



Delft University of Technology

**Frugal Innovations in Technological and Institutional Infrastructure
Impact of Mobile Phone Technology on Productivity, Public Service Provision and
Inclusiveness**

Altamirano, Monica A.; van Beers, C.P.

DOI

[10.1057/s41287-017-0115-2](https://doi.org/10.1057/s41287-017-0115-2)

Publication date

2017

Document Version

Accepted author manuscript

Published in

European Journal of Development Research

Citation (APA)

Altamirano, M. A., & van Beers, C. P. (2017). Frugal Innovations in Technological and Institutional Infrastructure: Impact of Mobile Phone Technology on Productivity, Public Service Provision and Inclusiveness. *European Journal of Development Research*, 1-24. <https://doi.org/10.1057/s41287-017-0115-2>

Important note

To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Copyright

Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy

Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.

Frugal innovations in Technological and Institutional Infrastructure.

Impact of mobile phone technology on productivity, public service provision and inclusiveness.

Abstract

This paper examines frugal innovations as processes, products and systems that affect the resource constraints that are typical for many developing countries. The focus is on the impacts of mobile phone technology induced frugal innovations' on the resource constraints and how these influence productivity, public services provision and inclusiveness. The effects are illustrated with the help of the case of the M-Pesa payment system and more specifically two particular services that use M-Pesa, i.e. Kilimo-Salama, an agricultural micro-insurance through mobile phones and M-Farm, market access services for small farmers. The results reveal positive impacts on private sector productivity and public services provisions due to among others reduction of transaction length and hence costs. With regard to inclusiveness it is likely that in the short term the application of IT-induced frugal innovations will not be inclusive. In the longer term the inclusiveness of these innovations can be expected to increase.

Keywords: Information Technology, resource constraints, productivity, public service provision, inclusiveness, M-Pesa

1. Introduction

Frugal innovations are a recent field of scientific interest in innovation economics and management. The focus is on a particular set of innovations that originate from engineering by which technological complexity and production costs of goods, services and systems are reduced substantially without sacrificing user value. As a result they can be supplied at very low prices and hence come within the reach of low and middle-income consumers in developing countries (van Beers *et al*, 2018).

The phenomenon frugal innovation opens a complete new interdisciplinary field of research that relates technology, design, management, governance and economic development. So far most attention has been paid to frugal innovations from the perspective of management (Prahalad and Hammond, 2002; Prahalad, 2010; Zeschky *et al*, 2011; Radjou *et al*, 2012). The main focus in these studies is to examine what frugal innovations are, why they are relevant for the strategies of private sector business in order to achieve sustained competitive advantage. Competition and strategy are the key words here.

An exception is Gerard *et al.* (2012) and a number of papers in a special issue of the Journal of Management who focus on the importance of inclusive development from a management-, entrepreneurship- and strategy perspective, that is they focus on how to address inequalities that may arise in the process of value creation and capturing. The present paper adds to this literature by focusing on the relationship between technology, governance and economic development.

Frugal innovations can be distinguished in two parts. First, they can be considered as innovative processes or products to be used in constrained economies as many developing countries are (van Beers *et.al.*, 2018) It requires design that takes into account the characteristic elements of resource-constrained economies but also co-creation with local entrepreneurs as information sources for design as well as business models to channel sales. The second kind of frugal innovations consists of processes, products or systems that affect the constraints in the local economic environment (Rao, 2013). While the first form of frugal innovations is expected to contribute to economic development by increased supply of products or production processes given the constraints in the developing economies, the second one addresses the constraints thereby providing potential for economic activities to become more productive.

This paper examines through the lens of a macro perspective the second kind of frugal innovations and aims to bring together several insights from the literature and policy documents. The focus is on the impacts of elements of Information Technology (IT) – more specifically mobile phone technology – induced frugal innovations’ on the resource constraints and how these effects influence productivity, public services provision and inclusiveness. Accordingly the key research questions are: (1) do recent technological developments in mobile phone technology provide scope for frugal innovations? (2) How do mobile phone technology-induced frugal innovations address the resource constraints in developing economies? Provided that innovations such as M-Pesa have inclusiveness reducing aspects, also the question arises on how these inclusiveness reducing factors can be dealt with. (3) What is the impact of these innovations on the provision of public services and effective access of the poor to them? Do they contribute to good governance and efficiency and productivity gains?

These questions will be illustrated with the help of cases at a system- and a product and/or service level. At the system level the payment system M-Pesa is examined and at the product and/or service level two particular services using M-Pesa are investigated namely 1) agricultural micro insurance through mobile phones and 2) market access services for small farmers. All of these cases are in Kenya and should be considered as an illustration of the conceptual framework. The conceptual framework based on these cases provides insights that can be applied in other developing countries.

The next section provides a short overview of the relevant literature. Section 3 presents the conceptual framework and research methodology, where the theoretical framework is operationalized by introduction of criteria that are relevant in order to assess whether or not (frugal) innovations are inclusive. In section 4 the cases are presented and these are discussed in section 5 using the framework presented in section 3. Section 6 presents some preliminary conclusions and section 7 suggestions for further research.

2. Theoretical Background

2.1 Technological Developments and Frugal Innovations

In the field of (international) economics the Law of Diminishing Returns predicts that capital will move from locations with low marginal productivity of capital (rich countries) to those

with high marginal productivity of capital (poor countries). In practice we cannot observe this prediction which can be attributed to a number of factors among others, differences in human capital availability between rich and poor countries and capital market imperfections due to political risks in poor nations (Lucas Jr, 1990).

Capital flows through foreign direct investments are an important channel for technology transfer from rich to poor countries. The main vehicle is multinational corporations (MNCs). In the 1950s and 1960s technology transfer from developed to developing countries was expected to take place by implementation of technology through affiliates of Western MNCs in developing countries. The related investments, however, were the result of investments decisions in the economic environment of rich countries with relatively high labour costs leading to labour-saving capital investments in labour abundant developing countries. This flaw led to the “appropriate technology debate” focusing on encompassing technological choices for developing countries characterized by labour-intensity, small-scale and locally controlled capital (Schumacher, 1973). The technologies produced and used in this view should come out of the constrained local economies themselves as a guarantee that it is adapted to local conditions. In the 1980s and 1990s a debate on technological capabilities in emerging economies started (Pack and Westphal, 1985). The focus in this research stream is on examining how indigenous firms and entrepreneurs can assimilate to and improve foreign technologies in order to strengthen their competitiveness (Kim, 1980). Lines of this way of thinking fed into the national innovation systems literature (Kim and Nelson, 2000).

The phenomenon of frugal innovations – products, services or systems with substantially reduced engineering complexity and production costs without sacrificing user value – can be considered as a way between these two extreme positions linking technology transfer to the appropriate technology requirements of low income groups as consumers and producers/ entrepreneurs. The term frugal innovation came in the spotlights by an article in *The Economist* in 2010 in which it was argued that frugal innovations were not just about redesigning products but also involved rethinking of entire production processes and business models. Three ways of costs reduction that proved particularly successful. *The first is to contract out ever more work. The second is to use existing technology in imaginative new ways. The third is to apply mass-production techniques in new and unexpected areas such as health care* (The Economist, 2010).

Frugal innovations can impact developing economies in two ways. First, recent technological developments in technological fields particularly IT have increased the potential to improve the fit between (re-) designed technological innovations to local resource constraints in developing economies. Second, it has the potential to affect the resource constraints such as information asymmetry and the resulting lack of transparency that are often impeding factors to economic and social development. If this is the case, frugal innovations have the potential to become disruptive innovations. The term disruptive innovations (Christensen *et.al* 2006) refers to innovations that create a new market and value network, and therefore disrupt existing markets and value networks by displacing leading firms and products that dominated the “old” market. Christensen (2003) makes a distinction between “low-end disruption” which targets customers that do not demand the full performance at the high-end of the market, and “new-market disruption” which targets customers with needs previously not served by existing suppliers. Frugal innovations that prove inclusive would probably be more of a new-market disruption type.

The background from this characteristic originates in the concept of General Purpose Technologies (GPT) leading to economic transformations. In a general sense GPTs have the following three characteristics: 1) pervasiveness, i.e. it spreads to most sectors in society, 2) improvement, that is GPT get better over time and costs for users go down often due to externalities of technical systems, and 3) innovation spawning, i.e. GPT is a kind of platform on which it is easier to invent and produce new products or processes (Breshanan and Trajtenberg, 1995; Lipsey *et al*, 2005; van Beers, 2010). More specifically Lipsey *et.al* (2005: 114 – 116) show how the different elements of IT-driven changes have huge impacts on the economy and the society.

Focusing on these three characteristics can be considered as important determinants of frugal innovations. Much of the innovation spawning takes place in newly established firms, start-ups, often with the help of incubators and hubs (Jovanovic and Rousseau, 2005). These firms are not only high-technology IT producing firms but also firms supplying new products or developing new production processes or systems that use IT platforms. The reduction of production and user costs over time provides opportunities for re-designed or newly designed products to become frugal. The lower production and user costs as well as the smaller scale of production (Brynjolfsson *et.al*, 1994) are favourable for the development of frugal innovations.

The pervasive characteristic of GPT is particularly important for developing countries as it provides opportunities to influence the resource constraints that are typical to a developing country:

- reduction of information asymmetry in markets leading to lower transaction costs. This results often in more transactions taking place and hence more economic activity.
- increasing transparency due to more anonymous and accurate registration of transactions. An example is M-Pesa, the phone-based money transfer system of Vodafone and Safari.com in Kenya. This system reduces the influence of individual bank men and hence potential bribery spots.
- reduction of monitoring costs. For example through IT driven Geographical Information Systems (GIS) in weather stations it is easier to monitor weather conditions relevant for crop insurances. This creates opportunities for affordable crop insurance services to local farmers.

2.2 Inclusiveness and Frugal Innovations

Van Beers *et.al* (2018) examine under what conditions frugal innovations are inclusive. Inclusiveness means that poor consumers and producers benefit from the development, production and use of the frugal innovations. The successful introduction of frugal innovations does not automatically mean that the poor consumers and producers in the Bottom-of-the-Pyramid (BoP), i.e. those living of less than \$ 2, - a day, will benefit from it. Inclusiveness of frugal innovations can be achieved through for example active participation in the design and innovation process of local entrepreneurs that are familiar with the local community preferences thereby increasing the chances to contribute to local economic development.

2.3 Institutions and Economic Governance

In order to better understand the pervasive characteristics of GPT and the impact of these characteristics on governance, user behaviour and hence on inclusiveness, productivity and service provision, it is required to grasp two concepts: institutions and transaction costs. These concepts are key to the New Institutional Economics (NIE).

NIE looks at different types and levels of institutions, more specifically at institutional arrangements, governance structures and the institutional environment. Meanwhile, the fundamental unit of analysis in Transaction Cost Economics (TCE), part of NIE is the transaction. “*A transaction occurs when a good or service is transferred across a technologically separable interface. One stage of activity terminates and another begins*” (Williamson 1996, 379). Transaction is therefore synonymous with the economic concept of exchange (Altamirano, 2010) and refers to the costs incurred by all parties when engaging in economic trade.

TCE as developed by Williamson (1979), matches transactions with governance structures: if the transaction has specific characteristics (asset specificity, frequency and uncertainty), then the most efficient governance structure for the organization of such transaction is a market contract, a hierarchy, or a hybrid (Groenewegen and de Jong 2008). In other words, governance structures are designed to mitigate the hazards, or minimize the costs, involved in effecting economic transactions.

Governance structures are defined by Furubotn and Richter (1997) as a system of rules plus the instruments that serve to enforce the rules, and by Williamson (1981) as the explicit or implicit contractual framework (including markets, firms and hybrids) within which a transaction takes place. According to Menard (1995: 175) a governance structure is a way to implement and operationalize the “rules of the game” as they are defined by the institutional environment. Governance structures or institutional arrangements act as supporting structure for transactions to take place.

Meanwhile the institutional environment refers to the man-made constraints that structure political, economic, and social interactions. It delineates the rules of the game within which the institutional arrangements (governance structures) operate, by prescribing the rules of conduct within which human actions take place.

Two differences between the institutional environment and the institutions of governance stated by Williamson (1996) are; firstly that the former mainly defines or can be thought of as constraints on the environment of the latter; secondly that the level of analysis of each is very different. Governance structures operate at the level of individual transactions while the institutional environment deals with multiple levels of activity.

The institutional environment consists of the basic formal and informal rules in a society and the so-called social capital. The most important component of social capital is trust. Formal rules include laws and rules of society and the way these are enforced and monitored.

Informal rules instead consist of common codes of behaviour, sanctions, customs, traditions, norms, values and beliefs; deeply rooted in a particular society.

3. Conceptual Framework

The use of mobile telephones in the last decades opened up a number of possibilities for the provision of services to people, particularly for those living in developing countries. With regard to poor customers in the lower upcoming middle classes as well as in the BoP living in remote areas, the use of mobile phones seems to be the end of “isolation” for world’s poor.

Triggered by the developments of a variety of IT and Financial Technology (FinTech) innovations around the world that seem to be reshaping the provision of key public services such as water, the authors were engaged in studying the impact of mobile phone technology on productivity, public service provision and inclusiveness. Therefore a conceptual framework combining information on how mobile applications work, the concept of GPT and the axioms of NIE have been constructed.

For the selection of the three cases to be used as illustration we used an inventory¹ of mobile applications in the water, agriculture and disaster risk management sectors in developing countries that are part of on-going research concerning the development of a Financing Framework for Water Security (Altamirano, 2017). In order to find innovative business models that ensure financial and institutional sustainability in the provision of (public) services, twenty mobile applications, their business models and their effects on resource constraints, productivity and quality of service provision have been examined. It is necessary to make a distinction in two waves. In the first wave the application is considered bringing systemic change beyond sectors in which they were designed. The second wave of applications build on a number of technical functionalities set in place by the first wave. In this second wave, these functionalities are combined with other IT technologies such as remote sensing and Geographic Information Systems (GIS), to solve specific problems. Both waves aim to improve public service delivery as well as private sector productivity

The framework that we will use to investigate the cases is presented in Figure 1 and Figure 3. Based on this framework the impacts can be explained by two effects. Changes in technology lead to 1) a direct effect on the users by giving them access to information and allowing them to undertake a larger set of actions due to lower transaction costs (van Beers,

et.al, 2018) and 2) an indirect effect on the governance structures facilitating the transactions and maybe even on the institutional environment such as for example reducing market failures (Rao, 2013). The incentives experienced by the users alter their behaviour, which is expected to cause a systemic change and to result in a) increased productivity in the case of (private) economic activities and/or b) increased efficiency when referring to the provision of public services. The a priori expected increase in productivity may translate into higher salaries and better labour conditions. Whether or not this result can be considered as inclusive depends on the indirect effect of changing governance or power structures will be conducive to inclusiveness (red arrows).

*******INSERT FIGURE 1 ABOUT HERE**

The concept of General Purpose Technologies refers to the introduction of new technological systems. These consist of a set of interconnected components that have been designed to fulfil a particular function without further human design input. For example, the central case to be worked out in the remainder of this paper – a mobile phone payment system – consists of the mobile devices but also the components of a cellular network such as transmitters and receivers necessary to communicate with each other. The given or constant design of a technological system guarantees that it is possible for a human being to use the system without knowing its technical details. Using a mobile phone can be done without knowing about details of the cellular networks. Though it is not necessary to have thorough technological knowledge on for instance the use of mobile phones, it is required that people have a certain level of literacy in order to be able to use and recognize potential uses of a mobile phone device such that it can affect the efficiency of economic processes along the indirect effect sketched out in Figure 1. A lower education or literacy level means that fewer benefits will accrue to the technological system users (mobile phones) and hence the less inclusive such a system is. Rogers (2003) argues that a diffusion process cannot be considered as successful if distant customers are not reached due to among others lack of awareness and/or local involvement due to cultural or political factors.

As presented in Figure 1, the introduction of a frugal innovation does not automatically result in immediate inclusiveness net gains for those in the Bottom of the Pyramid (living from less than \$ 2,- per day). In the short term the introduction of the innovation takes place within existing power structures and hence can be expected not to contribute to inclusiveness. It might even lead to less inclusiveness as people with literate

skills will benefit more than those that are illiterate.¹ People in the Base of the Pyramid (living from \$2 to \$10 per day) may be more ready to take up the innovation and experience its benefits. Baumüller (2015) compares for instance M-Farm users in different districts and finds that on the whole surveyed farmers and households using M-Farm tend to be better off, better educated, located closer to markets and have better access to phones and radio as compared to those that did not use M-Farm. This readiness can create a multiplier effect and upward social mobility which as depicted in Figure 2 translates in the longer term into more inclusiveness. Upward mobility could be the result of either higher income levels due to higher productivity of informal economic activities and/or a shift from the informal to the formal sector (The Economist, October 15th, 2016). Since many of these people are connected and related to the Bottom of the Pyramid, it may be expected that their upward mobility and increased purchasing power may translate into help – monetary and as role model- for their less fortunate family members.

The Bottom of the Pyramid may also be positively affected in the long term for two reasons: Firstly, a change in the power relationships – and long term impact on governance structures that enables them to gain access and therefore follow the same trajectory than the base of the pyramid. Secondly due to the impact of role models and money flows from their relative moving upwards. In many developing countries people are connected and extended families act as natural safety nets for the poorer members of the family For example, a number of studies (Parker and Short 2009, Tamasane 2009, Tamasane and Head 2010) have demonstrated the indispensable role played by extended families in Africa in caring for orphans. The care and protection given by the extended family is driven by what Tamasane (2011: 15) calls “compassion and sociocultural norms.”

The upward movement of a family member and his/her shift to the formal sector with frequency translates into money transfers to poorer members of the family and often with the specific purpose of paying for education or other important family investments to increase the potential of other family members to move upward in the longer term. This behaviour within families of collectivistic cultures has been documented for the case of Caribbean migrants to Western Europe by Cervantes-Rodriguez *et.al* (2008), where they found out that migrants may even sacrifice their own social status and take work as domestic servants in Spanish households to ensure that other members of the transnational household can benefit from upward social mobility back home.

*******INSERT FIGURE 2 ABOUT HERE**

The cases are examined and presented using the framework in Figure 1. For each of the applications the functionality provided as well as the direct benefits experienced by users will be described. Additionally the indirect effect of the application in the governance structure of the sector will be described, by first depicting the status quo before the introduction of the innovation and comparing it with the governance structures that have emerged from the widespread use of the innovation. Last but not least, the impact of this chain of changes in productivity and/or public services provision will be investigated.

3.1 Mechanisms driving changes on productivity

Figure 3 presents a diagram of the basic mechanisms that may explain the impact of mobile technology on governance structures and transaction costs as well as productivity. The causal links depicted in Figure 3 are based on our knowledge of how mobile applications work, the pervasive characteristics of these innovations as GPT's and NIE axioms.

In System Dynamics a key step in the conceptualization of systems is deciding what the basic mechanisms of the system are. These are the feedback loops in the model and represent the smallest set of realistic cause-and-effect relations capable of generating the reference mode of the system at hand (Forrester 1994). The reference mode refers to the behaviour of the most important variables over time, as presented for inclusiveness in Figure 3.

Given how mobile technology works the use of mobile phone applications often translates in an increase in a) traceability, b) registration accuracy, c) access to information – especially significant in the case of the poor who used to be disconnected and isolated, e) speed of information transfer, and f) decrease in cost of direct information transfer. These changes triggers changes in governance structures facilitating the specific transactions supported by each mobile application and consequently as shown in Figure 3 and activate a number of causal loops and mechanisms that explain the final impact of these mobile applications and their use on efficiency in service provision and/or productivity. These mechanisms can be explained as follows:

Firstly, increased transparency of the system due to greater registration accuracy and higher traceability leads to nearly equal information on a real time basis for all parties involved in the transaction therefore reducing information asymmetry to a minimum. Information asymmetry occurs when one party to a transaction has more or better information

that the other party. Within Agency Theory Information Asymmetry is related to the so-called “private information” (Lambert 2001) of the agent or the party doing work for the principal, in this context the client making use of the mobile application. The more private information the agent has, the more room he has to act opportunistically versus the principal and/or client in this case. In other words information asymmetry increases the room for opportunistic behaviour (Altamirano 2010).

Secondly, a higher speed and lower costs involved in direct information transfer often mean that the use of these mobile applications reduce significantly the number of intermediaries. Thirdly, this combination of a reduction in information asymmetry and number of intermediaries have both a positive impact on governance structures as they reduce the room for opportunistic and/or corrupt behaviour from the agents providing the service. All these three changes result in an increase in the (perceived) reliability of the transaction, ultimately leading to more trust from all parties in these innovative governance structures (the ones made possible by the introduction of mobile applications) and service provision channels and a reduction of transaction costs. The increase in perceived transaction reliability and therefore trust in the new governance structures supported by mobile applications closes the reinforcing loop as it triggers people to shift from their current channels more and more to the use of mobile technology.

Another important mechanism is triggered by the reduction in transaction costs, explained not only by higher levels of trust due to higher (perceived) reliability but also by the significant reduction in the costs of direct information transfer. If Transaction Costs are reduced, a larger share of resources becomes available for productive activities which ultimately affect the productivity of the sector positively.

The most important component of social capital – one element of the institutional environment- is trust. Low levels of social capital in a society lead to higher transaction costs. Meanwhile governance structures are designed to mitigate the hazards, or minimize the costs, involved in realizing economic transactions. For this reason institutions (backed or supported by innovative technologies) that facilitate the realization of transactions incurring in lower transaction costs are considered to contribute to a boost in economic growth (North 1992), as they free up resources that could now go towards productive activities.

Already in 1973, McKinnon and other authors recognize the important role of financial systems in economic development², while Kehinde and Adejuwon (2011) have demonstrated with their research that the financial sector could be a catalyst of economic growth if properly developed and healthy.

A third mechanisms depicted in Figure 3 relates to the increase in speed of information transfer along with the reduction in information asymmetry which is expected to have a positive effect on market consistency.

*******INSERT FIGURE 3 ABOUT HERE**

There are a number of factors that explain the gains and losses of the users of mobile phones systems induced innovations in the long term which relate to efficiency and inclusiveness gains. Efficiency gains consist of 1) more competition due to lower transaction costs and lead to more efficiency, and 2) more transparency due to the reduction of the number of intermediaries. Inclusiveness gains relate to 1) access of the poor to financial and other (public) services they did not have access to before, 2) reduction of information and power asymmetry, 3) design of frugal innovations taking into account cultural factors.

In the first wave the mobile payment system M-Pesa in Kenya will be studied. It addresses the market failures as well as the governance changes brought forward.

In the second wave two cases are reviewed that relate to Disaster Risk Reduction and Market Development in the agriculture sector. In these two cases a further analysis of these impacts will allow us to answer the research questions posed:

1. Do recent technological developments in Information and Communication Technology (IT) provide scope for frugal innovations?
2. How do IT-induced frugal innovations address the resource constraints of developing economies? Particularly the second wave applications Kilimo-Salama and M-Farming will be used to address this question.
3. What is the impact of these innovations on the provision of public services and effective access of the poor to them? Do they contribute to good governance and efficiency and productivity gains?

For the analysis of impact of the effects of the first and second wave of mobile applications on the primary user and its local economic environment will be examined. Especially the second wave applications – Kilimo-Salama – and M-Farming will be used to examine the extent of inclusiveness.

4. Case Illustrations

As explained above three cases are going to be analysed for illustration of the conceptual framework. In the first wave the case of M-Pesa will be analysed. M-Pesa is a mobile money transfer system which is supplied to the whole population in Kenya. It uses IT for the supply of banking services, and hence affects the financial structure of the Kenyan economy by “banking the unbanked”. It is a frugal innovation as it is a system innovation leading to banking services at low (affordable) prices in comparison with standard banking services. Further, it is simple to use and hence fit for users at a low education level.

The second wave cases are:

1. Kilimo-Salama, which is a micro-insurance program against unpredictable rainfall and droughts in Kenya, Rwanda and Tanzania, using M-Pesa as platform. Weather index-based insurance is making it possible to insure farms as small as one acre. By replacing resource intensive farm visits with measurements from weather stations as indicator of drought/flood conditions, thereby reducing assessment and administrative costs (World Bank 2017). Farmers pay 50% of the insurance premium and Syngenta (input supplier company) covers the other 50% (Syngenta Foundation).
2. M-Farm, which is an app or SMS direct to farmers in Kenya that provides up-to-date market prices as well as connecting farmers with buyers directly, cutting out middlemen through the "group selling" functionality (Solon, 2013). It has a "group buying tool" that allows farmers to pool resources to negotiate higher prices.

******INSERT TABLE 1 ABOUT HERE**

Table 1 describes the cases in both the first and the second wave of applications by introducing the case content, the suppliers, the business model and the (potential) users

First wave of applications: M-Pesa

M-Pesa is a mobile transfer solution that enables customers to transfer, deposit and withdraw money. Registered users are able to load cash onto their phones at an allocated outlet, found anywhere from the local chemist to the local petrol station. They can send money to a third

party by text message, which is collected by the recipient at the nearest vendor. It enables to transfer money fast and at very low costs as well as in a very reliable way. M-Pesa is considered as very successful: Alexandre (2010) reports that three and a half years after its launch in 2007, above 70% of the households in Kenya and, more important, more than 50% of the poor, unbanked and rural populations was using the service.

Table 2 reports the impact of M-Pesa on the user, in particular the direct benefits and the indirect benefits through governance (see also Figure 1), direct and indirect impact on productivity and inclusiveness.

*******INSERT TABLE 2 ABOUT HERE**

M-Pesa has revolutionized the money transfer industry through the increase in speed and decrease in cost of direct information transfer and consequently the reduction of transaction costs as a direct benefit for the user:

- Kabucho *et.al* (2003) has documented that before M-Pesa, the cost of sending US\$100 through formal channels was between US\$ 12 (Money Gram) and US\$ 20 (bank wire transfer); and the cost of slower formal channels started with US\$3 making use of bus companies, up to US\$6 in the case of postal money orders.
- M-Pesa introduced a relatively inexpensive method to send money instantly (approximately 1 minute). Transferring US\$ 100 to a non-registered user was in 2008 approximately US\$ 2.50, while the cost of sending to a registered user even less (Safari.com, 2008).
- On average, the commission charged on money transfers fell from around 7% in 2003 to 3% in 2010 (Mbiti and Weil, 2011).

Besides the benefits directly experienced by users, the introduction of M-Pesa has come to address a number of market failures such as information asymmetry and hence affecting the governance structures in the financial sector and ultimately resulting in changes in users' behaviour and productivity. As thoroughly reviewed by Mbiti and Weil (2011) the indirect impacts of M-Pesa in the Kenyan economy have been:

- M-Pesa has changed savings behaviour, remittances patterns and improved rural circumstances (Morawczynski and Pickens, 2009).

- M-Pesa enhanced the ability of households to smooth risks (Jack and Suri, 2010, 2011).
- Increased M-Pesa adoption leads to greater bank use. This opens opportunities for more cost reductions in using the service due to externalities and scale economies. Evaluated at the average adoption rate of 40% Mbiti and Weil (2011) observe that M-Pesa has increased the proportion banked by closely 11%, which all in all signifies an increase of 58% above the 2006 banking level.
- M-Pesa is used as a savings instrument, as people shift from informal tools to M-Pesa. Jack and Suri (2011) report that three out of four users indicate that they use M-Pesa to save money.
- Plyler *et al.* (2010) argue that M-Pesa has promoted growth rates of small-scale firms in the communities they researched, and that this was to a great extent the result of increased circulation of money in these communities.
- Increase M-Pesa use is associated with increases in any type of employment and also farm labour. Mbiti and Weil (2011) in their paper titled: Mobile banking: the impact of M-Pesa in Kenya show that for an average M-Pesa adoption level M-Pesa would increase employment by 12%, representing approximately a 15% rise in employment rate in Kenya versus the percentage in 2006. Through a significant decrease in the costs of money transfer M-Pesa has helped increasing market activities, especially in rural areas. *M-Pesa has made cash less scarce and businesses have responded* (Cull, 2010).

The indirect impact of M-Pesa through governance has been among others:

- Reduction of the number of middlemen, and hence a change in power asymmetry and less room for corruption (Solon 2013 and Okunseinde 2014).
- Increase in efficiency of the banking system and lower costs of money transfer-- due to higher competition among money transfer companies. M-Pesa has forced money transfer companies to lower prices, and also induced these firms and other financial firms to improve their products and services. The advent of M-Pesa has caused commercial banks to work toward speeding up the check clearing process.
- Even though M-Pesa is partly complementary to bank accounts, it also serves as a partial substitute for the formal banking system and has resulted in an increase of the

number of people banked in Kenya (Mbiti and Weil, 2011). Before M-Pesa, the great majority of Africans were excluded from modern financial services (Beck *et al*, 2007).

- Conversely, M-Pesa could have the effect of empowering certain family members who usually have less bargaining power, in particular women. Particularly among poorer segments of the population, money transfers sent and received via M-Pesa turn out to be less notorious than those transmitted by alternative means, such as sending it via a friend (Jack and Suri, 2010).

In terms of service provision M-Pesa also is expected to help in expanding the reach of the financial system and provide a platform to deliver financial services to the poor by supporting the expansion of branchless banking. In this type of banking the coverage of financial services is increased by using agents as intermediaries to provide services in rural and remote areas where the fixed costs of opening a local office would be unaffordable (Pickens *et al*, 2009). This depends nevertheless on banks willingness to serve the poorest segments of population and governmental regulations that promote or hamper branchless banking (Mbiti and Weil, 2011).

With regard to the inclusiveness aspects of M-Pesa two observations are in order. First, M-Pesa shows aspects of increased inclusiveness through more transparency, reduction of transaction costs (and therefore elimination of specific institutional voids), more access of the poor to financial services. It lives up to some extent to the expectation that it 'can bank the unbanked'. Second, M-Pesa also shows inclusiveness decreasing aspects because of unequal power relations (educated versus uneducated) in IT use. As pointed out by Peša (2016) in her study of mobile money use in Zambia, the poor have benefited to a lesser extent from the production and distribution mechanisms involved³. M-Pesa as well as other frugal innovations has resulted in employment with limited growth possibilities versus the jobs offered by informal economies and networks (Meagher, 2016).

Second wave of applications: Kilimo-Salama and M-Farm

The Kenyan insurance system Kilimo-Salama is an index-based micro-insurance program against unpredictable rainfall using M-Pesa as a platform. Index-based insurance uses weather data from satellites and automated weather stations as a proxy to estimate farmers' harvest situation. At the end of each growing season, the weather data are automatically compared to an index of historical weather data. If the season's rainfall is for instance 15% below the average, the insurance pay out to clients is calculated and sent. The fact that no

official claim from clients is required lowers the transaction costs to small famers and improves the affordability of the insurance product.

*******INSERT TABLE 3 ABOUT HERE**

Before the introduction of Kilimo-Salama no agricultural insurance was available, especially not for small scale farmers (Ogodo 2010). By then farmers and their families were highly dependent on disaster relief help (including seeds) to recover after weather disasters. The distribution channels of such help had limited reliability and were often subject to corruption. The direct benefits of agricultural micro-insurance in terms of productivity as well as their impact on user behaviour are (see Table 3):

- Effective reduction of the impact of severe weather as well as more investment in farm inputs – often of better quality- and therefore an increase in productivity. Insured farmers can buy certified seeds and invest in fertilizer. In the years after severe droughts, insured farmers continue farming due to contingent payments from the insurer.
- By reducing risks, insurance encourages farmers to invest in their farms raising yields. Findings from Kilimo-Salama's impact survey in October 2012 show that insured farmers increase investments in their farms for about 20 percent (Syngenta Foundation: <http://www.syngentafoundation.org>).
- Such ‘pay as you plant’ type of insurance enables farmers to ‘try out’ a product they never purchased before (World Bank 2017). This possibility is crucial as this product had a negative reputation in Kenya (Syngenta Foundation). The experiences reported by Kilimo-Salama suggest that as farmers get to know the insurance product and increase their trust on it, they increase their coverage and feel assured to invest more in their farm, raising their productivity while guaranteeing in the long term food security.

Meanwhile the impact on governance structures and service provision are:

- Small farmers – even smaller than 2 acres - gained access to insurance schemes due to reduction in transaction costs, time and effort for processing of claims (World Bank 2017). Kenyan farmers generally did not have access to insurance for their farms since traditional agricultural insurance relies on on-farm monitoring of losses,

evaluated through farm inspections. Additionally given that transaction costs to insure one acre are comparable to insuring a 200 acre farm, the premiums from the one acre farm would never cover the related transaction costs (Syngenta Foundation: <http://www.syngentafoundation.org>).

- Increased access to insurance for the poor, as insurance is made affordable through a "risk sharing arrangement" - that is easier and more transparent to manage due to IT. A 'premium sharing arrangement' means that each party pays a share of the premium depending on their vested interest (Syngenta Foundation). Input companies have a clear vested interest as they are directly hit together with their clients if excessive rainfall or droughts affect agricultural production.

Other noteworthy changes in terms of service provision and the institutional environment regarding the public task of disaster risk management in public service provision are:

- The public/international task of disaster relief is becoming more and more a shared responsibility, where citizens and insurance companies are taking a greater role. This solution is notable more effective and efficient. A new insurance market for small (poor) farmers has been created and therefore service provision for the poor has significantly increased. This is what Christensen (2003) would call a high-end or "new-market disruption" as it targets customers with needs previously not served by existing suppliers. As stated before, frugal innovations that prove inclusive would probably be more of a new-market disruption type.

Last but not least, regarding the impact on inclusiveness two inclusiveness increasing aspects of Kilimo-Salama are to be found in reduction of transaction costs (no need for traditional claim processing process), increase in access of the poor to agricultural insurance services and therefore increase in self-reliance of the rural poor.

The similarities in distribution channels used by Kilimo-Salama and M-Pesa may result in similar inclusiveness decreasing aspects as the ones pointed out for M-Pesa. This should be investigated in future research.

M-Farm has been successful in creating a consistent market in the agricultural sector. The direct benefits of users stemming from their access to market prices information and linkages with far away markets are their increase in earnings, which have doubled or even tripled. M-

Farm is connected to M-Pesa, Kenya's mobile money system, which allows unbanked farmers to manage their revenues easily.

The impact of M-Farm on the governance structures as agricultural markets are:

- 1) Empowered farmers with price transparency and market access. Before M-Farm the only source of information was their (potential) buyers (Solon 2013). Prior to M-Farm it took farmers a week to know the prices of the crops already sold. M-farm seeks to solve the problem of lack of transparency, and the farmer problem of not always receiving the best price for their products by providing up-to-date market prices via an app or an SMS to farmers.
- 2) Creation of a consistent market - lowering transaction costs across the agricultural supply chain. As documented by Karugu (2010) small scale farmers experience important constraints within existing agricultural markets as ; which includes *long chains of transaction between the farmer and the consumer, poor access to reliable and timely market information, small volumes of products of highly varied quality offered by individual smallholder farmers, and poorly structured and inefficient markets*(Karugu, 2010).
- 3) The M-Farm tool deals with the problem of low volume suppliers which resulted in buyers in big cities preferring other suppliers to avoid the high transaction costs involved in acquiring the larger volumes they required from multiple and different farmers. M-Farm offers a group selling tool which enables farmers to pool resources and achieve a higher volume supply – as required by the final client- by bringing their products to specified drop off points. Additionally to reduce transaction costs for buyers and increase trust in the system, all transactions are handled by M-Farm's integrated mobile money transfer system -- drawing on mobile payment technology M-Pesa. As described by Solon (2013) once an order is placed through M-Farm, the farmer brings the products to the corresponding collection point and sends a SMS to confirm its delivery. Following on that confirmation the buyer collects the products and sends a SMS to M-Farm confirming receipt according to the agreed quantity and quality. Only after this confirmation, the money is released by M-Farm to the farmer's account.

M-Farm is also working to facilitate access to the open market through their aggregators. The system works – as documented by Baumüller (2015) works as

follows. The aggregator sends an SMS to the farmers to inform them about the crops that a buyer wants to purchase. Farmers can then express their interest in selling their crops by sending an SMS to the short code, including a unique identifier for each farmer. The information is posted on the website. Once the transaction is approved by the buyer, the farmer supplying the crop sends another SMS to confirm the delivery. The quality is checked by the aggregator. The buyer itself takes care of the transport.

- 4) Increased international transparency of agricultural supply chains and accountability of companies towards the consumers in their home markets, as well as facilitating the enforcement of international regulations on for instance the use of pesticides (Solon 2013). An example is UK large retailers interested in the platform as they want to be more responsible in the way that they source their products.

The M-Farm innovation seems to have an impact beyond the agricultural sector. The reduction in transaction costs for all parties and therefore the increase in efficiency of agricultural markets are expected to translate in productivity gains as a larger share of resources is free up for productive activities. An example of these mechanisms is already seen in is the impact of M-Farm on poverty reduction and environmental health (Mungai, 2005) which is expected to lead to a sustainable increase in productivity levels in the agricultural sector. By increasing profitability of farming, the service indirectly allows farmers to increase their revenues without having to increase production. Accordingly it becomes easier to make a farmer aware and that he starts to value the benefits of protecting his land from pollution or unsustainable use in order to guarantee future returns on investment.

The most important contribution of M-Farm to inclusiveness is the creation of a consistent market that opens access to and benefits mostly small scale farmers. This increase in market consistency is the result of higher speed in information transfer, as farmers have near real time information about prices of different crops in different cities; and a significant reduction in information asymmetry and even power asymmetry given the architecture of the mobile application.

5. Discussion

The illustration cases seem to point that that our general conceptual framework – depicted in Figure 1- as well as the more detailed one regarding the impact of mobile applications on productivity and efficiency – depicted in Figure 3- is helpful in supporting the study and the generation of new insights regarding the impacts of these GPT innovations on productivity, public service provision and inclusiveness. These impacts are better understood when first looking at the changes brought forward by the use of mobile applications on governance structures and transaction costs.

In all three illustrations we observe that the use of mobile applications given through the direct consequences of the use of mobile technology – such as greater traceability, registration accuracy, access to information and speed of information transfer at lower costs- leads to more transparency of systems, less intermediaries and higher market consistency. And as these effects all together lead to lower transaction costs and reduced opportunities for opportunistic and/or corrupt behaviour both increasing the (perceived) reliability and trust of users on the governance structures backed by mobile technology; they trigger the generation of two virtuous cycles. Firstly an increase in the number of transactions that can ultimately translate into further improvements in mobile technologies and an exponential growth in the share of the population shifting towards the use of these new service provision platforms which often means a higher share of transactions taking place within the formal economy. Secondly, a larger share of resources all together can be invested in productive activities impacting positively the productivity levels of the sector.

While all these mechanisms and causal links seem present in the three illustration cases, each case is particularly strong in illustrating a number of them. M-Pesa appears to have the strongest illustration value in terms of its impact in behavioural change and its pervasive characteristics going beyond the financial sector. Kilimo-Salama is particularly useful to illustrate the effect that new business models backed up by mobile applications can have not only on governance structures but even further on the institutional environment; challenging the status quo regarding the allocation of responsibilities in the provision of public services such as Disaster Risk Management. In this case the introduction of affordable insurance schemes for small farmers is changing the traditional public good nature of the task of disaster relief and making possible a new paradigm of shared responsibility between government, farmers and input suppliers. Meanwhile M-Farm illustrates clearly the effect of

higher speed of information transfer and reduction in costs of direct information transfer and transaction costs on market consistency. It also exemplifies how the motivation of local entrepreneurs and their understanding of key constraints faced by the BoP can influence the design process and contribute to inclusiveness.

Through its functionalities M-Farm deals with key constraints faced by small farmers, enabling them to access new markets and negotiate better prices. Example of these functionalities are: collection points with cooling facilities, aggregation of production of different small farmers to satisfy the larger size of order required by the clients, mediation and quality control that increase the trust in the system. Local conditions and the motivation of the female trio of founders - all daughters of farmers- have shaped M-Farm endeavour to remove main barriers for smallholders.

Nevertheless it should be pointed out that M-Farm as all other SMS based market price systems could increase further their coverage within the Bottom of the Pyramid if mobile phones design is reconsidered and innovative education interventions are implemented to deal with cultural, educational and affordability constraints faced by the extreme poor. Wyche and Steinfeld (2015) discovered a mismatch between the design of Market Information Systems (MIS) and smallholder farmers' perceptions of their mobile phones' communication capabilities. Based on these findings they encourage software developers and development practitioners to adopt an "ecological perspective" when developing mobile applications for rural farmers especially in sub-Saharan Africa.

Baumüller (2015) is pointing out that M-Farm is a standalone service which is unlikely to be adopted by the poorest farmers as it requires a certain level of market orientation and market access for farmers to use price information effectively. Baumüller (2015) compares M-Farm users in different districts and finds that on the whole surveyed farmers and households using M-Farm tend to be better off, better educated, located closer to markets and have better access to phones and radio as compared to those that did not use M-Farm. M-Farm is also likely to target farmers that are organised in order to enable marketing of the price information service to a group and to facilitate the collective selling of produce. Baumüller (2015) concludes that to extend the reach and utility of M-Farm to the poorest, it is required that the service is integrated into a broader, long-term strategy to increase productivity, commercialisation and market linkages. M-Farm collaboration with the Anglican Church of Kenya Development Services (ADS) in the districts researched moves already in that direction, though still on a limited scale. Similar initiatives would need to be

supported by larger scale interventions, such as infrastructure developments (e.g. roads, storage facilities), extension services and the provision of inputs and other technologies.

It is important to note the importance of the choice of distribution channels. As mentioned before the similarities in distribution channels used by Kilimo-Salama and M-Pesa may result in similar inclusiveness decreasing aspects for both of them.

6. Conclusions

This paper examines how frugal innovations in IT affect the constraints of the local economy in developing countries. The three main research questions dealt with in each illustrative case have been: (1) do recent technological developments in mobile phone technology provide scope for frugal innovations? (2) How do mobile phone technology-induced frugal innovations address the resource constraints in developing economies? Provided that innovations such as M-Pesa have inclusiveness reducing aspects, also the question arises on how these inclusiveness reducing factors can be dealt with. (3) What is the impact of these innovations on the provision of public services and effective access of the poor to them? Do they contribute to good governance and efficiency and productivity gains?

Summarizing, what is the impact of mobile phone technology - as frugal innovations- on productivity, public service provision and inclusiveness?

Firstly, with the concept of General Purpose Technologies it is shown that the pervasiveness of recent mobile phone technologies as a specific IT technology has potential to generate frugal innovations. Secondly, mobile phone technology-induced frugal innovations – as illustrated by the three cases in Kenya- do seem to address the resource constraints in developing economies, ultimately resulting in efficiency and productivity gains as well as improvement in service provision. The pervasiveness of IT technologies can be expected to lead to improvements in governance due to the use of mobile phone technology via three main mechanisms: 1) IT and mobile phone technology means automatic registration of all transaction details, which increases the traceability of transactions and consequently the transparency of the system, 2) the mobile applications in most cases eliminate the need for middlemen or at least reduced significantly their power, which again translate in a reduction of transaction costs, 3) citizens have been empowered due to greater access to information,

which in many cases translate in less power asymmetry between citizens and their governments and/or services providers and higher demand for accountability.

The cases of M-Pesa and its applications in Kilimo-Salama and M-Farm reveal the potential of the first two mechanisms, which have a positive economic impact as they translate into an increase in productivity levels and improvements in service provision in general. Thirdly, the question whether or not the positive economic impacts of these mobile phone technology-induced frugal innovations are inclusive has been worked out conceptually by distinguishing between inclusiveness impacts in the short and longer term. Although these applications have the potential to change citizens' empowerment this impact can take momentum in the longer term after technology induced changes in power relations. In the short term technological shocks take place in existing power relations and are likely not contributing to inclusiveness of the benefits generated by these innovations.

7. Future research

Future research is necessary in order to cover the research limitations of this study. First, as the present study is based on case illustrations a follow-up study would be empirical addressing more precisely the impact of M-Pesa on informal distribution networks and consequent employment and the trade-off with inclusiveness. A systemic and dynamic modelling approach is required to allow for a more comprehensive and quantitative evaluation of the total (direct and indirect) costs and benefits for society as a whole as well as the poor in the BoP. Second, it would be interesting to investigate how the lack of inclusiveness in the short term can be softened. An aspect that deserves special attention is the study of whether without an enabling environment and an active role of public policies on protecting the weakest in society, an innovation can or cannot be expected to have on its own merit positive impact on inclusiveness in the short term. Third, private sector activities such as value sensitive design taking into account inclusiveness aspects a priori in design of new technologies are also a challenge for future research. Finally, in the context of the Sustainable Development Goals and the Addis Ababa action Agenda which introduced a new and global framework for Financing for Development post-2015 it is important to research the effect of these innovations in IT on efficiency in the provision of public services through addressing market failures. Are public services – generally considered natural monopolies to be provided by the government sector – becoming more and more suitable for private service provision?

And, does this increase efficiency along with the possibilities opened up by these mobile applications in terms of measurement, enforcement, market size and in the long term even on ideological attitudes and perceptions about service provision and willingness to pay by citizens; enlarges the potential of a blended finance strategy for these sectors?

Notes

¹ The inventory of mobile applications and their impacts as mentioned above is available upon request

² In 1973 Ronald McKinnon published his book *Money and Capital in Economic Development* in which he argued that financial systems in many developing countries were repressive due to corruption in an unreliable banking sector. Artificially low interest rates resulted in a low level of savings in the banking system and consequently less available funds for productive investments. Increasing the interest rates would be a remedy to reduce the repression. Experiences in South-Korea revealed that McKinnon's argument was right. M-Pesa has a similar effect as the better registration of transactions and hence the increased transparency increase trust in the banking sector which provokes more savings.

³ Peša (2016) executed an empirical study on mobile money use in Zambia and finds that for the moment that the power relations have hardly changed.

References

- Alexandre, C. (2010) *10 Things You Thought You Knew about M-PESA*. Retrieved from: <http://www.cgap.org/blog/10-things-you-thought-you-knew-about-m-pesa>
- Altamirano M. A (2010) *Innovative contracting practices in the road sector*. Technische Universiteit Delft, Delft
- Altamirano, M. A. (2017). *A Financing Framework for Water Security*. World Water Congress, Cancun, Mexico, Future Earth
- Baumüller, H. (2015) *Agricultural Innovation and Service Delivery through Mobile Phones. Analyses in Kenya*. Faculty of Agriculture, Doctoral dissertation, *University of Bonn, Bonn*.
- Beck, T., Demirgüç-Kunt, A., and Martinez Peria, S. (2007) Reaching Out: Access to and Use of Banking Services across countries. *Journal of Financial Economics* 85(1): 234–266.
- Breshanan, T.F. and Trajtenberg, M. (1995) General Purpose Technologies. *Journal of Econometrics* 65(1): 83-108.
- Brynjolfsson, E., T. W. Malone, V. Gurbaxani, A. Kambil. 1994. Does Information Technology Lead to Smaller Firms? *Management Science* 40(12): 1628-1644.

- Cervantes-Rodriguez, M., Grosfoguel, R., and Mielants, E. H. (Eds.). (2008). *Caribbean Migration to Western Europe and the United States: Essays on Incorporation, Identity, and Citizenship*. Temple University Press.
- Christensen, Clayton M. (2003). *The innovator's solution: creating and sustaining successful growth*. Harvard Business Press.
- Christensen, C. M., Baumann, H., Ruggles, R., and Sadtler, T. M. (2006). Disruptive innovation for social change. *Harvard business review*, 84(12), 94.
- Christensen, C. and Raynor, M. (2013). *The innovator's solution: Creating and sustaining successful growth*. Harvard Business Review Press.
- Cull, R., (2010) M-PESA. Mobile Payments. Improved Lives of Kenyans. Available at: <http://go.worldbank.org/0SE6OB70I0>.
- Durantín, A., Fanmuy, G., Miet, S., and Pegon, V. (2017). Disruptive Innovation in Complex Systems. In *Complex Systems Design and Management* (pp. 41-56). Springer International Publishing.
- Forrester, J. W. (1994). System dynamics, systems thinking, and soft OR. *System dynamics review*, 10(2-3), 245-256.
- Eirik G. Furubotn and R. Richter (1997), *Institutions and Economic Theory: The Contribution of the New Institutional Economics*, Ann Arbor: The University of Michigan Press, p. 5.
- Gerard, G., McGahan, A.M. and J. Prabhu (2012) Innovation for Inclusive Growth: Towards a Theoretical Framework and a Research Agenda. *Journal of Management Studies* 49(4): 661 – 683.
- Groenewegen, J., and M. De Jong (2008) Assessing the potential of new institutional economics to explain institutional change: the case of road management liberalization in the Nordic countries. *Journal of Institutional Economics*, 4(1), 51-71.
- Jack, W. and T. Suri (2010a) The Risk Sharing Benefits of Mobile Money. *MIT Working paper*.
- Jack, W. and T. Suri (2010b) The Economics of M-Pesa. *MIT Working paper*, Available at <http://www.mit.edu/~tavneet/M-PESA.pdf>
- Jack, W. and T. Suri (2011) Mobile Money: The Economics of M-Pesa. *NBER Working Paper 16721*.
- Jovanovic, B. and P.L. Rousseau (2005) General Purpose Technologies. In: P. Aghion and S.N. Durlauf (eds.) *Handbook of Economic Growth*. Amsterdam: Elsevier.

- Kabbucho, K, Sander, C. and P. Mukwana (2003) Passing the Buck – Money Transfer Systems: The Practice and Potential for Products in Kenya. *MicroSave*, Nairobi, Available at: http://www.microsave.net/resource/passing_the_buck_in_east_africa_money_transfers_systems_the_practice_and_potential_for_products_in_kenya#.WCA9US0rJhE
- Karugu, W. (2010) Kenya Agricultural Commodity Exchange (KACE): Linking Small-Scale Farmers to National and Regional Markets. *New York*.
- Kehinde, J. S., & Adejuwon, K. D. (2011). Financial institutions as catalyst to Economic Development: the Nigerian experience. *European Journal of Humanities and Social Sciences*, 8(1), 322-334.
- Kim, L. (1980) Stages of development of industrial technology in a developing country: a model, *Research Policy*, 9(3): 254 – 277.
- Kim, I. and R. Nelson (2000) *Technology, learning and innovation: experiences of newly industrializing economies*, Cambridge University Press, Cambridge, United Kingdom.
- Lipsey, R.G., Carlaw, K.I. and C.T. Bekar (2005) *Economic Transformations. General Purpose Technologies and Long term Economic Growth*. Oxford: Oxford University Press.
- Lambert, R. A. (2001). Contracting theory and accounting. *Journal of accounting and economics*, 32(1), 3-87.
- Lucas Jr., R.E. (1990) Why Doesn't Capital Flow from Rich to Poor Countries? *American Economic Review* 80(2): 92 – 96.
- Mbiti, I., and D.N. Weil (2011) Mobile banking: The impact of M-Pesa in Kenya, NBER Working Paper 17129. Available at: http://www.econ.brown.edu/faculty/David_Weil/Mbiti%20Weil%20NBER%20working%20paper%2017129.pdf
- Meagher, K. (2016) Cannibalizing the Informal Economy: Frugal Innovation and Economic Inclusion in Africa, *paper presented at the Centre for Frugal Innovation in African Conference on frugal innovations 2015*, The Hague.
- Ménard, C. (1995). Markets as institutions versus organizations as markets? Disentangling some fundamental concepts. *Journal of economic behaviour and organization*, 28(2), 161-182.
- North, Douglass C. (1992). Transaction costs, institutions, and economic performance. San Francisco, CA: ICS Press.
- Morawczynski, O. and M. Pickens (2009) Poor People Using Mobile Financial Services: Observations on Customer Usage and Impact from M-PESA CGAP Brief Online

http://www.cgap.org/gm/document1.9.36723/BR_Poor_People_Using_Mobile_Financial_Services.pdf

- Mungai, W. (2005) Using ICTs for Poverty Reduction and Environmental Protection in Kenya. The “M-vironment” Approach. In: Andejelkovic, M. (ed.) *A Developing Connection: Bridging the Policy Gap between the Information Society and Sustainable Development*. Winnipeg, Canada: IISD.
- Ogodo, O. (2010). *Kenyan Farmers Get Micro-insurance.*” Science and Development Network News, March 22. Retrieved from: <http://www.scidev.net/en/news/kenyan-farmers-get-micro-insurance.html>, accessed September 2010.
- Pack, H. and L. Westphal (1985) Industrial Strategy and Technological Change, *Journal of Development Economics*, 22(1): 87 – 128.
- Okunseinde, M. (2014) *The Electronic Wallet System: How Nigeria is Dialling into Its Agricultural Sector*. Retrieved from: <https://www.covafrika.com/2014/08/the-electronic-wallet-system-how-nigeria-is-dialing-into-its-agricultural-sector>.
- Pickens, M., Porteous D., and S. Rotman (2009) Scenarios for Branchless Banking in 2020. Focus Note 57. Washington, D.C.
- Peša, I. (2016) The “Transformational” Potential of Mobile Money in Zambia, *paper presented at the Centre for Frugal Innovation in African Conference on frugal innovations 2015*, The Hague.
- Plyler, M., Hass, S. and G. Nagarajan (2010) Community-Level Economic Effects of MPESA in Kenya: Initial Findings, IRIS Center Report, University of Maryland. <http://www.fsassessment.umd.edu/publications/pdfs/Community-Effects-MPESA-Kenya.pdf>
- Prahalad, C. K. (2010) *The Fortune at the Bottom of the Pyramid: Eradicating Poverty Through Profits*. Upper Saddle River, NJ: Wharton School Publishing.
- Prahalad C.K. and A. Hammond (2002) Serving the World’s Poor Today, Profitably. *Harvard Business Review*, September, Harvard Business School Publishing Corporation.
- Radjou, N., Prabhu J. and S. Ahuja (2012) *Jugaad Innovation. Think Frugal, Be Flexible, Generate Breakthrough Growth*. Jossey-Bass, USA: Wiley.
- Rao, B.C. (2013) How Disruptive is Frugal? *Technology in Society*, 35, p. 65-73
- Rogers, E. (2003) *Diffusion of Innovations*. New York: Simon and Schuster.
- Schumacher, E.F. (1973) *Small is Beautiful. A study of economics as if people mattered*. London: Blond and Briggs Publishers.

Syngenta Foundation. Fact sheet: Kilimo-Salama ("Safe Agriculture). Retrieved from: http://www.syngentafoundation.org/__temp/Kilimo_Salama_Fact_sheet_FINAL.pdf

Solon, O. (2013) M Farm empowers Kenya's farmers with price transparency and market access: <http://www.wired.co.uk/article/mfarm>.

Tamasane, T. (2011). Analysis of services for orphans and vulnerable children in Lesotho: a desktop review. Maseru: Human Science Research Council: 2011.

Tamasane, T., and J. Head (2010). The quality of material care provided by grandparents for their orphaned grandchildren in the context of HIV/AIDS and poverty: A study of Kopanong municipality, Free State. *SAHARA: Journal of Social Aspects of HIV/AIDS Research Alliance*, 7(2), 76-84.

The Economist (2016) *The shadow economy. Unregulated, untaxed, unloved*. October 15th, 53 – 54.

van Beers, C. (2010) *On Revolutions and Adjustments. Technological Shocks and Firm Performance*, Inaugural speech Delft University of Technology (in Dutch).

Van Beers, C., Knorringa, P. and A. Leliveld (2018) Can Frugal Innovations be Responsible Innovations? In: Ortt, R., Blaauw M., and, van den Hoven, J. (eds.) *Responsible Innovation*, Routledge Publishers, *forthcoming*.

Williamson, O. E. (1979). Transaction-cost economics: the governance of contractual relations. *The journal of Law and Economics*, 22(2), 233-261.

Oliver E. Williamson (1981), The Modern Corporation, *Journal of Economic Literature* 19 (4):1537-1568, p. 1544.

Williamson, O. E. (1996). *The mechanisms of governance*. Oxford University Press.

World Bank (2017) *ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions*. Updated Edition. Washington, DC: World Bank.

Wyche, S., and C. Steinfeld (2015) Why Don't Farmers Use Cell Phones to Access Market Prices? Technology Affordances and Barriers to Market Information Services Adoption in Rural Kenya. *Information Technology for Development* 22(2): 320-333.

Zeschky, M., Widenmayer, B. and O. Gassmann (2011) Frugal Innovations in Emerging Economies. *Research Technology Management* 54(4): 38-45.

The Economist, 2010, "*First break all the rules: The charms of frugal innovation*", The Economist Newspaper Ltd. Apr 15, 2010. Retrieved September 8, 2017.

Crabtree, J. "More with less." FT.com. May 19, 2012. Retrieved September 8, 2017.

The Global Research Alliance website, accessed September 8, 2017, <http://www.theglobalresearchalliance.org/index.php/inclusive-innovation>.

Graphics

Figure 1: Analytical framework

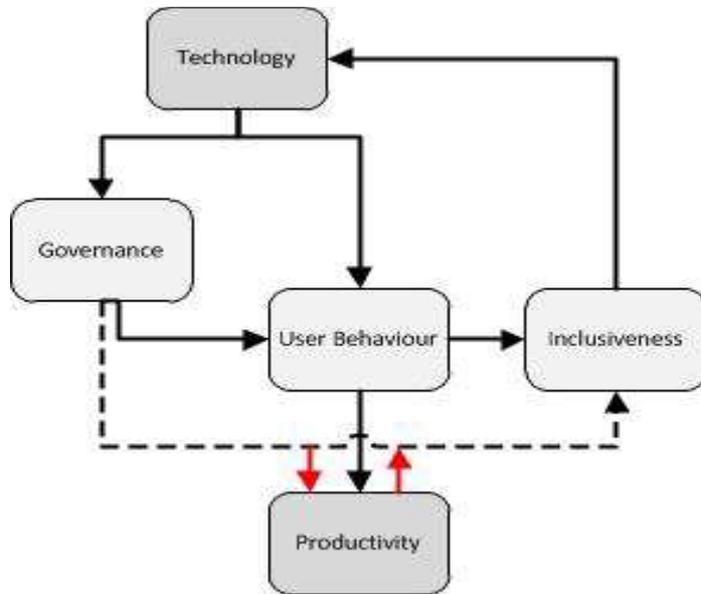


Figure 2: Relationship technological system innovation and inclusiveness over time

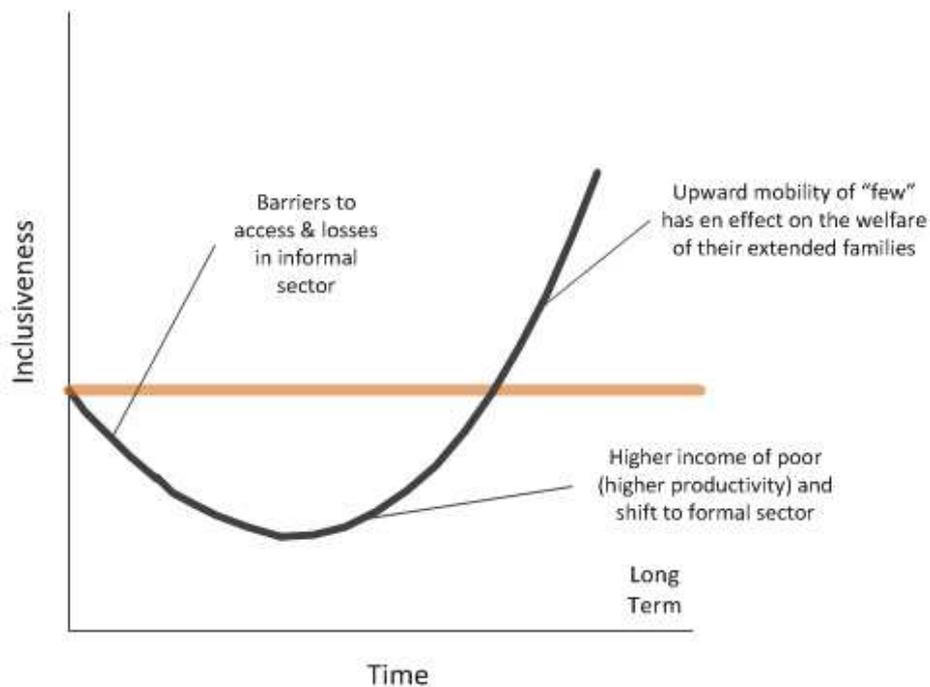


Figure 3: Causal Loops triggered by the Use of Mobile Technology that explain changes in productivity

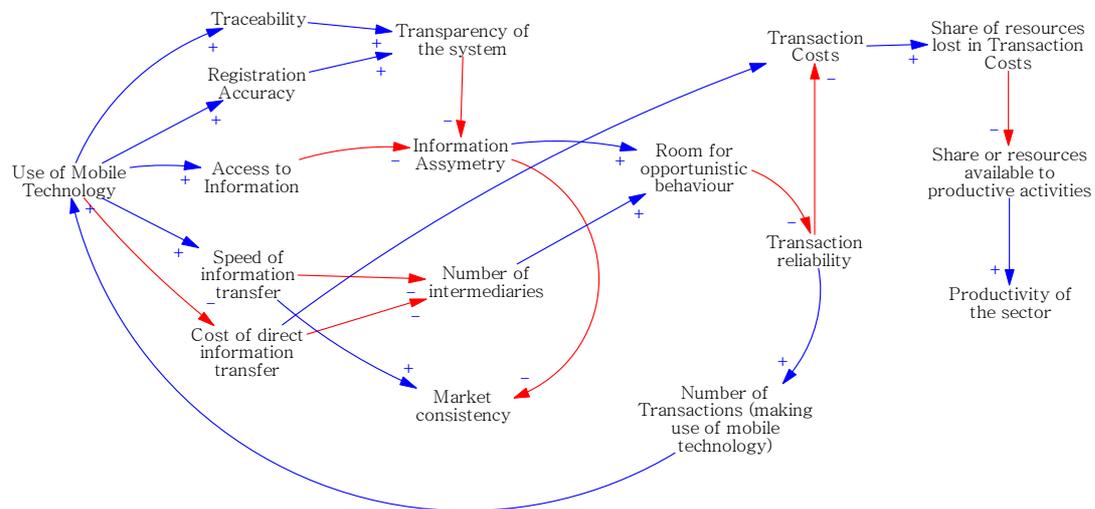


Table 1: Description of cases in the first and second wave of mobile phone applications

Application (wave)	Case content	Suppliers	Business model	Potential customers/users
M-Pesa (first)	Mobile transfer solution that enables customers to transfer, deposit and withdraw money with mobile phones	Vodafone/safari.com	Service is paid by users and there are clear incentives built for suppliers to actively continue offering the service. Pricing has been designed so as to achieve widespread adoption.	Whole adult population.
Kilimo-Salama (second)	Agricultural micro-insurance through mobile phones, for maize and wheat farmers so they may insure their farm inputs against drought and excessive rainfall; linked to M-Pesa.	Syngenta Foundation (Private company), UAP insurance company and M-Pesa	Farmers pay 50% of the insurance premium and Syngenta (input supplier company) covers the other 50%.	Farmers in Kenya, Rwanda and Tanzania. Before the introduction of the micro-insurance a limited number could afford such cover because of the elevated costs. <i>Almost all KS clients are smallholders scattered throughout rural areas (Syngenta Foundation)</i>
M-Farm (second) 2010	Gives farmers transparent market price information, aggregates their farm input needs and creates market linkages. It also connects farmers with buyers directly, eliminating the middlemen; linked to M-Pesa.	Female trio of entrepreneurs with strong IT background, all children of farmers (Private for-profit SME)	For every deal done a transaction fee is charged for using the platform. Other revenues come from addition selling data to research institutions looking at consumer behaviour and food security (Solon 2013).	7,000 users: farmers and groups of farmers, as well as buyers in Kenya. Target group are smallholder farmers.

Table 2: First wave of mobile applications: M-Pesa direct and indirect effects on user and local economic environment

Direct Effect	Indirect Effects		Direct and indirect benefits	
Direct benefits to user	Impact on governance of the sector (Market failures or governance problems dealt with)	Change in user behaviour	Impact on productivity	Inclusiveness
Reduction of transaction costs due to: <ul style="list-style-type: none"> - Faster –instant transfer (1 minute) - Cheaper (1/5th of instant sending through formal challenges) - More reliable (nearly 100%) 	<ul style="list-style-type: none"> - ↑↑ Transparency - ↓↓ number of intermediaries <li style="text-align: center;">↓ - ↓↓ Information asymmetry - ↑↑ Transaction reliability <li style="text-align: center;">↓ - ↓↓ Transaction costs - ↑↑ Poor’s access to financial services (banked the unbanked) - ↑↑ Higher market competition for serving the poor - ↑↑ Efficiency of banking system (speed) - ↓↓ Costs of money transfer 	<ul style="list-style-type: none"> - Changed savings behaviour and patterns of remittances - ↑↑ ability of households to smooth risks - ↑↑ 11% in bank use - ↑↑ use of formal saving instrument – shift from informal tools to M-Pesa 	<ul style="list-style-type: none"> - ↑↑ number of transactions - ↑↑ Share of resources going to productive activities - ↓↓ Scarcity of cash in rural areas - ↑↑ rural livelihoods - ↑↑ growth rates of (small-scale) firms in rural communities - ↑↑ farm employment - ↑↑ Market activity (especially outside cities) 	<p>Consumer households/ long term (Inclusiveness <u>increasing</u> aspects) In 2012 70% of households and more than 50% of rural, poor and unbanked population in Kenya used M-Pesa (Alexandre 2010). Additionally M-Pesa due to lower visibility of transfers may empower family members traditionally with less bargaining power so as women (Jack and Suri, 2011).</p> <p>Production and sales/ short term: (Inclusiveness <u>reducing</u> aspects)</p> <ul style="list-style-type: none"> - Generation of jobs with limited growth opportunities - Inequalities remain as tellers work long hours for low wages without prospects of career growth (Peša 2016)

Note: ↑ = increase; ↓ = decrease; ↓ = causal arrow

Table 3: Second wave of applications: Kilimo-Salama and M-Farm, direct and indirect effects on users and local economic environment

	Direct effect	Indirect effect	Direct and indirect effect		
Applica tion name	Direct benefits experienced by user	Impact on governance of the sector (Market failures or governance problems dealt with)	Change in user behaviour	Impact on public provision and/or on productivity	Inclusiveness
Kilimo-Salama	Food security and reduction in income volatility due to weather variability. Access to affordable Insurance products regardless of farm size.	<p>Citizens, scattered (poor) smallholders have been empowered by the possibility to take insurance on their inputs and hereby become less dependent on state/ international aid.</p> <ul style="list-style-type: none"> - ↓ Transaction Costs (no need for traditional claim processing process) - ↑ Access of the poor to insurance products 	<ul style="list-style-type: none"> - By reducing their risks, insurance encourages farmers to invest in their farms. This way, they can raise their yields. 	<ul style="list-style-type: none"> - disaster relief is becoming a shared responsibility, - A new insurance market for small (poor) farmers has been created - Farmers are being empowered and enable to take own responsibility. 	<p>Consumers:</p> <ul style="list-style-type: none"> - Increased access to insurance schemes for small farmers, e.g. maize producers smaller than 2 acres (micro-insurance) - Insurance is made affordable through a “risk sharing” arrangement <p>Production and sales:</p> <ul style="list-style-type: none"> - Similar inclusiveness reducing aspects as M-Pesa as it use the same structures for distribution
M-Farm	<p>Daily prices of different commodities in 5 markets that results in:</p> <ul style="list-style-type: none"> - Sales increase - Lower costs of (supplies) - Better margins - A consistent market 	<ul style="list-style-type: none"> - ↓ number of intermediaries <li style="text-align: center;">↓ - ↓ Information asymmetry (increase in price transparency) - ↑ Transaction reliability - ↑ Market access <li style="text-align: center;">↓ - ↓ Transaction Costs - ↓ Transportation Costs - ↑ Market consistency - ↑ Transparency of agricultural supply chains - ↑ Companies’ accountability towards their consumers. 	<ul style="list-style-type: none"> - Farmers start to negotiate with brokers on who to share the marginal benefit - Compare among markets – and after calculating transportation costs decide which market to supply - With M-farm price trends the make more informed decisions on when to plant 	<ul style="list-style-type: none"> - ↓ Transaction Costs across the agricultural value chain - ↑ Share of resources going to productive activities (less food is lost) - ↑ Investment of small holders in high quality inputs 	<p>Inclusiveness increasing aspects; main barriers for access to market for smallholders are dealt with:</p> <ul style="list-style-type: none"> - Access to storage infrastructure is provided through drop-off points - Low volume , through group selling tool - Trust and transaction costs for buyers – payment mechanism and role of aggregators

Note: ↑ = increase; ↓ = decrease; ↓ = causal arrow

