM serves a similar purpose as multiple regression analyses but also takes into account the modeling of interactions, nonlinearities, and correlated independents, provides information on the degree of fit of the tested model, and controls for measurement error. Therefore, SEM is often considered as the preferred causal modeling method (e.g., James et al. 2006). We used the correlation matrix and standard deviations as input to estimate of the structural model. Aggregation was conducted for each common construct to have unidimensional composite scales for the structural model (Anderson and Gerbing 1988).

We acknowledge that common method variance could be a factor given our use of survey instruments for data collection. Tests were conducted, and those analyses did not indicate that as an issue in this study.

Endnote

[a]Early-stage entrepreneurial activity rate (TEA) taken from the GEM report. This indicator includes percentage of the 18 to 64 age group who are either a nascent entrepreneur or owner-manager of a new business.

Competing interests
The authors declare they have no competing interests.

Authors' contributions
LG contributed to the study design, literature review and discussion.JK contributed to the study design, data analysis and discussion, TI contributed to the literature review, data collection and discussion. AC contributed to the literature review, discussion and conclusions. All authors read and approved the final manuscript.

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User innovation and entrepreneurship: case studies from rural India

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Abstract

Innovation research has abundant literature on technologically advanced innovations and entrepreneurship. However, literature from a rural innovator and entrepreneur perspective is sparse. Therefore, we explore rural user innovation and entrepreneurship in a developing country, India. Using multiple case study research method, we study cases of five rural user innovations in detail. These rural innovators innovated to alleviate the drudgery of their lives and to fulfill their need for a low-cost local solution to a widespread rural problem. They often face a resource void for commercializing their innovations and we find that external actors can play an enabling role in filling this void. The findings of our study help propose a framework for enabling rural innovation and entrepreneurship in developing countries like India. Further, in addition to poverty alleviation, we found that there was a positive social impact on the lives of rural entrepreneurs and their community.

Keywords: User innovation; Entrepreneurship; Rural innovation; Case study; Developing country

Background

User innovation and entrepreneurship is an important phenomenon, which competes with and may displace producer innovation in many areas (Baldwin and Von Hippel 2011). There is a growing interest in this field and we know very little about its applicability in the developing economies.

Research on user innovation and entrepreneurship to date has focused almost entirely on developed economy settings (Enos 1962; Knight 1963; Freeman 1968; von Hippel 1988, 2005; Shah and Tripas 2007). The phenomenon is understudied from the developing economy's perspective. Gupta (2006) reports numerous examples of rural innovations occurring in India. However, his study does not examine these rural innovations from the user innovation perspective.

Bruton et al. (2008) suggest that there is a need to examine the applicability of existing innovation and entrepreneurship theories in a developing economy context to advance our theoretical understanding of this field. This context is quite different from that pertaining in developed economies. For example, institutional arrangements supporting markets are either absent or weak in developing economies resulting in institutional voids (Mair and Marti 2009). This is impedes entrepreneurial activities in developing countries like Bangladesh (Mair et al. 2012) and India (Khanna and Palepu 2010).

In this paper we address this gap in the literature by examining rural innovation and entrepreneurship in India using the user innovation theoretical lens. Specifically, we ask the following research questions: (1) Why do rural users innovate? (2) How do they innovate? (3) How do they commercialize their products to become user entrepreneurs? (4) What is its impact on the individual rural user entrepreneur? (5) What is the impact of rural user entrepreneurship on the society or local community?

The paper proceeds as follows: First, we present a theoretical overview of user innovation theory and highlight the gap in literature. Next, we discuss the findings from our case studies and present a cross-case analysis. Then, we summarize our findings and discuss the implications of our study.

Theoretical overview

User innovation theory

von Hippel's (1988) work on sources of innovation reveals that users (both individuals and user firms) have developed some of the most important products and processes for their own use. He defines user innovators as a firm or individual that creates an innovation to use it. Examples of user innovation can include a surgeon inventing a new medical device for his/her use or a sports enthusiast creating new sports equipment for his/her own use.

Studies in many fields have documented the importance of user innovation. For example, in oil refining, user firms developed nearly all of the important innovations (Enos 1962). Users developed nearly 80% of the important scientific instruments (von Hippel 1976). Users also developed majority of the major innovations in semiconductor processing (von Hippel 1988) and in sports equipment (Hienerth 2006). In British firms, considerable fractions of inventions were for in-house usage (Pavitt 1984). Literature on user innovation reports empirical evidences from various countries like USA, UK, Canada, and Netherlands. Empirical studies reveal that users ranging from 6% to 40% develop and modify products (Baldwin and Von Hippel 2011). All this highlights the fact that users are developers of a significant number of innovations that exist in the world today. Baldwin and von Hippel (2011) argue that we are now witnessing a paradigm shift from the traditional producer innovation model to a user and open collaborative innovation model. von Hippel (1986) also suggests that needs of user innovators can be idiosyncratic or can reflect the needs of a larger population.

User entrepreneurship

We define user entrepreneurs as firms or individuals that initially create an innovation for their own use and then later commercialize the innovation for sale in the marketplace. The conventional understanding of entrepreneurship suggests that recognition of a commercial marketplace opportunity precedes prototype development (Venkataraman 1997). In contrast, the emerging literature on user innovation and entrepreneurship suggests that the process can be reverse. That is, user entrepreneurs first develop prototypes and subsequently recognize the commercialization potential of their product or service (Shah and Tripsas 2007; Haefliger et al. 2010). User innovators develop this insight into commercial potential by using and gaining experience with the product or service they have developed for their own use (Haefliger et al. 2010).

Shah and Tripsas (2007) pp. 124 define user entrepreneurship as 'the commercialization of a new product or service by an individual or group of individuals who are also users of that product or service.' They further classify user entrepreneurs as professional-user entrepreneurs and end-user entrepreneurs. Professional-user entrepreneurs are those individuals who use a product/service in their professional lives while remaining embedded in the organization. And end-user entrepreneurs are those individuals who use a product/service in their daily life and then commercialize it. Professional-user entrepreneurs have been studied in the ice-harvesting industry (Utterback 1994) and in probe microscopy (Mody 2006). End-user entrepreneurs have been studied in rodeo kayaking (Baldwin et al. 2006), mountain bicycle (Luthje et al. 2005), and automobile industries (Franz 2005), among others.

Research also highlights that user entrepreneurs are different from other entrepreneurs due to their direct experience with the need and prototype solutions. Although the importance of users as sources of innovations is well established in the existing literature on innovation studies (von Hippel 2005), the importance of users as a source of entrepreneurial activity is a relatively understudied area (Shah and Tripsas 2007). Shah and Tripsas (2007) argue that even though users innovate, commercialization of their innovations will be rare. Using the case of juvenile products, they suggest that users are most likely to be 'accidental entrepreneurs' and that accidental community interactions play a key role in their entrepreneurial pursuit.

User entrepreneurs derive benefits from the feedback and contributions through a collective social process. Using the example of firms founded by users of video games, Haefliger et al. (2010) suggest that user entrepreneurs derive their designs from existing products or technologies. Using the case history of rodeo kayaking, Baldwin et al. (2006) discuss how the level of entrepreneurial activity changes with changing economics of manufacturing. This is because subsequent user innovations and investment in production technology changes the nature of products and its demand.

At the macro level, Saemundsson and von Hippel (2010) study the level of user entrepreneurship in a country and how user entrepreneurs differ from other entrepreneurs in their attitudes and aspirations. Chandra and Coviello (2010) present a four-part typology of 'consumers as international entrepreneurs.' Shah et al. (2006) posit that the likelihood of users engaging in entrepreneurship is highest during the early phases of an industry lifecycle and declines rapidly over time. Furthermore, Shah and Tripsas (2007) posit that user entrepreneurship is likely to exist in industries where usage of the product or service provides enjoyment as opposed to pure economic benefits.

Paucity of user innovation and entrepreneurship literature from India

The existing literature on user entrepreneurs employs case studies from sports (Baldwin et al. 2006), specialized technology (Haefliger et al. 2010), and juvenile products (Shah and Tripsas 2007) - all examples of innovations from developed economies. There is a paucity of literature from developing economies. We carried out an extensive search in the online available databases like Proquest, EBSCO, JSTOR, and Google scholar to look for studies from rural areas in developing countries. To search, we used combinations of keywords like 'user innovation + rural/grassroots/developing country/developing economy/India,' 'user entrepreneurship + rural/grassroots/developing country/developing economy/India' and searched for words in title or author supplied keywords or

abstract. The search results either displayed no papers or put forward a few papers that were not relevant for our search criterion. To decide on relevance, we read the abstracts of these papers and then dropped those papers that were not studies of Indian user innovation or user entrepreneurship. As a result, our search yielded no papers on user innovation or user entrepreneurship from India. Our search was restricted to papers published in journals and we did not search working and conference papers. Thus, our study is an important stepping stone to theory building from a developing country perspective in the area of user innovation and entrepreneurship.

Results and discussion

We began our research by looking for evidence of user innovation and user entrepreneurship occurring in rural India. We focused primarily on rural India because 70% of the Indian population lives in rural areas (PTI Press Trust of India 2011). The next step was to understand the phenomenon in detail and examine the unique manifestations of 150 user innovation theory in the Indian context. This could be feasible only through qualitative research design, and case study emerged as the logical research method. This section discusses the findings from our case studies. We first provide a brief description of the individual cases (see Table 1 for comparative descriptions). Then, we discuss the cross-case analysis in the light of our research questions.

Brief case summaries

Innovation case 1: cotton stripper

In India, the traditional process of separating cotton lint from its shell is manual and involves separating by hand the firmly attached lint from the inner side of the cotton shell. Mansukhbhai Patel, a farmer, says that mainly women and children are employed to do this. In this process, cotton dust is emitted in the air, which is a serious health hazard. It has been found that workers exposed to an environment laden with cotton dust can become patients of byssinosis, a lung disease (Kumar 2008). Patel well understood the pain of the manual process as he was employed for cotton stripping in his childhood days.

> *I have seen the manual and tedious work. It was time consuming, it would take months and the rains would come and there would be huge losses for the farmers... Women and children had to do this backbreaking work and school going children were also employed in this job. I was also allocated this task. Studying or going to school was last priority. Father - mother said,'this much work has to be done and then study or go to school'.* - Patel (translated from personal interviews)

Since then, he felt that he should do something to alleviate this drudgery. He dropped from school after 9th grade due to poverty and continued to work in his cotton field. He also did many odd jobs and picked up mechanical skills by working as an electrician and mechanic in cotton mills. In 1991 to 1992, he developed a machine that could mechanically strip cotton from its shell by borrowing money from his family and friends. He tested the machine in his farm and built many prototypes before it operated as per his satisfaction. Patel finally achieved a workable commercial solution with the seventh prototype and GIAN helped in mobilizing the technical support from premier

Table 1 Comparative case descriptions

Case No.	User Innovation	Occupation of User Innovator	Age of Innovator (as on 2012)	Family Background of the Innovator	Educational Background of the Innovator	Product Description and Selling Price	Product Units Sold (till 2012)
1	Cotton Stripper	- Helper and farmer in cotton fields. - Also worked as an electrician and mechanic in cotton textile mills.	62	-Belonged to a *poor farmer family* in rural India. - He hails from a small village near Viramgam in Ahmedabad district of Gujarat state.	- Dropped out of school due to poverty. - Studied till 9th grade.	*Agricultural equipment*:The machine mechanically strips cotton lint from semi-opened or unopened pods for various varieties of cotton. It can process 800 kg of cotton per hour.*Price*: US$ 8000	400 units
2	Mitticool-(Clay Products)	- Potter - Also, ran a tea stall and worked in a factory.	47	- Belonged to a *poor potter family* in rural India. - He hails from a small village near Morbi in Rajkot district of Gujarat state.	- School drop out. - Studied till 9th grade and failed in X grade.	*Clay Creations*: - Clay Refrigerator- (US$ 36) - Non-stick Earthen Tava (US$ 2.75) - Clay Pressure Cooker (US$ 9) - Other Clay Utensils	7000 clay refrigerators, 100000 clay tawas and 500 clay cookers
3	Bullet Santi-(Motorcycle-driven Ploughing machine)	- Farmer and farm mechanic	42	- Belonged to a *poor farmer family* in rural India. - He hails from Mota Devaliya village in Amreli district of Gujarat state.	- Dropped out of school due to poverty. - Studied till 5th grade.	*Agricultural equipment*: Motorcycle-driven Ploughing machine having innovative attachments that can be used for various farming tasks. *Price*: US$ 450 for a complete set of unit with 3 implements.	500 units
4	Biomass Gasifier	- Farmer and farm mechanic	48	- Belonged to a *poor farmer family* in rural India. - He hails from a small village called Thaldka in Ganganagar district of Rajasthan state.	- Illiterate. - Received no school education.	*Biomass gasifier*: A gasifier unit, which generates producer gas from bio waste that can be used to run diesel engines/ produce electricity *Price*: US$453 (per kilowatt) Price varies from US$2275 for 10 KW unit to US $5914 for 35 KW unit.	80 units
5	Multipurpose processing machine	- Rickshaw puller - Farmer	46	- Belonged to a *poor farmer family* in rural India. - He hails from a village called Damla in Yamuna Nagar district of Haryana state.	- Dropped out of school. - Studied till Xth grade.	*Food processing equipment*: Multipurpose processing machine, which can work as pulp extractor, dry grinder, boiler or sterilizer, pressure cooker. *Price*: Large version US$2457 and small version is US$1183	25 units

education institutions like National Institute of Design (NID) and Indian Institute of Technology (IIT). He also obtained intellectual property rights protection for his product in India and in the USA with the help of NIF. Patel now owns five small firms with a turnover of over US$ 0.3 million.

Innovation case 2: mitticool (innovative clay products)

Clay pottery was the traditional business of Mansukhbhai Prajapati's family living in a small village in rural India. Prajapati failed in 10th grade and dropped out of school. Due to meager financial returns, Prajapati gave up pottery. He ended up earning his livelihood by doing odd jobs at various places like running a small tea stall or working in a factory for 4 years. While working for a brick roof tiles factory, he was inspired to build a machine to make clay products with high efficiency. So, he returned back to his family occupation - pottery. The clay used for this is somewhat different than the clay used for hand pottery and it took him some time to master this clay composition. He began by making earthen clay pots and hot plates in 1988. Most people in rural India use clay pots to store drinking water and hot plates or *tawa* for cooking flat wheat bread. In rural areas, the earthen pots are a natural way of keeping drinking water cool in summers. In January 2001, an earthquake registering 7.9 on the Richter scale devastated the Indian state of Gujarat and all earthen pots of Prajapati were broken.

> *A photographer took pictures of my broken clay pots and published in the newspaper with a headline 'Garib Ka Fridge Tut Gaya' (Refrigerator of the Poor has Broken). I thought; he is calling my pot a fridge. We also want a fridge but do not have money to purchase one… so…why don't I make a clay fridge for myself… and I started experimenting with clay to make a clay refrigerator that did not need electricity to cool.*
>
> *In 2005, my wife wanted a nonstick pan for cooking and when I went to the market to buy one, I saw the cost was INR 450 (US$8). It was very expensive for me and I thought- can't I do something to my clay hotplates to make them nonstick. I worked on it for 1.5 years…* - Prajapati (translated from personal interviews)

Prajapati created many innovative clay products like the Mitticool clay refrigerator, the nonstick clay *tawa* (hot plate) and the clay pressure cooker. The name of the refrigerator 'Mitticool' comes from the Hindi word *mitti*, which in means 'clay.' The clay refrigerator can be used to store cold water, food, fruits, and vegetables without any electricity or any artificial form of energy. It works on the simple principal of cooling by evaporation. Water from the upper chambers drips down the sides and evaporates, which leaves the inner chamber cool. It can be good alternative for people living in rural areas where electricity is not available or for those who are poor and cannot afford the conventional refrigerator. Financially, Prajapati has been able to move out of poverty and he received 25 awards including one from the President of India.

Innovation case 3: Bullet Santi (motorcycle-driven ploughing machine)

In 1994, the region of Amreli in the western part of India faced severe drought. The cost of manual labor was high and tilling the dry farmland became difficult. There was also shortage of cattle fodder and Mansukhbhai Jagani could no longer afford to use his

cattle for tilling his farm. These difficult conditions compelled Jagani to sell his bullocks and his farming suffered. He started thinking of ways by which he could come out of this misery.

> *With no money and bullocks, I had no choice but to think of an alternative way to plough our 20 bighas of land. I got this idea of developing a 'Bullet Santi' from 'Chhakdas', the common mode of three-wheeler transport in Saurashtra.* - Jagani (translated from personal interview)

Jagani had also worked as a farm mechanic repairing diesel engines and farming equipment. He borrowed his friend's Royal Enfield Bullet motorcycle and tried attaching a tiller to it. He created attachments using cheap and used components from foundries. The idea seemed to work and he further experimented with different ploughing attachments that could be fixed behind the motorcycle for farming. Jagani replaced the rear wheel with a set two smaller wheels and attached a metal plough behind the bike. He began using it for ploughing in his farm. It eliminated the need of bullocks or laborers for ploughing and Jagani named it 'Bullet Santi,' where *Santi* means 'plough.' The motorcycle had a 5.5 horsepower diesel engine and with the attachments it could be used as a multipurpose machine for ploughing, sowing, interculturing, spraying insecticides, or a small goods carrier. Other farmers also saw value in his invention and started approaching him for similar solutions.

The machine worked as a faster alternative to the traditional farming method that uses bullocks and as a cheaper alternative to modern farming methods that use tractors. In 1994, Jagani had developed the first prototype. Subsequently, the Council of Scientific and Industrial Research (CSIR) Lab in India helped Jagani improve the product design, and NIF and GIAN helped in its commercialization. His product got a patent in India and in the USA. Jagani has been able to move out of poverty and also received national level awards by NIF.

Innovation case 4: biomass gasifier

While other children went to school, Rai Singh Dahiya worked and helped his parents in their farm in rural India. He would weed and water the plants, look after the cattle, and do other jobs. They lived in a temporary or *kutcha* house made of mud and clay. Water would often come inside the house during rains and having a good meal was a luxury. Even though he could not attend school due to poverty, he had a keen desire to learn and was a regular listener of BBC radio for Science called *Gyan-Vigyan*. Dahiya had an inquisitive mind and he would often experiment with things. He would dismantle and again assemble anything that he could lay his hands on, for example, watches, clocks, radio, or farm machinery. He would often make models with mud and felt that he understood the language of machines.

In 1982, he started a brick kiln in which bricks are baked by burning the agriculture waste. He noticed that burning of biowaste in the kiln was producing gas. He thought whether he could store this gas and explore what it could be used for. Later in 1991, he opened a small workshop to repair tractors and farm equipment because he found machines fascinating and enjoyed identifying and solving problems. During

that time, the fuel prices were going up and Dahiya felt that he must find some cheaper alternative to fuel.

> *LPG (liquefied petroleum gas) was becoming expensive, diesel was becoming expensive. I thought let me try to use the gas produced in my kiln to run the engine… this gas can also replace our cooking fuel and can be very cheap.* - Dahiya (translated from personal interviews)

Dahiya thought about making an engine that could run on gas from farm waste or even cow dung. He made product designs using bricks and contemplated how he could make them using iron, other metal and old diesel engines. After years of experimenting, in 2001, he succeeded in running a diesel engine on biofuel by converting biomass into producer gas.

> *I faced lot of problems in the process. The engine would run for some time and then would stop. I had to open it, clean it, and then run again. I had no idea about filtration then… I thought about it and worked on it… Finally, in 2002, I made a fan filter and the engine ran successfully.* - Dahiya (translated from personal interviews)

The unit consisted of a gasifier, which was conical in shape surrounded by a water jacket. The gasifier generated producer gas from biowaste and Dahiya used it to run diesel engines. Dahiya did not even know what to call his invention. In 2001, NIF scouted him and provided commercialization support. He has sold over 80 units of varied capacity and the latest version of the biomass gasifier is made of steel. It has the capacity to produce 1 kilowatt power to run an engine for 1 h from 1 kg of biowaste.

Dahiya has come a long way from extreme poverty to now owning property, which is a three-story building having his shops on the ground floor. He himself is illiterate and worked hard to ensure that his three children get education.

> *My eldest daughter is doing PhD. My younger daughter has completed MBA and my son is doing BBA.* - Dahiya (translated from personal interviews)

Innovation case 5: multipurpose processing machine

Dharamveer Kamboj hails from a poor farmer family in the northern part of rural India. He studied in school until the 10th grade and then started assisting his father. Overburdened with loans, he decided to go to the nearby metropolitan city Delhi and work as a rickshaw puller to earn some money. He worked there for 2 years but had to return back to his village after meeting with an accident. He was bedridden for months and his family faced severe hardships. After recovering, he thought about growing medicinal herbs in his farm and visited the horticulture department in a small city called Ajmer in India. He had heard that there was a need for herbal plants during his stay in Delhi. Kamboj started with plants like aloe vera and stilia and built a small nursery.

Then came the problem of processing these herbal plants. He knew that there was a demand for aloe vera gel and he could make money by extracting and processing the aloe vera gel. But Kamboj did not have the money to buy the expensive machines

existing in the market. Additionally, these machines could not carry out multiple functions that he wanted. Kamboj thought about building a processing machine something on the lines of a food processer which would not only extract pulp or juice from the plants that he was growing but also convert them into powder form. He borrowed money and struggled for 8 months in designing and building the machine. In 2005, he was able to build the first prototype. He took help of a local factory for fabrication and welding.

NIF scouted and helped commercialize his product. GIAN assisted Kamboj in product design improvement. Kamboj has made several changes in product design and the latest version is capable of extracting oil and juice from various herbs, fruits and vegetables. It can also work as pulp extractor, dry grinder, boiler, or sterilizer. It can be used to boil rice, make ketchup or puree from tomatoes, or make dry powder from spices or fruits. It can also be used to extract ripe mango pulp without breaking the seeds. Kamboj now earns a decent income per month that enables him to live comfortably and provide education to his children. He also provides employment to more than 25 people from the village in his manufacturing unit.

Cross-case analysis

RQ1: why do rural users innovate?

The common aspect found in all the five case studies was that the user innovators were poor and professionally dissatisfied. They had experienced hardships due to poverty in their lives. In case studies of Patel, Jagani, and Kamboj, we find that they innovated to automate a manual process that was time-consuming and laborious. Four case studies also reveal that the users innovated to fulfill a necessity for a low-cost solution as compared to the existing products in the market. For instance, Dahiya innovated a biofuel because the diesel was expensive, Jagni innovated a motorcycle-driven plough because tractors were very expensive, Prajapati innovated a mitticool fridge because existing market refrigerator unaffordable, and Kamboj innovated the multipurpose machine because the existing machines were expensive and offered limited functionality. However, Patel's need to innovate was driven by desire to alleviate drudgery of the manual cotton stripping process.

RQ2: how did the rural users innovate?

In this question, we tried to study the process of rural user innovation. We find that the users were well aware of their local need and the constraints of their environment. This drives them to develop an idea of a product. For example, Patel got an idea to build a machine for stripping cotton, Prajapati got an idea to build a clay-based refrigerator, Jagni got an idea to attach ploughing implements to a motorcycle, Dahiya thought of using the gas produced in his kiln, and Kamboj got an idea to build a machine on the lines of a food processor. The next step in the innovation process was to seek financial help to build the product, as all of them were poor. They primarily relied on informal means of obtaining finance either from family members or friends. All of them had little or no educational backgrounds and were not conversant with the process of obtaining financial support from financial institutions. Additionally, they had no collateral to submit to banks. After acquiring financial support from informal

sources, they built an initial working prototype.

RQ3: how did rural users commercialize their products and become entrepreneurs?

The rural user innovators initially developed the product to meet their individual need but also thought about its commercial viability mainly to earn some money. They start using their product and show its use to other people living in their rural community. The rural innovators also tried to sell their product but were not able to successfully participate in the market and experienced a chasm. They tried to pick up business skills while on-the-job primarily through experiential learning. External organizations like NIF helped these rural innovators and they received financial support, without collateral, from NIF's Micro Venture Fund. They also receive marketing, intellectual property rights (IPR), and business development support through NIF and its partner organizations like GIAN, SRISTI, and Honey Bee network. Four rural user innovators, namely, Patel, Jagani, Dahiya, and Kamboj, received product design and development support from premier educational institutions in India with the help of NIF. As a result, they are able to improve their products and build technologically better commercial prototypes. With support from external institutions, they are able to sell the final product to more number of customers from different geographic locations in India. Some user entrepreneurs also sell their products in international markets like Dahiya received queries for his biomass gasifier from Africa, Germany, Singapore, and Pakistan. Prajapati has exported his mitticool refrigerator to Nairobi in Africa. Kamboj has exported his multipurpose processing machine to Kenya and has queries from Ethiopia.

RQ4: what is the impact on the individual rural entrepreneur?

We find that the five rural user entrepreneurs not only experience economic but also social gains. All the five rural entrepreneurs are able to generate livelihood for themselves and earn money by selling their products. All of them report that by becoming an entrepreneur they have been able to move out of poverty. In four cases, we also see increased productivity and efficiency of work. For instance, Patel reported his cotton stripper brought down cotton stripping cost from US$ 0.02 per kg to US$ 0.02 per 20 kg. All the five user entrepreneurs state that their entrepreneurial career has impacted them at a personal level. It has helped build self-confidence and has instilled a sense of self-respect. They proudly report that their community also respects them now as they have received national level recognition through awards and media coverage. All of them report that their standard of living has improved and they are now able to provide school and college education to their children.

RQ5: what is the impact of rural entrepreneurship on society or local community?

Through this research question we tried to explore whether there was any spillover effect of their entrepreneurial career on the society at large. We find that the creation of entrepreneurs, in our case rural user entrepreneurs, offers economic, social, and environmental gains for the society. Specifically, we find that customers get access to low-cost products like the mitticool refrigerator or the motorcycle-driven plough or low-cost biofuel. Two user entrepreneurs, namely, Patel and Kamboj, report their customers have experienced economic gains as reduced cost of production after using their machines. After analyzing the interview data of user entrepreneurs and the NIF chairman,

we find that there is also a society-level impact like employment generation, improving quality of life for the poor, health benefits, and building a sense of pride in the community of the user entrepreneur. For example, Kamboj provides employment to 25 rural villagers in his small factory. Further, many rural women who bought Kamboj's machine have generated employment for themselves by processing and selling herbal products from their homes. Mitticool refrigerators offer cold water and food storage options to the poor. The cotton stripper offers health benefits by eliminating the harmful manual procedure traditionally used for cotton stripping.

All the five user entrepreneurs state that there has been a development of social pride within their communities. In one case, we find that the user entrepreneur has brought about change in their community, for instance, Kamboj states that there has been a *parivartan ki lahar* meaning 'a wave of change' that has enabled self-employment in whichever village his machine has reached. Finally, two case studies also reveal environmental benefits in the form of ecofriendly products like biofuel and clay-based natural refrigerators.

Towards a framework of rural user innovation and entrepreneurship in India

In this section, we discuss the findings of our study in the light of literature on user innovation theory and posit a framework of rural user innovation and entrepreneurship in India (see Figure 1). As discussed earlier, prior literature suggests that user innovation is driven by in-house use benefits (von Hippel 1988, 2005). Prior literature also indicates that innovators develop their innovation using primarily the information and resources they have (Luthje et al. 2005). Prior literature on user entrepreneurship indicates that users innovate for their own use and only later discover the commercial possibilities in their products (Shah and Tripsas 2007). Finally, prior literature indicates that 'lead' users - those ahead of an important market trend - will tend to innovate (von Hippel 1986).

In our case studies, we observed that these factors hold in the case of rural innovators in India. The innovators' need for a low-cost solution or alleviating drudgery of their lives was their key driver for innovation. In other words, *necessity is indeed the*

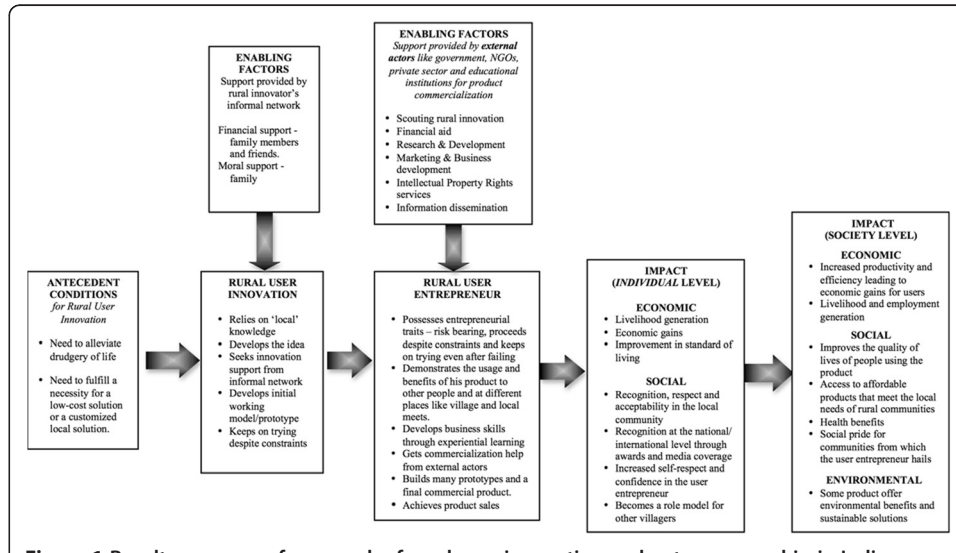

Figure 1 Results summary: framework of rural user innovation and entrepreneurship in India.

mother of invention in the case of rural user innovators. These are proposed as antecedent conditions/factors for rural user innovation in our model of rural user innovation and entrepreneurship in India (see Figure 1).

Driven by these antecedent factors, the rural user innovates and develops a product. His understanding of the local environment and its constraints shapes the product development process. Most of the rural innovators did not have any formal education or training; yet, it is this familiarity with their environment that enabled them to develop local solutions. They understand the needs as well as the constraints of the communities and its environment. This is in concurrence with the finding of Lujthe et al. (2005) where they suggest that user innovators mostly use 'local' information both for determining the need for and for developing solutions for their innovations. Lujthe and von Hippel (2006) define local information as knowledge already in possession of the innovators or the innovators themselves have generated it.

Next, we find that some of these innovations are built on existing products that are meant for purposes other than what the original product was meant for, like Jagni modified a motorcycle for use as a farm ploughing machine. This transformation is not unique to rural user innovations as prior literature also reports transformations in other cases of user innovation. The shooting films in video games (Haefliger et al. 2010) and the transformation of a phonograph turntable from a playback device into a musical instrument (Faulkner and Runde 2009) in its own right are examples of similar innovations with technological transformations.

The antecedent factors drive the user to conceptualize the idea for an innovative solution and the user now initiates the process of developing the user innovation (Figure 1). The process of rural user innovation is an interplay of local knowledge and innovative transformations in order to seek solutions for local problems and alleviate drudgery. The rural user tries to overcome his constraints by seeking financial and moral support from family and friends. This is represented as enabling factors for rural user innovation in the model. It is import to note that at this stage, the rural user is dependent only on his informal network for support. His low educational background, poor financial conditions, and limited knowledge on how to seek finance from financial institutions limit him to reach out to only his informal network for innovation development support.

In our five cases, the innovators were lead users with respect to the important general trend - driven by 'bottom of the pyramid' demand - for extremely low-cost solutions. In each case we studied, expensive solutions existed in the marketplace for the needs each experienced - but in each case, the rural innovators were too poor to purchase these solutions. In addition, given their poverty, the solutions were not appropriately designed to suit their needs. Thus, commercial tractors did exist which could perform the same task as the Jagni-modified motorcycle, which he developed as a farm ploughing machine. Similarly, commercial gas and electric refrigerators do exist which could perform the same task as Prajapati's evaporative cooling clay refrigerator. The innovations that these five entrepreneurs developed performed the functions of existing products - but filled a leading-edge marketplace demand in the sense of being well ahead on the dimension of low cost.

Going forward, having a good and useful innovation does not necessarily translate into an entrepreneurship. Entrepreneurship literature suggests that to be an

entrepreneurial individual, one needs to possess certain core human attributes (Shane 2003) like willingness to bear uncertainty (Kihlstrom and Laffont 1979), tolerance for ambiguity (Schere 1982), or need for achievement (McClelland 1961). We find in our case studies that the rural user innovators kept on trying despite their difficult living and working conditions. They all wanted to alleviate drudgery of their lives by innovating. In other words, as an individual, they all were willing to take risk and face uncertainty. They kept on trying even after losing money or their personal belongings like their house as seen in the case of Prajapati.

Further, if we look at the traditional model of new product development, we find that it is a process that starts with the generation of ideas, which undergoes a number of iterations and finally lead to the commercial launch of new products (Cooper and Kleinschmidt 1993; Cooper 1996; Fox et al. 1998). This is in line with the findings from all our case studies. We find that the rural user develops an idea and initiates the process of user innovation by building a prototype or initial product, which undergoes a series of changes before it could be commercialized. The cotton stripper was modified seven times over a period of 10 years. The motorcycle-driven plough, biomass gasifier, mitticool refrigerator, and multicrop thresher were all modified multiple times during the commercialization process.

Our case studies also reveal that rural innovators had poor understanding of obtaining formal finance from financial institutions, little exposure to the world at large, and limited technical know-how to make advanced product design modifications. As a result, there existed a chasm, which they had to overcome in order to bring their product to market and achieve profitable sales. This chasm or void was filled by the external organizations who not only provide financial support but also other forms of support, which is required to commercialize a product. Our finding is contrary to the finding of Lettl et al. (2006) where they report that users of medical equipment technology are not only inventors but also codevelopers. These advanced users play an entrepreneurial role and themselves organize the required innovation networks to commercialize their products. In our case studies, we find that the rural users are able to organize only informal innovation networks for seeking finance and resources to build their initial product. Due to their educational and financial backgrounds, they are unable to organize formal innovation networks to grow and achieve sales in markets outside their immediate community/village. Thus, a void or a chasm impedes their market participation and some form of external institutional support is required to enable participation in larger markets.

The literature on institutional voids also suggests that in many developing economies, formal institutional arrangements that support markets are absent, weak, or fail to achieve stated goals (Mair and Marti 2009). The biggest challenge for developing economies like India is to enable participation of the poor in markets. Puffer et al. (2010) used institutional theory to study entrepreneurship in China and Russia. They report slow development of efficient and legitimate formal institutions in Russia and China resulting in institutional voids. These entrepreneurs mainly relied on informal institutional arrangements of their trusted networks to fill the void of formal institutions. In our case studies, we also find that the rural users sought help from their informal network of family and friends. This is clearly different from the case of entrepreneurs from developed economies who operate with relatively higher certainty under effective formal institutions.

We find that external actors played an enabling role in product commercialization in our case studies. All the five rural user innovators took help from external organizations such as NIF, GIAN, SRISTI, and educational institutions in India such as IIT and others. Specifically, they got financial support, marketing and business development support, and IPR-related services from these external organizations. Therefore, in our model, we posit that the support provided by external actors like the government, non-government organizations, educational institutions, and private sector organizations act as critical enabling factors that can help the rural user entrepreneur cross the chasm by acquiring the required resources and skills to commercialize their product. This is a two-way interaction wherein the rural user entrepreneur primarily seeks financial support, but these external actors like NIF scout the rural innovator and extend not only financial but also marketing, business development, and legal support. We also posit that the rural user innovator is able to commercialize his product and become a user entrepreneur only when he possesses some individual level entrepreneurial traits like bearing risk and trying to build product prototypes despite all constrains (Figure 1).

After the commercialization of an innovation, the economic benefits for the entrepreneur are well documented (Wennekers and Thurik 1999; Van Praag and Versloot 2008). We found this to be true in our cases as they all were able to move out of poverty. In addition to the economic benefits, we found that there was a positive social impact on the lives of these rural user entrepreneurs. The user entrepreneurs enjoyed social recognition and also experienced greater self-esteem, social respect, and acceptability. For example, Patel's social acceptability took a dramatic turn with the success of his entrepreneurial venture. He was initially critiqued as a failure but after his entrepreneurial pursuit he became the 'pride of his community.' Furthermore, coverage of such stories by television channels like Discovery or NDTV increased confidence and self-esteem in rural user entrepreneurs.

In addition to the impact at an individual level, rural user entrepreneurship is likely to make a significant impact at the society or community level. The products innovated and commercialized for the rural level improve the users' quality of life by having access to products that are usually considered as basic necessities in developed economies. In addition, the commercialization of innovated products may also provide health benefits in the form of reduced harmful impacts as seen in the case of cotton stripper machine and the nonstick clay *tawa*. The use of cotton stripper increased the production and improved the quality of cotton ready for ginning, which increased profitability. This suggests that the increased efficiency and productivity with the use of the product also leads to the economic prosperity of its users. Instances of such cross-pollination would be in line with the suggestions of World Bank's published research (Dutz 2007) on increasing India's innovation potential. The report suggests that supporting networks and institutions like NIF and others can promote grassroots level rural innovations, which are likely to assist in poverty alleviation and sustainable development (Utz and Dahlman 2007).

As seen in the case of Prajapati, individuals who may have been considered ordinary on becoming successful can be a 'source of pride' for their community. On the whole, this sense of social pride is likely to lead to a feeling of well-being in communities. Furthermore, the products of rural user entrepreneurs can also offer environmental benefits and can possibly offer sustainable solutions for future generations. The case study of Prajapati's mitticool clay products and Dahiya's biomass gasifier discussed earlier is an example of environmental friendly products.

To conclude, in our framework, we suggest that antecedent conditions motivate rural users to initiate the process of rural user innovation. This rural user innovator is likely to commercialize his products and become a rural user entrepreneur with the help of enabling factors. Moving forward, rural user entrepreneurship is likely to have an individual level as well as societal/community level impact.

Conclusions

Implications for research, practice, and policy

Innovation is seen as crucial vehicle for increasing India's growth and helping reduce poverty and rising living standards (Dutz 2007). Nearly 90% of India's workforce is employed in the informal sector, which is typically characterized by low productivity and low-skill activities, and about 60% is employed in the informal agriculture sector. India would benefit from encouraging rural level innovation by promoting creative efforts by the poor (Utz and Dahlman 2007). To overcome institutional voids in developing countries like India, there is a need to create and strengthen formal institutional arrangements that can support rural level innovation and entrepreneurship.

We studied cases of five rural user entrepreneurs using the case study research method. From our findings and cross-case analysis, we posit a framework which suggests that rural user innovation is likely to occur when there is a strong desire to alleviate drudgery and a need to fulfill a necessity for a low-cost local solution. Further, we suggest that rural users experience a chasm/void and the commercialization of their product is more likely to occur with the help of enabling factors, such as individuals (like friends and family) and external institutions (like the government and non-government organizations, educational institutions, and private sector organizations).

In addition to the economic benefits to the entrepreneur, we also found that there was a positive social impact on the lives of the rural user entrepreneurs. The rural user entrepreneurs enjoyed social recognition, experienced greater self-esteem, social respect, and acceptability. Further, rural user innovation and entrepreneurship is likely to make an impact at the community/society level also. The increased efficiency and productivity with the use of the product is likely to lead to the economic prosperity for its user community. The users of such products are likely to experience improved quality of life by gaining access to affordable low-cost products meeting their local needs. Further, some of these products can also offer health benefits in the form of reduced harmful impacts of existing products/methods as seen in the case of Patel's cotton stripping machine.

Overall, our study contributes to the growing area of user innovation and entrepreneurship. It extends the applicability of user innovation theory in the context of developing economies like India. However, our findings need to be supplemented with large-scale quantitative studies to draw generalizations. In particular, policymakers can help promote entrepreneurship in rural areas by creating innovative mechanisms and institutional arrangements that facilitate rural entrepreneur's participation in markets.

Methods

We followed Yin (2003) for our case research design and Miles and Huberman (1994) for analyzing the qualitative data.

Sample and data collection

We began our study with an online search for data on user innovation and entrepreneurship in rural India. This led us to online databases and websites of four nodal organizations for rural innovations in India, namely, National Innovation Foundation (NIF), Honeybee Network, Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI), and Grassroots Innovations Augmentation Network (GIAN). We crosschecked the applicability of these databases for our study with four academic experts in India.

We found that these organizations maintain a database of grassroots innovations and related activities. As part of the documentation, the members of Honey Bee network go on *shodh yatras*, which is a 'journey of exploration' to scout for innovations from rural India (Gupta 2006). They meet villagers, farmers, and artisans individually and prepare a report on their experiences. Finally, they create a documentation of the scouted innovation, which is maintained in an electronic database.

For data collection, first we used the online databases of NIF, SRISTI, Honey Bee, and GIAN to create our sampling frame, as they have an exhaustive list of rural innovations listed in its database since year 2000. Some examples of these rural innovations include agricultural machinery, food-processing machinery, bamboo-processing machinery, dairy machinery, handlooms and textile-related devices, and herbal products. NIF has tried to file over 550 patents on behalf of its listed innovators. Out of this, 35 patents have been granted in India and 4 have been granted in USA. NIF has Micro Venture Innovation Fund (MVIF), which has provided capital to 178 projects.

Next, we searched for cases of rural innovators who had turned into entrepreneurs. Using the user innovation theory, our selection criterion for a case of user innovation and entrepreneurship was whether the fundamental definition of user innovator was applicable to that case. In other words, we checked whether the rural user entrepreneur initially invented the product for his or her own use and then commercialized the product. We selected five entrepreneurs who had received commercialization support from NIF and/or GIAN. Our sampling was purposive and we do acknowledge that there could be other instances of rural user entrepreneurs in India. Our sample, even though purposive, had a potential to offer rich insights to lay the foundation for future research in this area.

Our unit of analysis or the 'case' was an individual user entrepreneur, and we used the multiple-case design (Yin 2003, pp. 41). We conducted total 11 personal interviews. Eight in-depth personal interviews were conducted in the Indian national language 'Hindi' as the respondents were not conversant in English. Two in-depth interviews were conducted in a regional language 'Gujarati' with the help of a translator. The final interview with the NIF chairman was conducted in English. Before starting the interview process, we created an interview guide based on our research questions. The subquestions and supporting probes were also written in the interview guide to facilitate the flow of the interview. The interview guide was translated in the local language wherever required. The interviews were tape-recorded. They were later translated and transcribed in English.

Each case of the rural user entrepreneur was used to understand why he invented the X product, how he invented the X product, how he commercialized the X product and became an entrepreneur (with probes on understanding the process and enabling

factors), what was its impact on him at a personal level, and was there an impact of his entrepreneurial work on the society/his local community. The interview guide used for interview with the chairman of NIF was modified to understand the larger picture of rural innovation and entrepreneurship in India. For instance, the question 'How did

Table 2 Selected coding tables

Code	Indicators	Examples from interview transcripts
User-background	Financial situation	'I belong to a poor potter family. We used to get food grains for making pots.'
		'I grew up in a poor farmer family.'
	Professional situation	'I worked as a mason, this did not interest me, then I set up a tea stall… after some time I worked in a factory for sometime…'
		'I worked as a mechanic and electrician since childhood and learnt about machines.'
Reason for innovation	Automation of a manual process	'The manual process of cotton stripping was very time consuming and led to a lot of wastage. I always wanted to automate this process.'
	Cost of the product	'Poor people also have a desire to use good products, but they can't afford many of these products. So, I wanted to make products which the poor could also afford.'
Process-user innovation	Genesis of the idea	'*Amla* was grated by hand for making *ladoos* and process for making *gulab jal* was also very manual. I wanted to do something about it.'
	Financial resources	'My brother in law gave me money to build the cotton stripper.'
	Product development	'The engine used to run for a 3–5 hours and had to be opened and cleaned after that because of faulty filter. I made several changes to the gassifier before it worked properly.'
	Challenges faced	'There were times when there was no food for even a meal… I have struggled a lot…'
Enabler-user innovation	Financial support	'The biggest financial support I received was from my friends and family.'
	Moral support	'I could not have done any of this, without the support of my family.'
Process-user entrepreneurship	Business development	'I have exported to many countries including Singapore, South Africa, Germany and Kenya.'
	Demos of the product	'I took the machine to *Churu* for a demonstration and I got an export order from that.'
	Sales	'I have a turnover of around Rs. 1 Crore.'
	Role of external organizations	'NIF was a very big support- they helped with patent, money…'
Enabler-user entrepreneurship	Financial help	'NIF provided Rs. 2.5 lakh.'
	IPR help	'NIF helped with patent of the product.'
	Marketing help	'NIF arranged for demos of my product at many exhibitions.'
	Recognition help	'It is because of NIF that I got the President's award.'
	Product development help	'NIF has helped with the redesign of the multi-processing machine so that it can process milk products also.'
Impact - individual	Economic	'Financially today I am very comfortable.'
	Social impact	'If you type "Mansukhbhai" on Google, I am on the top of the list. I have become famous as "Mitticool".'
Impact - society	Economic	'There are many women in my village who are using this machine to make herbal products.'
	Social impact	'Every village this machine has gone to there has been a "wave of change".'
	Environment impact	'The gassifier emits no pollution and is a very good alternative to diesel.'

Table 3 Sources of data for the case studies

Case	Personal interviews with user entrepreneurs	Personal interview with NIF Chairman	NIF database records	GIAN and SRISTI website data	Newspaper articles	Magazine/Internet articles	Other data (videos on TV and Internet)
1	X	X	X	X	X	X	X
					Hindu	business.rediff.com; Forbes; theweekendleader.com; creativityatgrassroots.wordpress.com	Times Now TV
2	X	X	X	X	X	X	X
					Economic Times	business.rediff.com; Forbes; creativityatgrassroots.wordpress.com	Discovery channel; NDTV
3	X	X	X	X	X	X	X
					Economic Times	theweekedleader.com; Forbes; business.rediff.com; creativityatgrassroots.wordpress.com	video.india.com
4	X	X	X	X	X	X	X
					Times of India; Hindu	creativityatgrassroots.wordpress.com	NIF youtube video
5	X	X	X	X	X	X	X
					Tribune	India Today; FnBnews.com; business.rediff.com; creativityatgrassroots.wordpress.com	Documentary on youtube

X denotes source used to collect data.

you commercialize the X product?' was modified to 'How did the innovators listed in NIF database commercialize their products? What was the role of NIF and other organizations in this process?' These questions explored the impact and outcome of NIF's work at a national level.

Data reduction and coding

To begin with, we created high-level categories or codes deductively from user innovation and entrepreneurship theory to explore our research questions wherein codes were developed for user background, user innovation, enablers for innovation, user entrepreneurship, enablers for user entrepreneurship, and outcome of user entrepreneurship. These codes were further refined inductively using the data collected through personal interviews. The list of codes with few examples from translated interview transcripts is included in Table 2 of the paper.

Multiple sources of data and triangulation

Yin (2003) emphasizes that the strength of case study is in using a variety of evidence ranging from documents, reports, interviews, and observations. To strengthen our case study, we used a variety of evidence for data triangulation, which helped validate information from the interviews (Maxwell 1996). Our study includes primary data from personal interviews and secondary data from various sources like national level databases, company documents, reports, newspapers, and Internet sources (see Table 3). After each interview, we created individual case memos summarizing the interview. The primary data for each interview was triangulated with secondary data available from different sources listed in Table 3. Finally, we then created individual case summaries from the triangulated data.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
VY conceived the research and worked on it during a Fulbright funded research fellowship year at MIT. Both VY and PG together worked on the paper, PG collected primary data from innovators, and VY collected primary data from chairman. Both VY and PG collected secondary data and analysed the primary and secondary data. Both drafted and coordinated the paper. Both authors read and approved the final manuscript.

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Challenges facing small-firm managers in growing manufacturing firms

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Abstract

Purpose: The purpose of this article is to better understand the management challenges facing managers in small growing firms.

Design/methodology/approach: Empirical data have been collected in Sweden through structured observations (approx. 20,000 min) of the working days of six top managers in fast- and six managers in slow-growing small manufacturing firms in order to compare managerial behaviour in two different contexts.

Findings: Managers in small firms are engaged in many different activities, but a small number of activities tend to take up the majority of the managers' time. These activities can be classified as either operational or administrative. There are notably small differences (both in variance and differentiation) between the behaviours of managers in fast- and slow-growing firms; actually, there are more similarities than differences. There is also surprisingly little time spent by the managers on strategic work, even in the group of fast-growing firms. This might explain why growth and innovation in many cases come to a halt or even decline in these firms and represents such a challenge for the managers when they do not prioritize strategic work.

Originality/value: The study shows that managerial work in small firms is characterized by a generic behaviour and that the managers mainly use a habitual and limited behavioural repertoire. Many managers have difficulties in changing their mainly operational and administrative behaviour and thus the underlying strategy of the firm. They are 'stuck' in a path-dependency mindset, even though the development of the firm might require another strategy taken by the manager, as a response to meet environmental demands.

Keywords: Managerial strategies, Observational studies, Habitual and limited behaviour, Path dependency, Innovation, Networks

Background

How is rapid small-firm growth described in the academic literature? In reviewing the literature, there are many different attempts made to explain this relation. Researchers from diverse disciplines are taking part in this quest and searching for explanations on many different analytical levels. Some have focused on the impact of factors in the environment of the small firm (e.g. Covin and Slevin 1989; Sadler-Smith et al. 2003; Iraj and Besnik 2011), while others have focused on the structure of the firm (Pelham and Wilsson 1995), and still, others have been concentrating on the significance of top managers (Wiklund 1998).

One of the most influential and pioneering articles in this field was written by Birch (1979), who showed that fast-growing small firms are important when it comes to creating new jobs. Since then, there has been an ever-increasing interest in the relatively few small firms that grow fast and the question of what makes some small firms[1] grow while the bulk of them do not and why it is so hard for small firms to continue and grow (for a conceptual review of the relationship between the manager and growth in small firms, see Andersson and Tell (2009)).

The focus in this article is on the analytical level of the leader, sometimes referred to as the upper-echelon perspective (Hambrick and Mason 1984), which contends that firm performance is a reflection of its manager, or as Morrison et al. (2003, p. 418) write concerning characteristics associated with growth in small firms: '*It would appear that there is a common, dominant thread woven through these characteristics, that is, the human factor of the owner manager*'. The study of managers is well established, and that top managers have an effect on their firms' performance is an accepted proposition (e.g. Day and Lord 1988; Carpenter et al. 2004). Numerous studies have focused on this relationship from the perspective of managerial efficiency (Kotter 1982), business performance (Thomas 1988), and firm growth (Russel et al. 1994).

In focusing on the relationship between the manager and growth in small firms, three dominant views on and distinctions within this relationship seem to be presented in the academic literature (Andersson and Tell 2009, p. 589).

1. Whether it is something the manager has concretized as personal characteristics or traits (see for instance Gartner 1988)
2. Whether it is something the manager wants concretized as the motivation or the aspiration (see for instance Wiklund and Shepherd 2003)
3. Whether it is something the manager does, concretized as a behaviour (see for instance Gartner et al. 1992; Sarasvathy 2001 or Sadler-Smith et al. 2003)

These distinctions of the manager are well established in the academic literature concerning entrepreneurship and small businesses, and we found support of this in a large literature review conducted where we searched in more than 60 journals (see Anderson and Tell (2009)) for the relationship between the manager and growth in small firms.

A closer analysis of the research that focuses on top-management shows that the greater parts of the research have focused their explanatory proposals on leader characteristics and motivations. This analysis has been done using primarily quantitative methods and conducted from a trait perspective. Although some psychological traits have been found to be slightly more common among managers and entrepreneurs, research has shown that these people constitute a very heterogeneous group (Davidsson 1992).

From a theoretical point of view, this kind of explanatory approach has been exposed to some critique, and it has been suggested that research should be directed towards producing a better understanding of how leader behaviour affects small-firm performance (Gartner 1988; Gartner et al. 1992; Sarasvathy 2001; Sadler-Smith et al. 2003). It is only when characteristics/traits and motivation are put into action that they affect growth, or as Denison et al. (1995, p. 524) put it, '*Leadership must inevitably be performed through action, not cognition*'.

Additional critique has been directed towards this primary quantitative research from a methodological point of view; it has been argued that many aspects of the phenomenon of management and entrepreneurship are not very likely to be understood with quantitative and survey method techniques (Gartner et al. 1992, p. 26). Hence, it has been argued that research in this area should allow itself to deviate from its pursuit of 'rigorous research' and that researchers should spend more time with managers and entrepreneurs as part of the theory-building process (ibid., p. 22). This focus is also put forward as central in organizational behaviour management (OBM) studies, in order to understand effective organizational contingences (Houmanfar et al. 2009).

Wiklund (1998) brings up an interesting limitation of research focusing on management and entrepreneurial characteristics/traits, and that is that they have only an indirect effect on growth. If instead of focusing on defining the characteristics/traits of the manager, one follows the idea of Wiklund (1998), focusing on what the managers actually do and how this work relates to growth, it seems a promising way to reach an understanding of the relation between top-managers' work and growth. This view also opens the possibility of joining the research tradition of traits with studies that have focused on the behaviour/roles of the entrepreneur/top-manager (for instance Choran 1969 in Mintzberg 1973, Noel 1989, O'Gorman 2001, Florén and Tell 2004).

So, in spite of the fact that the growth phenomenon has been researched for some time, research is still relatively limited, and the phenomenon is still not very well understood (Hendrickson and Psarouthakis 1998; Simpson et al. 2012). Both from theoretical and methodological points of views, new approaches have been sought (Hales 1986, Tipu and Arain 2011).

The purpose of this article is to try to understand better the challenges facing managers by comparing the behaviour of managers in slow- and fast-growing small firms, in order to see how their behaviours differ and how these could be related to the growth of the firm, and why it is so hard for small firms to continue and grow.

Theoretical framework

What then constitutes the successful manager of a growing firm? Central to most theories and empirical findings in the literature concerning SME growth that try to explain the successful top-manager is something that is well cited by Denison et al. (1995, p. 525) as '*the notion that leaders can be classified in either one category or the other, or that certain styles and behaviors can be matched with certain situations to produce effective leadership*'. However, this dichotomizing perspective has been criticized, and other approaches to studying leadership have been taken by, for instance, Slevin and Covin (1990) that sees upon leadership as situational.

From this perspective, successful companies are those which manage to cycle between different styles. The idea of seeing the phenomena as situational is also present in the leadership literature, where the general implication is that effective managers have the ability to both conceive and perform multiple and conceptually contradictory roles (Quinn et al. 1982; Denison et al. 1995; Hooijberg 1996), and which presents a more comprehensive way to describe the work of the managers.

From a situational theoretical perspective, the managers' interpretation of the internal culture of the company, as well as the external environment in which the company

operates, a broad behavioural repertoire of leadership roles, and the frequent performance of conceptually contradictory roles seem to correlate to firm growth. '*Effective leaders are those who have the cognitive and behavioral complexity to respond appropriately to a wide range of situations that may in fact require contrary or opposing behaviors*' (Hooijberg et al. 2001, p. 526).

So, from this theoretical perspective, it seems as if successful managers are those who manage to have a broad behavioural repertoire, compared with the less successful mangers' more limited repertoire. On the other hand, as seen from a management perspective, the business environment in which many companies operates is often described and perceived as increasingly complex, unpredictable, and unstable (one statement that many managers share and that is well portrayed in articles in the field; see for instance, Simpson et al. 2012).

Managers' perception of their operating environment interacts with the ways in which they organize and process information. It is very difficult for individuals to process large volumes of incoming information comprehensively, so theories of managerial cognition (Stubbart 1989) suggest that managers utilize habitual ways of organizing and processing information to adjust to these complex information processing demands. This contradicts a situational perspective when it suggests that managers do not use a broad behavioural repertoire in order to cope with the complex everyday life of managing a small firm. Another way of describing the limited use of different behaviours by small firm managers is the use of a simplistic strategy-making process, which Verreynne (2006) found is the most commonly used strategy in small firms. The simplistic strategy-making process is defined by Lumpkin and Dess (1995, p. 1386) as '*an overemphasis on the very things that made them successful in the first place*'. This is also referred to as the informal strategic management mode (Mintzberg 1978 and Charles et al. 2015).

So, managers in slow-growing firms seem to use a more habitual behaviour, representing a more limited behavioural repertoire, and this might explain their more limited ability to respond to the external environment context and might shed some light on why they do not grow. This implies that managers having a broad behavioural repertoire and performing different roles frequently will perform better than their peers having a simplistic strategy-making process, which is characterized by a lack of variance in the behaviour of the manager.

In daily life, this means the managers in slow-growing firms take on to a larger extent a specialist or substitute role working mainly with a few tasks such as the firm's competitive advantage. As the dominant leader, even though he/she completes many tasks during the workday, the manager has a narrow focus of attention, often on a single goal or strategy, that is a low differentiation in the manager's attention. Dess et al. (1997, p. 686) make this point when they write that a manager in their study has '*a blueprint set some time ago that has changed very little*'. In adopting the simplistic strategy, managers often neglect other important factors because of this single-focus goal. They are 'stuck' in a path-dependency mindset, even though the development of the firm might require another strategy taken by the manager. On the other hand, managers who show a broad behavioural repertoire and perform different roles frequently will be more successful when they can adopt better to different situations. According to the strategic management literature, fast-growing firms seems to be more successful in adopting management strategies that are

suited to the environment in which they are applied (Parker et al. 2010), which suggests that these managers have a broad behavioural repertoire.

This study addresses the following key research questions:

1. Do managers in fast-growing firms possess a larger behavioural repertoire than managers in slow-growing firms?
2. Do managers in slow-growing firms possess a more limited and habitual behavioural repertoire than managers in fast-growing firms?
3. Can the larger behavioural repertoire explain why managers in fast-growing firms have the ability to take decisions that could explain growth of the firm?
4. Can the behaviour of the small-firm manager explain why it is hard for small firms to grow?

Results and discussion

From observations of the actual behaviours of the managers, they have been inductively classified to 13 main functions that the managers perform. Then, the variety (that is the variance and differentiation) of the functions between the two groups, the external and internal orientation and the dominance in the behaviour of the manager, has been studied in order to see what managers in fast-growing firms do differently from managers in slow-growing firms.

The analysis of the strategic behaviour of the managers has been done in two steps. First, after three rounds of classifications of the approximately 2500 activities, a decision on a final classification of three main activities has been done, that is, strategic, administrative, and operational activities. Within these main activities, 13 sub-activities have been identified (see Fig. 1).

Strategic activities are activities in which the managers work with important, long-term decisions related to the company's future. Administrative activities relate to support areas such as finance, administration, and personnel. Operational activities relate to the daily work of production, including purchasing, manufacturing, marketing/sales, and delivery.

In the second step of the analysis, the variety has been examined (that is, the variance and differentiation) of the 13 sub-activities at the individual and the group levels, the manager's external and internal orientation, and the manager's leadership dominance.

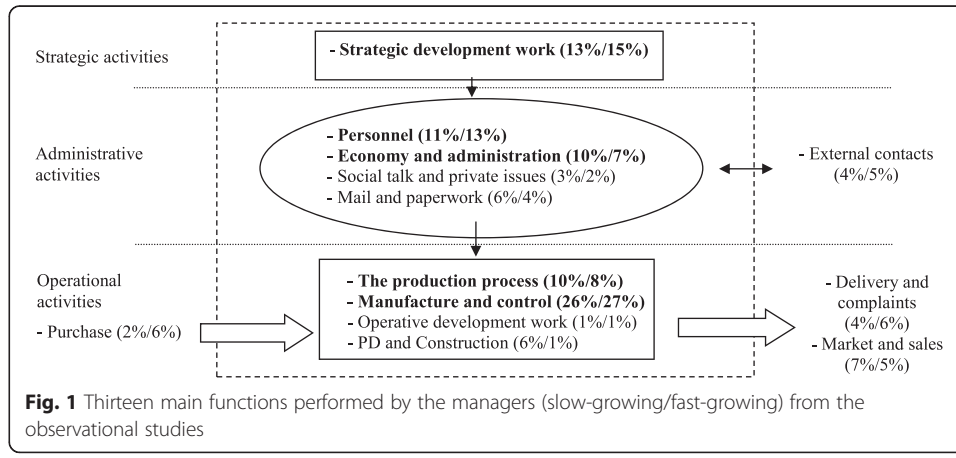

Fig. 1 Thirteen main functions performed by the managers (slow-growing/fast-growing) from the observational studies

The purpose was to determine the percentage of time the managers spent on each sub-activity in order to identify their main strategy according to the typology developed.

Coming back to the two first key research questions, the findings show that managers in fast-growing firms do not possess a larger behavioural repertoire than managers in slow-growing firms. Neither do managers in slow-growing firms possess a more limited and habitual behavioural repertoire than managers in fast-growing firms.

What instead becomes obvious when studying the different functions carried out by the two groups of managers is that there are more similarities than differences. The variety (that is the variance and differentiation) between the functions fluctuates very little.

Three functions or management roles (Mintzberg 1973) take up most of the manager's time and are the same for both groups, and they are as follows: manufacture and control (monitor), working with personnel-related questions (leader), and strategic development work (entrepreneur) taking up 50 % of the time in slow-growing firms and 55 % percent of the time in fast-growing firms. When looking at five of their functions that they work most with, economy and administration take up 10 % (slow-growing firms) and 7 % (fast-growing firms) of the time, respectively, and the production process takes up 10 % (slow-growing firms) and 8 % (fast-growing firms) of the time, respectively. This then adds up to exactly the same distribution of time and functions carried out by the managers, which is 70 % of the time they spend on the same five functions. That is, the variety of tasks and the differentiation are the same between the groups.

The remaining eight functions that make up the last 30 % of the managers time are also equally distributed, with very few differences, as shown in Fig. 1. These functions consist of generic small-firm managerial work such as the following: market and sales, the handling of delivery and complaints, external contacts, the purchase of all kind of material, product development (PD) and construction work, operative development work, mail and paperwork, and social talk and private issues. The numbers of internal contacts are also almost identical between the two groups.

This also means that the focus on operational, administrative, and strategic activities is the same between the two groups—that is, approximately 55 % of the time is spent on operational activities, 30 % on administrative activities, and 15 % on strategic issues. The conclusion is that although managers perform many activities during the workday, they narrowly focus on a few activities. This suggests that there is a low variance/differentiation in behaviour as the managers prioritize some activities over others, which suggests the use of limited and habitual behaviour (as discussed by for instance by Verreynne (2006)).

The finding that slow and fast-growing firms have more similarities than differences is built on almost 20,000 min of observational studies and connects to the last two key research questions. First, the study shows that managers in fast-growing firms do not have a larger behavioural repertoire than slow-growing firms that could explain growth of the firm. Neither could the behaviour of the small-firm manager explain why it is hard for small firms to grow.

The findings, however, raise some interesting reflections and further questions. One question is if it really matters what the top-manager does or is the growth just built on luck or external forces out of their control? Another reflection is whether the work of the top-manager in small firms is so generic that only a minority of the hours per week are spent on activities that generate a difference in value, or whether the method of observation is not precise enough in catching the unique features of leadership in small growing firms?

Conclusions

Research on small-firm growth clearly indicates that firm growth presupposes that the degree of formalization will increase (Greiner 1972; Mintzberg 1983). It therefore could be expected that managers in fast-growing firms work more with strategic and administrative questions than operational questions when the company grows. However, it is important to take into consideration that the majority of the small firms do not want to grow due to '*the managers' perception of how feasible and desirable the strategy is and their propensity to follow this course of action*' (Mazzarol et al. 2009, p. 323). Many firms are survival-oriented firms that are controlled by a family and are seen as providing a small income, but the managers see that growth might jeopardize the existence of the firm (Poutziouris 2003). One expectation is, therefore, that there ought to be differences between how fast-growing and slow-growing firms are led by the managers.

One interesting conclusion in the study is, therefore, that due to the generic features of managerial work, managers in small manufacturing companies, irrespective of whether they grow or not, engage in similar activities that take almost 90 % (30 % administrative, 55 % operational) of their time. A total of approx. 15 % of the manager's time is spent on strategic activities, and when there is no difference in the length of time spent between the managers in the two studied groups, as well as no difference in the variation or differentiation of their focus on different activities, it seems that managerial behaviour cannot explain the difference in growth between firms.

Another conclusion of this study is that the managers in slow-growing firms find it hard to let go of the very thing (e.g. operational issues such as production processes) that caused the firm to grow initially (a simplistic strategy). There may be a strong tendency towards path-dependent behaviour by managers. Parker et al. (2010, p. 223) state that '*firms are unlikely to be successful if they attempt to draw lessons from observing growth in one period and applying these lessons routinely at a different point in time*'. Imitating past managerial policy may result in future inflexibility with little innovation. As Leitner and Güldenberg (2010) claim, a small firm requires a combined strategy of innovativeness and efficiency. However, under the constraint of scarce resources typical of small firms, it is difficult for the top managers to change their behaviour in order to find time to focus on strategic issues. The small firm that was once fast-growing may be stuck in the paradox of its own success. Such success, as Elsass (1993, p. 84) writes, makes '*organizations lose the ability to recognize and respond to environmental demands*'. This could be seen in the growth patterns of fast-growing firms, where the growth rate is substantially lower in the 5 years after the first growth period, and even this growth pattern is non-linear rather than linear. Parker et al. (2010) claim these findings follow Gibrat's rule of proportionate growth: growth is not serially correlated but randomly distributed. As a result, the typical gazelle growth pattern is a short spurt of growth followed by a return to the industry average growth rate (Acs and Mueller 2008).

Practical implications

For managers, the findings imply the need to take one step back and reflect on the way the firm is managed and find a better balance between innovativeness, meaning having a broad behavioural repertoire to be able to see and respond to different situational contexts, and efficiency, using a habitual response, representing a more limited behavioural repertoire, in order to be cost effective. One way to create this possibility for

reflection is to engage in critical dialogues not only with suppliers and customers, but also with intermediates and universities in different network constellations (see for instance Street and Cameron (2007) or Laforet (2011)), in order to get new perspectives. This is sometimes referred to as a specific type of dynamic capability, that is, '*the capacity to purposefully create, extend, or modify the firm's resource base, augmented to include the resources of it alliance partners*' (Furlan et al. 2014, p. 35).

In the field of managerial development, collaborative learning in so-called learning networks has been found to be one way to overcome internally the problem of scarce resources. Learning networks are defined as '*network(s) formally set up for the primary purpose of increasing knowledge, expressed as an increased capacity to do something*' (Bessant and Francis 1999, p. 377). A learning network could be understood as a platform for conversations/talks, reflection, and sense-making, where managers come together in a non-competitive environment to discuss and reflect upon different issues in their day-to-day work. The learning network approach is, in this respect, a highly interactive pedagogical model where participants are encouraged to discuss different issues related to their own organizations. These actors provide a non-hierarchical arena for experience exchange and learning, which is expected to increase entrepreneurs' abilities to take advantage of business opportunities. This could help the managers overcome the difficulties to find a better balance between innovativeness and to be cost effective.

Future research directions

The finding that very little time is spent on strategic work and the weak correlation to growth is consistent with findings from a study by Coad (2009), in which he found that in 12 reviewed studies, eight report R^2 values of below 10 % and six report R^2 values of 5 % or less in explaining the relationship between the growth of the firm and strategic work by top management in small firms.[2] How could this be explained?

One interesting reflection is if, over time, the behaviour of the managers in fast-growing firms is becoming more and more generic and habitual (similar to managers in slow-growing firms) due to external and internal demands on the firm, as well as the situation when the managers become more experienced. The managers' perception of their operating environment interacts with the ways in which they organize and process information, and managers utilize more and more habitual and limited ways of organizing information after a while to adjust to the complex information processing demands. Also, what Mazzarol et al. (2009) refer to as strategic myopia, a condition characterized by a short-sighted focus on the daily operational matters, makes most mangers gravitate to a similar behaviour. Here, experience is negative only when it seems to hamper the innovativeness[3] of the firm and thus the capability to grow. This could explain why growth in many firms comes to a halt after a couple of years (Coad 2009).

One future research direction is to develop the method of studying further, by gathering managers (of slow- and fast-growing firms) and conducting an experiment as Isenberg (1986) did. He asked two different groups (experienced managers and students) to think aloud about how to solve different business cases. If one uses the same approach in comparing the behaviour of managers in slow- and fast-growing firms, solving different cases or situations they face in their daily work in simulated situations, this method might find the unique features of leadership in small growing firms not seen in the use of observations.

Methods

This study draws on the method of structured observation designed by Mintzberg[4] (1973). Data for the six slow-growing companies were collected during the winter of 2002/2003, and for the six fast-growing 'gazelle' companies, data were collected during the winter of 2006/2007. During the 6 weeks of observation (1 week for each manager in the group of slow-growing firms and 3 days at the fast-growing firms), Mintzberg's chronology, contact, and mail records were used. In total, approximately 20,000 min of work and approximately 2500 activities were observed and characterized according to their activity pattern and roles. During the observations, extensive field notes were taken to support the recapitulation of 'stories' and 'events'.

In our observations, we noted all the managers' activities contemporaneously, minute by minute in chronological order (see Appendix). During the observations, I and a colleague took turns observing the managers and we shared the task of typing each day's data into Excel spread sheets the day after each observation. We then summarized and presented this data to the managers in focus groups for our joint analysis. We used these focus groups to verify the 'normality' of the data and of the sense-making related to the data. In short, these sessions helped us understand the data at a higher level than that of mere activity patterns.

The sample in the study comprises two groups of six small-firm managers, respectively (i.e. 12 managers in total) (see Table 1). The managers taking part in the study are managing Swedish manufacturing companies in traditional branches having between 10 and 99 employees. The group of growing firms was selected from a list of 'Gazelle-firms' developed by the major daily economic journal in Sweden (*Dagens Industri* [Industry Today]). Their definition of a growing firm is as follows:

- Should have published public accounts at least 4 years
- Should have a revenue over 10 million Swedish crones (approx. $14 million)
- Should have at least ten employees
- Should have increased their revenues continuously the last 3 years
- Should have doubled their revenues during the same period
- Should have positive accumulative operating results for four accounting years

Table 1 A comparison between the two groups of no/slow growth and fast growth companies

Study	Focus of study/number of employees	Sex/age	Time as manager	Empirical data
No/slow growth	6 owner-managers	Male/between 43 and 58 years	Between 1 and 28 years	1 week of observation
−3 % in average increase turnover 6 years prior to observation	(17–43 employees)			A total of approx. 12,240 min of observation. A total number of 1634 activities documented
	Manufacturing industry			
Range −61 to +28 %	Average 26 employees	Average 49 years	Average 14 years	Data collected in 2002/2003
Fast growth	6 owner-managers	Male/between 35 and 65 years	Between 3 and 20 years	3 days observation
+241 % in average increase in turnover 6 years prior to observation	(10–38 employees)			A total of approx. 7500 min of observation (+2 days of observation of 4 of the managers (approx. 67 h) by master students). A total number of 855 activities (+418 activities by stud.) documented
	Manufacturing industry			
Range +93 to +406 %	Average 24 employees	Average 49 years	Average 12 years	
				Data collected in 2006/2007

- Growth should be organic and not by acquisition

The slow-growing firms represent the typical firm, which has almost no growth at all.

There is a danger in this study's approach to exploring the relationship between managerial behaviour and small-firm growth. The danger is that the conclusions from a sample population are not generalizable to a larger population owing to the number of variables influencing the results. I have therefore, together with a colleague, invested time and effort in identifying small manufacturing firms that have similar characteristics in order to keep as many variables as possible constant.

An advantage of direct observation compared to interviews is that observational data are less subject to participant constraint and interpretation. It is, however, necessary to consider the 'researcher effect' (or the 'Hawthorne effect' as it is often labelled). Although this effect is neither avoidable nor measureable, it is important to recognize that the presence of the researcher in observations may affect the data and the research results. In this research, I dealt with possible distortions from the researcher effect by frank discussions with the managers, both individually and in groups.

Endnotes

[1]A number of definitions of small firms are available. In this article, I use the definition by Storey (1994), in which a small firm employs 10 to 99 employees.

[2][Beaver (2007):12] suggests four reasons that many small firm managers do not work with the strategy process: not enough time, unfamiliarity with strategic management techniques and processes, lack of skills, and lack of trust and openness.

[3]Innovativeness reflects a firm's tendency to engage in and support new ideas, novelty, experimentation, and creative processes that may result in new products, services, or technological processes (Lumpkin and Dess 1996).

[4]For a thorough description of the use of this methodology, see Mintzberg (1973), Appendix.

Appendix

Table 2 Chronological record

Chronological record	Date:	Managers name:	
Time of day	Medium	Reference	Time (min)

Table 3 Mail record

Mail record		Date:	Managers name:		
Reference	Form	Sender/-recipient	Purpose	Measure	Action

Table 4 Contact record

Contact record		Date:	Managers name:			
Reference	Medium	Purpose	Participants	Initiative	Time (min.)	Place

Competing interest
The author declares that he has no competing interests.

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We would like to thank all the contributing authors for lending their expertise to make the book truly unique. They have played a crucial role in the development of this book. Without their invaluable contributions this book wouldn't have been possible. They have made vital efforts to compile up to date information on the varied aspects of this subject to make this book a valuable addition to the collection of many professionals and students.

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The publisher and the editorial board hope that this book will prove to be a valuable piece of knowledge for researchers, students, practitioners and scholars across the globe.

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