

# ICT4D in Rural Settings

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*Towards an Evidence-Based Causal Model; a Systematic Review*



SPM5910 – Master Thesis

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## I. Preface

The reason for choosing this research topic was twofold: trying to make sense of a large amount of information in a systematic way seemed an interesting challenge and experience, and the domain of ICT4D seemed valuable to the world at large. It is up to the reader of this research to value the extent to which I have contributed to the latter, but it sure was an interesting and valuable experience.

For this I would like to thank my graduation committee, and especially Leon Hermans for his patience, balanced and positive mood and general inspiration. My gratitude goes out to Ruben Ruerd as well, for offering me his confidence and the position at the Dutch ministry of Foreign Affairs where I was able to write this thesis. Additional thankfulness goes out to Laurien for her support at home and to Rens for his guidance.

It was a great and interesting experience, with at least as much value in the process as in the results.

Martijn Harmsen





## Summary

### Introduction

With the economic situation limiting public sector budgets in the Western world, policy makers face increased scrutiny, resulting in increased interest in evidence-based policy design. This trend is of particular relevance to the field of international development, especially in the Netherlands where budgets for development aid have recently been cut. As a result, concerns for visibility of project success are growing, as is the interest for evidence-based policy. An upcoming field where evidence on impact is little, is that of information and communication for development (ICT4D). This research conducted on behalf of the policy and evaluations department (IOB) of the Dutch ministry of Foreign Affairs, and aims to contribute to evidence-based understanding of the field of ICT4D. In order to set a workable delimitation for the research, and match the ministry's interests in the field of development, the research will be centred on the agricultural value chain in rural areas.

The method of the research is that of a literature review, as this seems the best approach to establish an empirically based systemic overview. In order to limited bias, the review process will follow a systematic approach. Although various systematic literature review approaches have already been designed and tested, a method suitable to the characteristics of complexity of the ICT4D field was not found. Therefore, the aim of this research is twofold. Firstly, the research aims to increase insights on the use of information and communication technology (ICT) among the agricultural value chain in rural areas in developing countries. Secondly the research aims to design an improvement method for systematically gathering and synthesising evidence.

Initially, the field of using ICT for development (ICT4D) was explored in order to come to a rough sketch of its characteristics. From this exploration, it was noted that ICTs encompass a relatively broad range of technologies, and that outcomes can vary. In general, it is assumed that using ICT for development aims at reducing poverty. However, definitions of poverty were found to vary. While poverty is sometimes related to the quantitative measurement of (monetary) income, others have argued that it rather relates to the ability of people to influence and improve their livelihood. Potential impacts from ICT use predominantly match this latter notion of poverty. In total, this renders the field of ICT relatively complex, as it consists of various technologies interacting with various actors and context to achieve a range of outcomes. Therefore, a method was sought that allowed for the empirical exploration of complex interventions.

### Methods

A systematic review is a method for the systematic collection, appraisal and combination of evidence from primary research while minimizing bias. For doing so, the method follows an explicit protocol and aims for transparency and replicability of process execution and decisions made. This protocol consists of a number of steps. Initially, the research question will be (re-)formulated, and criteria for primary studies will be design. The question and protocol indicate the type of intervention(s) that will be studied, and the participants and outcomes of interest, as well as the methodological quality by which outcomes will have to be determined in order to be deemed reliable. This field of interest is subsequently translated into criteria for inclusion of primary studies. Once these inclusion criteria are established, the next step entails the searching for relevant studies. For this search process it is decided what databases will be searched and what search strategy will be used (e.g. specific search queries). Once the search process is completed the collected studies are screened against the criteria

for inclusion, and the final set of studies relevant to the research question is selected. These studies are subsequently read, and the data and findings relevant to the research question are extracted. In the final step of the review, the extracted data are combined in order to draw generic conclusions on the set of selected studies and ultimately answer the research question.

For the design of the research protocol, two broad orientations can be identified: that of exploring theory in order to distil generic concepts, themes and connections, and that of testing theory by combining empirical results from experiments. Reviews aiming for the first are often termed interpretative reviews, while those aiming for the latter are considered to be aggregative. The former generally have a more qualitative orientation, while the latter hold a more quantitative perspective. With the perspective adopted, the validity assigned to review findings also tends to vary. The theory oriented integrative reviews tend to have a broader scope, but their results are not easily replicable and more prone to bias. Aggregative reviews on the other hand follow a more rigorous approach and their findings are generally deemed more reliable. However, they tend to have a relatively narrow focus.

For this research, a method was sought that is able to provide empirically grounded results, while allowing for a relatively broad focus. Although some combinations of previous review protocols were identified, none seemed to explicitly match these requirements. Therefore a new review protocol was devised. In this approach, explicit inclusion criteria for the methodological approach of primary studies were used to ensure reliability of findings, while studies on a relatively broad range of relationships were included. Where synthesis of results is often done narratively when a broad range of effects is included, this research conducted a graphical-interpretative synthesis.

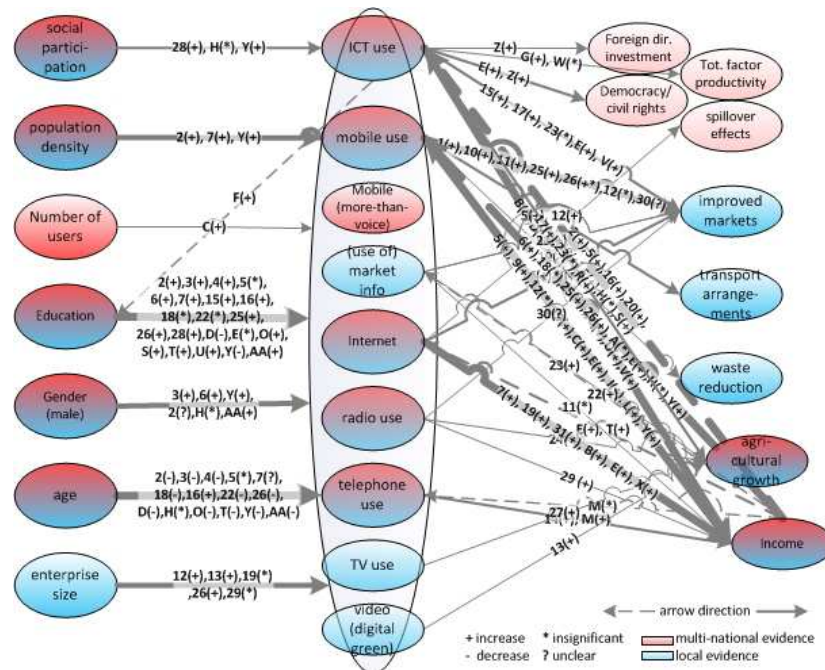
## Results

In order to satisfy constraints on time and resources, search efforts were limited to scientifically published material. Ultimately, a total of 58 studies were selected for the final research. All included studies adopted a quantitative approach towards identification of the relationships they studied, and based their analysis on a minimum sample size of 100 observations. For the analysis all reported effects and correlations from the included primary studies were extracted, and extracted relations were interpretatively combined into a graphic overview. The resulting effect map from the synthesis is depicted on the next page (**Error! Reference source not found.**). Significant effects from primary studies were categorized in a number of broad categories, and the effects signs of primary studies were noted along the resulting pathways. Although not all studies were unanimous in their findings, a relatively high level of conformity was found among them. In general, ICT use was found to improve efficiency of agricultural markets, and market participation of farmers. Other effects identified were improved international trade, the reduction of (agricultural) waste and improved transport arrangements. Agricultural output was also found to increase by ICT use, among others by increasing the adoption of improved agricultural practices. Finally, ICTs were found to increase income.

Regarding the use of ICTs, it was found that their uptake was not equally distributed among the populations studied. ICT users were generally found to be better educated, younger and more prosperous than non-users. ICT use was also found related to gender on some occasions, but the relationship varied among different studies, most likely due to differences in local context. Finally,

evidence for so called network-externalities was noted in some studies, indicating that marginal use benefits improve with the number of users of a service.

Figure 1: resulting overview of ICT4D components and relationships



## Implications

For the use of ICT4D by practitioners, the study offers various understandings. Although significant developmental effects among poor populations were found, the concentration among typical users indicates a risk for ICTs to increase local inequalities by an uneven distribution of impact. As ICT usage was found to be higher among wealthier people, interventions could focus on ICT provision to the poorer among a population. In doing so it should however be noticed that education was also found to influence ICT adoption. Therefore, ICT oriented efforts should take education levels of intended users into account. Regarding intended benefits the effect categories identified in this study could provide a starting point for intervention design. Two of the most promising impact areas are that of market improvement and agricultural extension support.

Where the method for the review is concerned, results from this case study seem interesting. Although further application is likely to increase understanding of its uses and limitations, the method helped to get a grip on relatively complex intervention spectrum and provided interesting systemic insights. It was deemed especially helpful that the method allows for explicit guidance in exploring complex domains and the formation of an evidence-based systems perspective. Where otherwise heavy reliance would be placed on (tacit) expert knowledge, the approach adopted here facilitated the use of more explicit evidence from published research in a systematic way. The use of this approach does not guarantee a complete and exhaustive overview, as decisions on breadth of search and criteria for evidence could still be set by the researcher. The method does however provide for more transparency on these decisions, and within the criteria set a more systematic and less biased approach is facilitated. Additional use might be found in following conflicting findings for the identification of relevant contextual factors.





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# Introduction

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## 1 Introduction

This report has been written on behalf of the Policy and Operations Department (IOB) of the Dutch ministry of Foreign Affairs with the aim of synthesizing evidence on the effects of ICT in development settings.

### 1.1 IOB

The Policy and Operations Department (IOB) is the Dutch ministry of Foreign Affairs' independent evaluation bureau. Its objective is *'to increase insight into the implementation and effects of Dutch foreign policy'* (IOB, 2012). In order to do so, IOB undertakes independent evaluations. These evaluations aim both to *'enable the ministers to account to parliament for policy and the allocation of resources'* and to *'derive lessons for the future'* (IOB, 2012). One of the areas of interest for IOB is that of development cooperation.

### 1.2 Accountability

Public support for development cooperation has recently been on decline, and budget reductions have been discussed as a tool to limit public spending in many OECD countries (Ruben, 2011). The call for policy accountability has increased over the past decade, resulting in a shift towards so called 'evidence-based policy' with decision makers increasingly focussing on the cost-effectiveness of policy options (Leeuw & Vaessen, 2009), (Shemilt et al., 2010). Credible evidence of what works and what does not can aid policy makers in directing their efforts (IOB, 2011), (Head, 2008) and might help in re-establishing public support for international aid (Ruben, 2011). As put by Paul Wolfowitz: *'one must convince [...taxpayers...] that their generosity will bear fruit, that there will be results'* (Savedoff, Levine, & Birdsall, 2006). A key question in evidence-guided policy is: *what are we getting for the money we're spending* (McLaughlin & Jordan, 1999). With public resources tightening, policy makers are increasingly turning to scientific evidence when choosing among alternatives (Anderson et al., 2011). As a result, funding for impact evaluations has increased, and the ability to assess the 'net effect' of an intervention has become an important aspect within the field of evaluation (Mallett, Hagen-Zanker, Slater, & Duvendack, 2012), (Ton, 2012). This research aims to contribute to the evidence base in the field of international development.

### 1.3 International development

The Dutch ministry of Foreign affairs aims to promote the interests of the Kingdom of the Netherlands abroad. Among those interests global conditions favouring Dutch interests such as foreign trade, and issues such as human rights, climate change and poverty alleviation are regarded part of those global circumstances. Priorities for the domain of development cooperation have been identified in the four spearheads of water, food security, security and the legal order, and sexual and reproductive health and rights. Although not an explicit spearhead, the ministry does however have an explorative interest in the use of ICT in development settings as indicated by (then) Minister for European Affairs and International Cooperation Ben Knapen already in 2011 (Rijksoverheid, 2011).

## 1.4 ICT in development settings

As the use of information and communication technologies has seen a rapid rise in the West over the past decades, it is argued that this has led to significant productivity increases (Hilbert, 2012), and some expect similar benefits for developing countries. An early statement about such expected benefits of ICT for development was for instance made by Al Gore, who – in an address about what he named 'the global information infrastructure' – proposed that *"...we will derive robust and sustainable economic progress, strong democracies, better solutions to global and local environmental challenges, improved health care and ultimately, a greater sense of stewardship of our small planet... [ICT] will help educate our children... it will be a metaphor for democracy itself..."* (Gore, 1994) as quoted in (Gomez & Pather, 2012). Regarding such benefits the notion of a 'digital divide' became popular around the turn of the century (Chapman & Slaymaker, 2002). From this perspective, ICT were seen as a *societal revolution* that was not spread equally throughout the world. Especially less developed countries risk falling behind, which in turn will increase the gap with the developed world (Chapman & Slaymaker, 2002). Wilson III and Wong (2003) for example stated that *Africa ... stands on the doorstep of a global information revolution ... that presents a seeming cornucopia of opportunities. According to them, [i]nexpensive, reliable, and ready access to information and communication is no longer a luxury for the few; it is a necessity for the many* (Wilson III & Wong, 2003). They noted however that it would be difficult to reach clear-cut conclusions about the precise impact of this 'revolution' for Africa (Wilson III & Wong, 2003). However, such debates about new technology have always been polarised between techno-optimists and techno-pessimists (Chapman & Slaymaker, 2002), and so is this 'information revolution' (Lee, Jang, Ko, & Heeks, 2008). Scepticism about impacts was illustrated by Bill Gates who, – at the start of this century – argued that *'the world's poorest two billion people desperately need healthcare, not laptops'* (Helmore, 2000). Other critics claimed that ICTs would strengthen existing socio-economic inequalities and favour already privileged people without doing much for the poor (Gigler, 2011).

Over time, expectations of (positive) effects grew stronger, supported by for instance the World Summit on the Information Society (WSIS) who proposed a growing role for ICTs as *'a development enabler and as a tool for the achievement of [...] the Millennium Development Goals'* (ITU, 2005). Simultaneously, the interest in ICT4D has grown quite drastically over the past decades, (Heeks, 2002a), (Gomez, Baron, & Fiore-Silfvast). As Bussell (2005) worded it: *[w]hile it continues to be unclear the actual benefits that will accrue to developing countries from the introduction of these technologies, the magnitude of activity is worthy of attention in and of itself.*

In the beginning, ICT4D efforts often focused on replicating practices that had been successful in the West without much consideration for local circumstances, which often resulted in *failure, restriction, and anecdote* (Heeks, 2008), (Walsham & Sahay, 2006). Heeks (2006), argued that the field had seen *a bias to action, not a bias to knowledge*. He noted that the research was often descriptive without being analytical, and criticised a lack of interpretation and understanding. According to him, such research has *a close-to-zero shelf life* and is analogically comparable to *stones being thrown into a pond, each one making a ripple but then sinking without trace* (Heeks, 2006). A similar call for better analysis of the mixed results from the field – especially for policy makers - was made by Batchelor et al. (2003), who stated that the research field was often descriptive and anecdotic, and that *[h]owever spectacular, successful, moving, or important some of these anecdotes may be, they remain a precarious basis for justifying major policy or investment decisions* (Batchelor et al., 2003). Therefore, various authors have called for a deeper understanding on the relationship between ICTs and

development (Gigler, 2011). This point was stressed by Donner and Toyama (2009) who argued that more evidence on the (non-) effectiveness of ICT in development settings is required. This research aims to contribute to such insights by accumulating previous research efforts.

## 1.5 Synthesis of evidence

A method for credible gathering and summing evidence on development effectiveness is the technique of systematic literature reviewing. Designed as a rigorous approach using explicit methods for search, appraisal and synthesis findings of research (Dixon-Woods et al., 2006), (Kitchenham et al., 2009), a systematic review is a scientific tool that can aid in processing quantities of research that might otherwise be unmanageable (Sally Green, 2005). By summarizing a collection of scientific research, systematic reviews can identify credible policy options and implications and in practice-level decisions (Anderson et al., 2011). Evidence collected through systematic reviews is increasingly being used to inform policy in for instance public health (Baxter, Killoran, Kelly, & Goyder, 2010). This research will therefore systematically review existing evidence.

## 1.6 Research focus: rural areas and agriculture

The focus for this research has been set to the agricultural value chain in rural areas. The focus on agriculture matches the spearhead of food-security of the ministry of Foreign Affairs, while a focus on rural areas is a good way of targeting the poor as three quarters of the poor population is living in rural areas (Michiels & Van Crowder, 2001), (Berdegue & Escobar, 2001), (World Bank, 2007). For those people, agriculture is a major source of livelihoods provision (World Bank, 2007).

## 1.7 Research goal

The general aim of IOB is to find out more about the use of ICT in development settings. This is however too broad a question to answer in a single report given constraints on time and resources. Therefore a choice was made to limit focus to the rural agrarian value chain (in developing countries). Motivation for this decision is that the world's poorest people often live in rural areas and are – to a large extent – dependent on the agricultural sector for their livelihood. The focus on rural areas is guided by the idea that differences in population density and terrain between urban and rural areas pose different constraints on possibilities and costs for infrastructure. As an aside this focus aligns with the priority topic of food security in the policy of the Dutch Ministry of Foreign Affairs.

## 1.8 Research questions

Two general guiding questions be formulated for almost any review (Heeks & Molla, 2009): 1. *What do we not know that we need to know?* and 2. *How are we going to find that out?*

The answer to those questions will be the starting point for this research. The answer to the first question denotes the main topic of interest of this research, as the interest is in the (proven) impacts of ICT in development settings. As indicated, 'development settings' in general is likely to be too broad a concept. Therefore focus will be aligned with 'food security' – one of the four priorities of the Dutch ministry of Foreign Affairs, by limiting it to the agricultural value chain in rural areas. The main question for this research will therefore be:

- Main question: *What impacts of ICTs on the agricultural value chain in rural areas have been rigorously studied and what can be learned from those studies?*

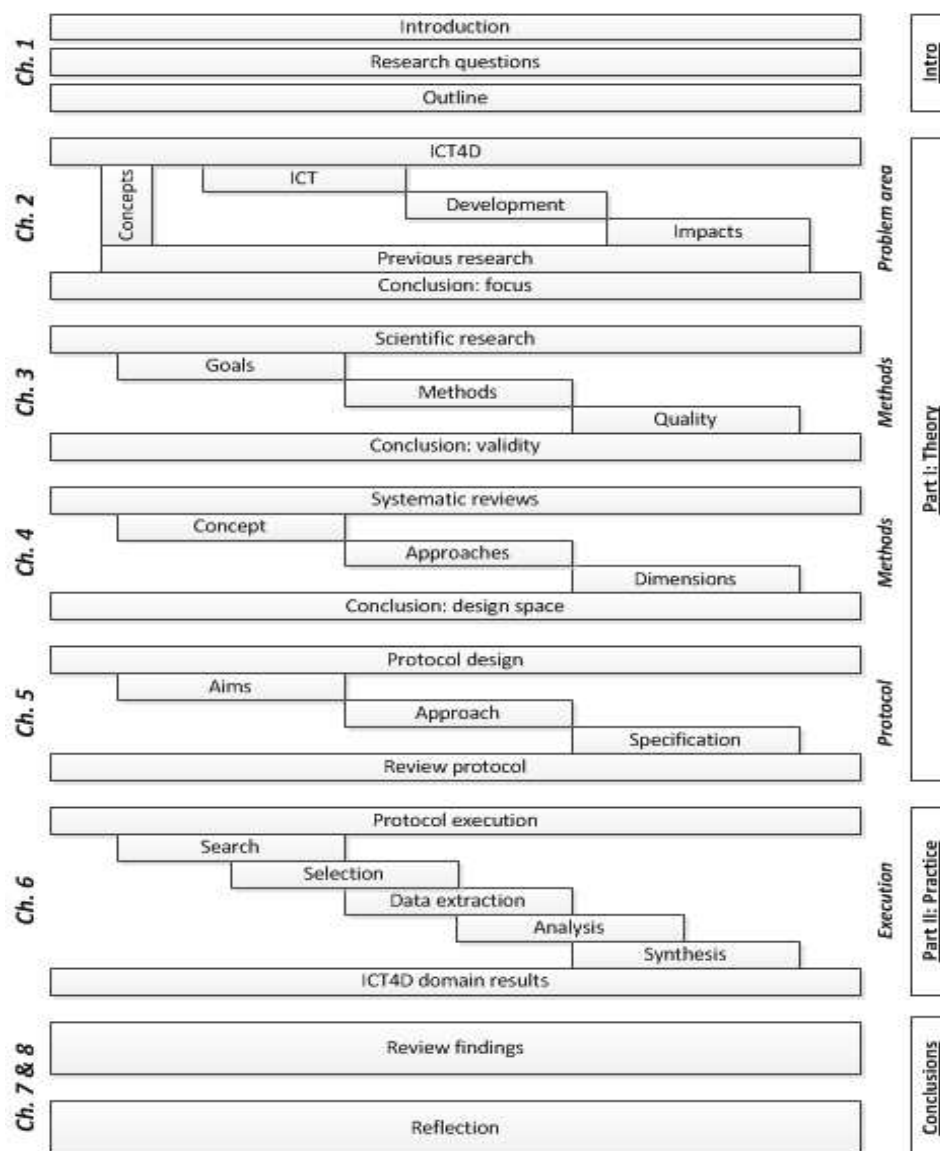
In order to find the answer to that question, the second question from above comes into play: how am I going to find that out?

The methodology that seems most suited for drawing 'correct', unbiased conclusions from a body of research seems to be the 'systematic review' discussed above. However, as this methodology originally came up within the field of medicine, and was focused on quantitatively aggregating narrowly defined interventions, it might not fully match the relatively broad question of this research.

1. What are the generic characteristics of the field of ICT4D
2. What is a useful way of providing an overview of current scientific knowledge regarding ICT4D in rural/agricultural settings?
  - a. What strengths, weaknesses and dimensions are there to the method of systematic reviews?
  - b. How should to review be positioned among those dimensions to match the field of ICT4D?
3. What are the outcomes of applying that protocol?

## 1.9 Outline

Figure 2: outline



# Part I – theoretical backgrounds

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## 2 ICT for development – an introduction

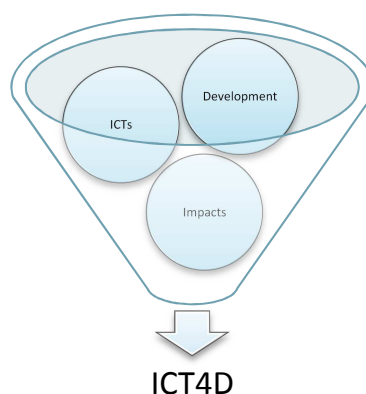
### 2.1 Introduction

This chapter provides an initial overview of the subject of this review: the use of information and communication technologies (ICTs) in development settings. This field is often referred to by the phrase 'Information and communication technologies for development' (ICT4D), and comprises *a range of activities which considers how electronic technologies can be used towards socio-economic development of developing communities worldwide* (Donner & Toyama, 2009).

This definition covers a variety of multi-purpose technologies that can be used for diverse development outcomes, and the related services and devices can be applied in almost all domains of global development (Donner & Toyama, 2009), (Geldof, Grimshaw, Kleine, & Unwin, 2011). The nucleus of the field lies in the dispersion of information through ICTs; for instance for attenuation of information asymmetries in markets or on crop conditions and credit access (Cecchini & Scott, 2003).

An example of the use of ICT in a development settings is Babajob<sup>1</sup>, an initiative in India where potential employers can outline profiles of low-skilled jobs, which are then sent to possible candidates by SMS. Other examples could be the use of ICTs for distributing information on price, agricultural developments or the weather to farmers such as e-Choupal<sup>2</sup>, or using ICTs to organize farming tasks that cannot be completed timely by individual households (Heeks, 2010a). In addition, Walsham and Sahay (2006) provided an interesting initial overview of the use of ICT in development.

As the ICT4D domain comprises (at least) three main elements (ICTs, development and impact), this chapter briefly elaborate upon them, in order to provide guidance for the review. This will – in contrast with the actual review itself – not be based on a systematic approach, but rather on a 'quick and dirty' selection of literature from databases such as Google Scholar<sup>3</sup> and Scopus<sup>4</sup>. The chapter is organized as follows. The next paragraph (0) will explore the domain international development. The following paragraph (2.3) will elaborate on the role of ICT in international development, followed by a summation of existing research on ICT4D in paragraph 2.4 and conclusions in paragraph 2.5.



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<sup>1</sup> <http://www.babajob.com>

<sup>2</sup> <http://www.echoupal.com/>

<sup>3</sup> <http://scholar.google.nl/>

<sup>4</sup> <http://scopus.com/>

## 2.2 International development

The field of 'international development' is known by many names, and can be characterized by an almost similar amount of perspectives. Other names given to this field are 'development', 'development aid', 'development cooperation', 'development assistance', 'poverty alleviation', 'official development assistance', or 'foreign aid'. The generic idea shared throughout these notions is to enable, by some sort of intervention, some sort of 'progress' in the poor(-est) areas in the world in order to reduce poverty by some conceptualization. The precise interventions used and definitions of progress and poverty aimed for may however vary, as do theories about how change will be brought about.

Walsham and Sahay (2006) characterised development as *broad and diffuse topic with a range of theorists being used*. A similar opinion was expressed by Akpan (2003), who noted that *[d]evelopment means different things to different people*. She used the definition of McLean (1996, p. 138), denoting development as: *"the fulfillment of the necessary conditions for the realization of the potential of human personality, which translates into reductions in poverty, inequality, and unemployment. (It is also) the increasing satisfaction of basic needs such as food"* (Akpan, 2003).

In order to get a better grasp of the field, the next paragraph will provide some historic background, followed by an elaboration of various conceptualizations of poverty.

### 2.2.1 History of the field

Development theory started in the 1950s, after a speech in 1949 (on Jan. 20<sup>th</sup>) by US president Truman where he *announced the formation of policy intended to make the benefits and advances of western science, technology, and progress available to the 'underdeveloped areas' of the world* (Fair & Shah, 1997). The idea of development back then was about modernisation: transforming the newly independent states of Africa, Latin America and Asia by modelling them after Western-type societies (Akpan, 2003), and relieving them *the burden of being 'underdeveloped'* (Fair & Shah, 1997). Developing countries would grow through a number of stages along the *'urban industrial route'* to ultimately come to resemble the modern societies of the developed world (Madon, 2000). This perspective on development and its goals were to a large extent defined by the USA and based on their own political-economic system and transnational corporations (Servaes, 2008). Development goals were primarily stated in terms of GDP growth (Madon, 2000).

As many developing countries showed little progress, from the 1960s onward focus shifted to less-economic aspects such as social well-being (comprising of among others health and education), political structures (focusing on democracy) and the physical environment (Madon, 2000). In this period the paradigm of dependency theory gained popularity (Lee et al., 2008), albeit largely focused on South America. This paradigm saw developed countries as the economic centre and developing countries as periphery. In essence, it was argued that integration with the West for poor countries entailed the risk of becoming locked into a dependency relation of being supplier of cheap labour and resources, while receiving little compensation. At the core of this relation was *the inability of the periphery to develop an autonomous and dynamic process of technological innovation* (Vernengo, 2006). The dependency era was characterized by two strains of thinking (Madon, 2000). In one, local goals and traditional values were given more attention, as were local redistribution of wealth and poverty alleviation. The other adhered to a more globalist perspective, advocating a global, integrated market with information and knowledge as a major force in development (ibid.).

Over the 1980s dependency theory was gradually replaced by the 'neoclassical perspective', where attention shifted from the state – which was increasingly seen as a source of problems rather than solutions – to the private sector under the credo 'less state, more market' (Rapley, 1996). This perspective incorporated many of the traditional assumptions on efficient markets that were refined only later by notions such as transaction costs, imperfect markets and uncertainty (Bedi, 1999).

Towards the end of the century a brief outburst of 'post-development thought' arose, a line of thinking where development theory in general was discarded altogether. This was followed by a shift of focus more towards the needs and concerns of the third world and emphasis on individual well-being and empowerment (Rapley, 1996) and participatory approaches (von Braun, 2010). In the past decade this was followed by greater attention for aid effectiveness and focus on control, accountability and impact assessment (von Braun, 2010).

The dynamics described above were summarized by Heeks (2005) as development having *a state agenda in the 1960s and 1970s; a private sector agenda in the 1980s and 1990s; and now perhaps an NGO agenda in the 2000s*, while Lee et al. (2008) saw eras of modernisation theory (1960s), dependency theory (1970s) and human development (2000s). Kleine (2010) argued that perspectives on poverty range from positions where development is defined by economic growth, to those arguing that inequality, dependency and uneven development are inherent to capitalist growth models, to bottom-up approaches stressing social and ecological goals besides an economic focus to *radical "post-developmental" critiques that often dismiss the entire "development project" altogether*.

The general takeaway from all this is twofold: firstly, development goals apparently are subject to change as are the impacts aimed for, and secondly, the role of technology seems most clear in the 'modernisation paradigm', while the other, more sociologically oriented paradigms might provide a less intuitive match. Additionally, multitude of perspectives and dynamics therein can be interpreted as an argument for an open minded exploration of the effects of ICTs. A fundamental question in development research is that of what is defined by 'development' (Kleine, 2010). As development fundamentally revolves around poverty alleviation of some sort, the conceptualization of poverty is a core component of development. In order to position ICTs in the development domain, a clear conception of poverty is hence required (Blake & Quiros Garzon, 2012).

### 2.2.2 Poverty

Poverty can be (and has been) defined in various ways. As worded by Berdegue and Escobar (2001), *[p]overty is multi-dimensional and is a highly heterogeneous phenomenon*; an aspect that, if neglected, might lead to *simplistic 'one size fits all' approaches* (Berdegue & Escobar, 2001). In the following paragraphs some of the main perspectives on poverty are briefly presented.

#### *Monetary metric*

A commonly used definition for poverty is the money metric, focusing on (monetarily measured) income levels. A clear practical advance of an income-based perspective lies in the aspect of measurability. Although not always as straightforward as it might seem, this is approach is possibly the most easily quantifiable one. Some problems to this approach are that not all poor people receive monetary income; often barter is used among poor societies and some people live off subsistence farming and might not receive any income at all. There is also some debate on what measures to use, e.g. on purchasing power parity versus market-based ratio's (Stiglitz, 2000).

The World Bank set an international poverty line at \$1,25 per person per day at 2005 purchasing power parity (Ravallion, Chen, & Sangraula, 2009). Regarding this benchmark, it is sometimes argued that ideas are changing from a universal, absolute measure to a definition based on relative indicators focusing on for instance social inclusion – so called 'weakly relative measures' (Ravallion, 2012).

### *Livelihoods and capabilities*

Although financial capital can enable people to live the life they value and achieve their substantive freedoms (A. K. Sen, 1999, p. 14), the monetary-measure is (also) an attempt to abstract reality in order to measure it. In somewhat of a contrast, broader concepts such as the capabilities approach seem better suited to increase understanding. Baulch (2006) for instance argued that income based perspectives fail to recognize the heterogeneity of the poor and the processes leading people to fall below or rise above the poverty line. As worded by the UNDP, *we are rediscovering the essential truth that people must be at the centre of all development. The purpose of development is to offer people more options. One of their options is access to income - not as an end in itself but as a means to acquiring human well-being. But there are other options as well, including long life, knowledge, political freedom, personal security, community participation and guaranteed human rights. People cannot be reduced to a single dimension as economic creatures... People are the real wealth of a nation. The basic objective of development is to create an enabling environment for people to enjoy long, healthy and creative lives. This may appear to be a simple truth. But it is often forgotten in the immediate concern with the accumulation of commodities and financial wealth* (UNDP, 1990).

Chapman, Slaymaker, and Young (2003) reasoned that livelihood approaches can assist in creating strategic coherence in interventions and improve the focus of programmes and policies by drawing attention to ways in which they influence access to resources and available strategic livelihood options. According to them a notable element of those (livelihoods) approaches is in transcending individual sectors (ibid).

Another, and more recent approach to (or perspective on) poverty is Amartya Sen's capabilities approach. From this perspective, poverty is linked to the (economic) freedom of people to 'cope with their livelihoods' or 'achieve their substantive freedom' (A. K. Sen, 1999). In this approach, (poor) people are considered agents of themselves, presented with a given resource base and options to use it. Poverty is defined not so much as an income level, but rather as access to vital assets. These assets can be conceptualized as *'a broad array of resources that enable people and communities to exert control over their lives and to participate in their societies in meaningful and effective ways'* (Ford Foundation, 2002). This can include things such as natural resources, technologies, skills, knowledge and capacity, health, education, access to credit, or networks of social support (IFAD). Given this perspective, the capabilities approach can be regarded a change in perception as it sees the poor as active agents rather than passive victims, and employs conceptualization of poverty beyond the monetary metric (A. K. Sen, 1999, p. 24) stressing the dynamic, multi-dimensionality of poverty (Moser, 2006). A. K. Sen (1999, p. xii) found five basic dimensions of freedom: political freedoms, economic facilities, social potentials, transparency guarantees and protective security.

The capabilities approach stretches in the same direction as the concept of sustainable livelihoods as introduced in 1992 by Robert Chambers and Gordon Conway (Krantz, 2001). Sustainable livelihoods according to a later definition *comprise the capabilities, assets (including both material and social*



resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base (Krantz, 2001). This approach also focuses on a relatively broad array of assets (and capabilities) that can facilitate or limit strategies of coping with one's environment. The sustainable livelihoods approach also identifies five types of capital: physical, financial, human, social, and natural capital (Moser, Norton, Conway, Ferguson, & Vizard, 2001).

A commonality between all approaches can be found in the metric of income. Although being the sole determinant in the money metric, the livelihoods and capabilities approaches see in financial wealth one type of resource, leaving other resources out of focus. Despite the intuitive appeal of the broader conceptualizations, scholars have however been struggling with their operationalization (Kleine, 2010), although some broader measures have been put into practice such as the human development index (Fukuda-Parr, 2003), comprised of indicators for life expectancy, education and income.

Chambers (2010) described the spectrum of poverty as laying between 'a paradigm oriented at things' and one 'oriented at people'. According to him the first is a centralised, top-down, reductionist and standardised approach, while the latter is more participative, local, decentralised and bottom-up.

**Table 1: Conceptions of Poverty, their Key Characteristics and Evaluation Approaches**

	<b>Income poverty</b>	<b>Poverty indices</b>	<b>Livelihoods approach</b>	<b>Capability approach</b>
Poverty is...	Lack of money.	Hunger, poor life expectancy, literacy, and/or education.	Impediments to people's livelihood strategies.	Impediments to an individual's means to achieve, freedom to achieve, and actual achievement of personal goals.
Typically measured by...	Income per day (\$US)	Population undernourishment and child mortality, GDP per capita, life expectancy, literacy, school enrolment.	Identifying available livelihood strategies and analyzing institutional and social structures and processes that influence their achievement.	Considering the political freedoms, economic facilities and social opportunities that enable an individual to achieve personal development.

Source: (Blake & Quiros Garzon, 2012)

As was shown above, capturing poverty in a single definition and measuring it by a single indicator is not a straightforward task and neither free of debate. The monetary metric – referring to income-based measurement – can fail to capture valuable capabilities that might matter in the road to higher income. ICT is likely to affect and possibly improve those capabilities, and hence gaining insight in ICT impact requires a broader definition of poverty. For this research, that means that studies reporting effects other than income increase are likely to be relevant for answering the research question.

## 2.3 ICT in development settings

### 2.3.1 History of the field

Despite ICT4D's connotation with modern times, the field of studying ICTs in development settings has existed for over a half century (Colle, 2008). Under the different name of DevCom – an abbreviation of 'development communication' – communication technologies such as radio and telephone were already pushed on the agenda of governments and donor agencies in the 1980s, while attention for communication in development settings dates even further back to the 1950s and 1960s (Hanna & Schware, 1990), (Donner & Escobari, 2010).

*Knowledge is an integral component of human development... Speaking, writing and reading are, thus, the cornerstones of knowledge culture for any society – they are the basic human capabilities for individuals to participate in learning; in social, cultural and economic activities; and in individual and collective decision-making* (Garai & Shadrach, 2006). They noted that development to a large extent depends on the spread and adoption of knowledge, as is illustrated by agricultural extension services where improved agricultural techniques are transferred to farmers (Garai & Shadrach, 2006).

The initial focus of 'development communication' in the 1950s and 60s was primarily on mass communication through media such as newspapers, radio and television, and less on technology for interactive communication between individuals such as telephone or computers (Servaes, 1995), (Coldevin, 2008). In that period the field of communication was boosted by the new electronic media that was put to use for persuasive communication such as advertising, public relations and propaganda (Quebral, 2011). An example of such use in development can be found in the use of communication means such as pamphlets, radio and television increase acceptance of birth control methods (Servaes, 2008). This period was characterized by hierarchical, top-down view on communication between sender and receiving public. The dominant perspective of that period is perhaps best illustrated by Laswell's formula: *'Who says What through Which channel to Whom with What effect?'* (Servaes, 2008).

The definition of 'development communication' has however varied differed with time and place, sometimes leading to regrettable confusion (Manyozo, 2006). A reasonable definition was provided by Nora Cruz Quebral in a 1971 article, stating: *If I were pressed for a definition of development communication, I would say that it is the art and science of human communication applied to the speedy transformation of a country and the mass of its people from poverty to a dynamic state of economic growth that makes possible greater social equality and the larger fulfillment of the human potential.... The purpose of development communication is to advance development.* (Quebral, 2006).

The term ICTD and some variances such as ICT4D, ICT4P (poverty), ICT4B (billions) first appeared in academic and industry circles in the 1990s, as ICTs and the internet had already begun their rise to popularity in the developed world – illustrated by the dotcom boom at the end of the millennium (Patra, Pal, & Nedeveschi, 2009). The importance of information and communication in human life was acknowledged officially by the UN General Assembly when it endorsed a statement on the Universal Access to Basic Communication and Information Services in December 1997 (Colle, 2008).

In the same period some authors (both scholarly and popular) argued the computer was to give birth to a (new) technological revolution that would lead to the 'information age' and deeply impact

society – see e.g. Toffler (1980), Hilbert (2012). A similar growth in interest for ICTs occurred in the field of development studies as illustrated by e.g. Howkins and Valantin (1997) or Mansell (1999). From these ideas on the importance of ICTS the concept of the digital divide arose, whereby too wide a divergence in IT-capabilities between the developed and developing world would cause major setbacks for the latter, while increasing the presence of ICTs would (according to some) lead to so called leapfrogs in their development. While these argumentations were often based on assumptions and expectations, after over a decade of experience the debate seems to shift towards establishing impact, of which efforts this thesis aims to provide an overview. Two of the most influential forces driving development communication in the early years of this century have been the Millennium Development Goals (MDGs) and the World Summit on the Information Society (WSIS) (Colle, 2008).

As illustrated by Fair (1989) and Fair and Shah (1997), the field of development communication shifted from a rather top-down approach where communication was seen as a silver bullet in the beginning, to more bottom-up approaches with more attention to local, contextual factors at the turn of the century. Methods of communication also shifted. In the previous century attention was mostly aimed at mass-media, later to radio and telephone and from the start of the millennium to interactive communication between individuals. The focus on 'newer ICTs' has led to introduction of all sorts of new projects, such as 'telecenters' where a bunch of computers with an internet connection was provided to poor communities in a setting similar to an internet café in the developed world. By the end of the previous century thousands of such projects had been initiated. As the initial focus was often to copy initiatives that had proven successful in the developed world, many of the projects turned out not to fully match the context of the developing world, resulting in a high percentage of failures.

The current scholarly field encompasses a relatively broad array of disciplines, including among others sociology, anthropology, economics, political science, information systems, and development studies (Brown & Grant). As can be expected, such breadth of disciplines provides funding for ample perspectives.

### 2.3.2 Information and communication technology

As indicated, the term information and communication technology is often abbreviated to the acronym ICT. In a broad sense, ICTs have been with us for a long time. Cave drawings, smoke signals, clay tablets, banging drums and the bible can all be seen as technological extensions (or tools) facilitating human communication and the sharing of information. Contemporary examples can be found in newspapers, television, radio and telephone, or – even more recently – smartphones, tablets or the internet.

Conceptually, one could argue for a distinction between technologies for non-interactive, one-way sharing of information (information technologies), and those supporting interactive, two-way communication, but in practice this distinction is hardly made. Another distinction that is sometimes made dissents between (relatively) old – e.g. radio and television – and new ICTs – e.g. computers. For this research such splits will not be made.

As the field of ICTs can encompass basically any tool that processes data, there exists no clear, agreed upon definition, although efforts to providing one have been made by various authors (Garai & Shadrach, 2006). Useful definitions have been provided by Duncombe and Heeks (1999), indicating ICTs as *electronic means of capturing, processing, storing, and disseminating information*, or denoted

somewhat more extensively by Hamelink (1997) as *[encompassing] all those technologies that enable the handling of information and facilitate different forms of communication among human actors, between human beings and electronic systems, and among electronic systems*. Due to resource constraints this review will however focus on a more limited definition. Given the main interest in poverty alleviation, the review will concentrate on those tools that are likely to be accessible and useful for less developed societies. Therefore, the focus of this review will be limited to relatively simple electronic tools that facilitate in the exchange of information between human actors. More complex equipment capable of tasks such as extensive processing of information or autonomous decision taking will be excluded.

### 2.3.3 Positioning technology in poverty

Depending on the perspective taken on poverty, (the lack of) ICTs can be part of poverty or a means to its alleviation. Under asset-based approaches (such as the capability and livelihoods approaches), ICTs can be regarded an asset or capability. Improved systems of information and communication could for instance help supplying the poor with the information they need in order to pursue sustainable livelihood strategies (Chapman & Slaymaker, 2002). This perspective was for instance taken by Duncombe (2006) who used the sustainable livelihoods framework to analyse poverty reduction through ICT application in microenterprises. Kleine (2010) argued for approaching the measurement of poverty reduction through ICTs in a *'holistic way'*, making use of Sen's capability approach. According to her, *the mainstream discourse's conceptualisation [of development] remains heavily focused on economic growth, which is too narrow to capture the impacts of ICT* (Kleine, 2010).

### 2.3.4 Connecting ICT and development

Evaluation of ICT effects is not a simple task, and one with which even the (Western) business sector has had problems with it from the start (Gomez & Pather, 2012). Similarly, *[i]dentifying the specific contribution of the use of ICTs to specific development goals has proven to be extremely difficult* (Kleine, 2010). Problems lie in uncertainty and unpredictability concerning costs and benefits, shortcomings in tools and methods for measurement and the *mismeasurement of outputs and inputs*" (Gomez & Pather, 2012). Evaluation tools employed have varied from (among others) *simple accounting measures to complex multi-dimensional balanced score-card type metrics and surrogate measures such as user satisfaction, service quality, individual, and organizational impact* (Gomez & Pather, 2012).

Perspectives on ICT4D primarily vary with the extent to which social aspects are incorporated. Basically, ICTs in themselves do no more than provide the means to handle already existing sources of information (Adeya, 2002). However, by providing new means to do so, ICTs can ultimately redefine social relations and have a transformative effect on organizational structures (Michiels & Van Crowder, 2001). Perspectives on ICT can hence surpass the technological artefact to include its users and services offered. Such perspectives argue that in order to understand ICTs, their use and the system within which it is used should also be studied.

Curtain (2004) noticed a distinction in approaches between studies with a primary focus on the use of ICTs and those where ICT played a supporting role. Similar divergence was noted by Brown and Grant (2010), who argued that ICTD research can be divided into two separate streams of research: one is focused on *technology 'for development'*, the other on *technology 'in development'*. Heeks (2008), in somewhat of an extension, noted a similar division in perspectives and called for an

integration of the two with development studies. He called the first perspective – focusing primarily on computer science – *technocentricity*. According to him, the techno centric approach was the root of several failures in ICT4D. The so called *information systems perspective* has a broader orientation and offers the tools for understanding many of problems with ICT4D projects. This perspective enables an understanding of the *human, political, and contextual reasons* for ICT4D project failure. However, it seems overly focused on social context and – according to Heeks (2008) - had lost the connection to technology. Apart from that, he found it to lack insight into the development context. He argued for the integration of development studies, but noted that they [had] *so far failed to adequately conceive or support ICT4D*. According to him, an integrated approach was required, where ICTs are conceived as tools for handling the information and communication that development requires.

According to Heeks (2008) perspectives can incorporate both technical and social components, which can be combined in and 'information systems' view. Another illustration of variance in perspectives was provided by Orlikowski and Iacono (2001), who in a review of 188 research papers published in the Information Systems Journal between 1990-1999, extracted five broad conceptualizations of IT:

- *Nominal view* (25%) – Technology in name only, not as fact; conceptual focus lies elsewhere.
- *Computational view* (24%) – Concentrates on computational power of IT; IT as algorithm or modelling tools.
- *Tool view* (20%) – technology as engineered artefact, does what designers intend it to do. Technology is independent of surrounding context; means to a goal; a tool.
- *Proxy view* (18%) – technology as some key elements representing it; surrogate measure.
- *Ensemble view* (13%) – technology as element in broader package, including additional resources such as training, skills, staff, etc.; involving social and cultural context.

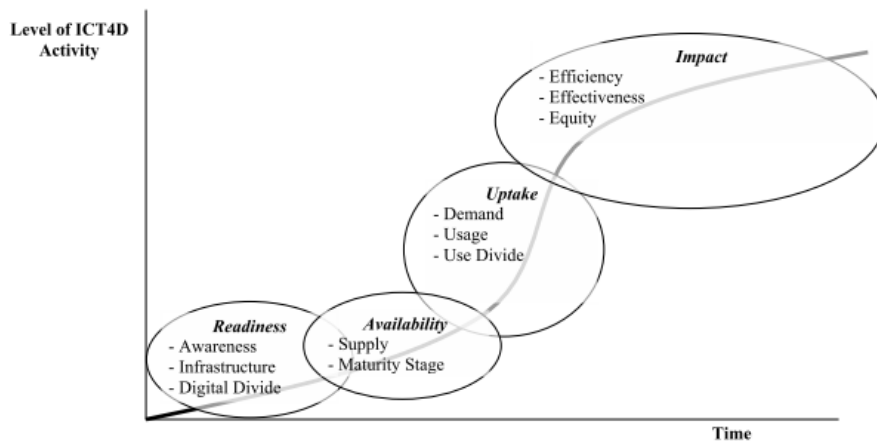
These dimensions again that various perspectives can be taken on technology. As this study primarily focuses on the use of technology to achieve another, broader goal – that of poverty alleviation, a focus on technology alone will not suffice, and contextual factors are likely to be of influence as well.

Regarding types of impact, Gomez and Pather (2012) found three rough phases of impact of information systems. Initially (in the 1950s), ICT primarily brought changes of a technical nature; mostly comprising automation of clerical procedures. This was followed by impacts on managerial control (in the 1960s and 1970s), while impacts on institutional activities such as *products, markets, suppliers and customers* took over (in the 1980s) Gomez and Pather (2012). Based on Zuboff (1988)'s model they classified those phases as *Automate, Informate and Transformate* (Gomez & Pather, 2012). According to them, the Automate phase related to technical aspects of IT, the Informate phase to measurement of production and management while the Transformate phase related to business benefits, including less tangible aspects such as trust, loyalty and brand improvement. They linked these phases to the IT value perception model of Wiggers, Kok, and De Boer-de Wit (2004), depicted below. In line with a capabilities oriented perspective, Gomez and Pather (2012) argued that development perspective on ICT warrants a focus on ICT as an enabler, while noting that such perspective increases complexity as it incorporates a broad range of outcomes.

As ICTs facilitate social interaction, there effects can be multiple. Usually the aim of impact evaluations is in identifying long term influences (Leeuw & Vaessen, 2009). However, in the broad, dynamic, interdisciplinary field of ICT4D establishing such influences is difficult, especially given the

relatively low age of many of the newer applications. As a result, research has often focused on steps prior to impact establishing, such as assessment of readiness for ICTs usage, availability, usage patterns and effects (Heeks & Molla, 2009). In the early years of ICT4D research, efforts focused on evaluation of outputs –such as numbers of computers, users etc., while focus later turned to tangible outcomes (Gomez & Pather, 2012).

Figure 3: Changing focus of ICT4D assessment over time



Source: {Heeks, 2009 #42}

Bhavnani, Chiu, Janakiram, and Bhatia (2008) made a distinction between direct, indirect and intangible benefits. Classified as direct were impacts such as GDP growth, job creation, productivity gains, and tax revenue. Indirect benefits referred to impacts such as increased entrepreneurship, reduced information asymmetry, reduced (other) market inefficiencies and transport substitution. As these indirect benefits are not always easy to monetize or measure, sometimes factors such as 'willingness to pay' or 'consumer surplus' are used as proxy indicators for indirect benefits (Bhavnani et al., 2008). The term intangible benefits was used to denote impacts on dissemination of educational and health information, improved jobs, and social capital and social cohesion (Bhavnani et al., 2008), (Gomez, 2012). Gomez and Pather (2012) mentioned quantifiable, unquantifiable, tangible, intangible and unexpected benefits. They noted that factors such as *teledensity, bandwidth per capita, number of connection points, number of training certificates issued, etc.* might be easily measured, but added that “*measuring computers, cables, and connections tells us very little about the actual state of society*” (Gomez & Pather, 2012). The problems of measuring intangible effects were also noted by ITU (2006), who noted about ICT impacts that *[their] measurement is elusive. Part of the difficulty is that both ICTs and electricity are “enabling” or “General Purpose Technologies”, which means their use and their impacts are ubiquitous yet difficult to measure because they are mainly indirect.*

Regarding lessons from failures, Walton and Heeks (2011) advised projects to *facilitate participation of intended beneficiaries and users; maintain a flexible approach; focus on continuous learning; utilise and strengthen local institutions; and provide good leadership that is sensitive to local realities.*

### 2.3.5 Contextual factors

Apart from the inputs (ICT) and outputs (poverty alleviation), the ICT4D domain can be open to various contextual factors. Logically, one might expect local skills, societal patterns and other cultural issues to co-shape interventions. According to Donner and Toyama (2009), ICT4D projects often took

insufficient account of their context, and Heeks (2002b) opined that difficulties in ICT4D projects are often related to contexts, approaches and actors. According to Heeks (1999) *information is a necessary resource for poverty alleviation but it is by no means a sufficient one*. Geldof et al. (2011) also mentioned the *added complexity of the social setting of an intervention*.

A wide array of contextual factors has been specified as possibly relevant to ICT4D impacts. (Cecchini & Scott, 2003) for example remarked that local issues of public policy, infrastructure, costs of access and illiteracy can influence potential impact. Bhavnani et al. (2008) mentioned constraints such as infrastructure, population density (which influences marginal costs of infrastructure), institutional environment and regulations. Adeya (2002) – referencing a study by Boer and Walbeek (1998) – mentioned possible threats to success in feeble infrastructure, restrictive laws, problems with energy supply, lack of awareness and (computer) illiteracy, problems with maintenance and operation, technical support, coverage and ineffective governance. Aspects such as income, literacy and affordability and access of ICTs have also been thought to matter (Guerrieri, Jona Lasinio, & Manzocchi, 2004). Curtain (2004), Lee et al. (2008), Donner and Toyama (2009), von Braun (2010) worried that ICT4D impacts might not be distributed evenly, and might be skewed towards the better educated and richer part of populations due to skills requirements such as literacy and education while leaving the poorest people behind.

Hamel (2010, p. 59) described this importance of context as: *ICTs alone cannot improve peoples' lives; the use of ICTs needs to occur within broader strategies that are tailored to make the most use of these tools and techniques in order to reap their potential benefits for human development*. Warschauer (2004) remarked that ICTs are interwoven with social systems, and *do not exist as an external variable to be injected from the outside to bring about certain results*. Similarly, Wilson III and Wong (2003) argued that policy and institutional settings are of fundamental influence on ICT-dispersion.

## 2.4 Existing research

This paragraph will briefly explore the existing research on ICT4D impacts. In general, *rigorous impact evaluations are still thin on the ground for many interventions* within the field of international development (Waddington, White, et al., 2012). Evidence for claims of impact in international development is often *anecdotal*, based on a single study alone, or – when based on multiple studies indeed – it is unsure whether the evidence presented truly is representative of the literature (Waddington, White, et al., 2012). This seems to hold for the field of ICT4D as well (Heeks, 2008), where relatively large claims often seem based on a few single studies as well – see e.g. von Braun (2010). This notion was shared by (Pade-Khene & Sewry, 2012) who indicated that *ICT4D is, at best, a "working hypothesis"*.

### 2.4.1 Other reviews

#### *World Bank*

The study from the World Bank (Halewood & Surya, 2012) is part of a larger study on ICT4D: (World Bank, 2012), and focuses exclusively on mobile phones. This report to a large extent builds on earlier research: (World Bank, 2011); a relatively large study project also published online<sup>5</sup>, focussing on ICT in agriculture. Regarding the selection of evidence, an overview of how studies were located or

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<sup>5</sup> <http://www.ictinagriculture.org/content/ict-agriculture-sourcebook>

whether any inclusion criteria were applied has not been provided. As a result, the general strength of the evidence presented is unclear. The study totals over 400 pages, and little effort was undertaken to provide a focused summation. An overview will be provided here.

In the introductory module a distinction is made between two themes: 'why' and 'how'. 'Why' relates to the drivers for using ICT such as increased availability at lower costs, changing business models and the '*democratization of information*' (McNamara, Belden, Kelly, Pehu, & Donovan, 2011). 'How' relates to the lines along with (potential) impacts are established and the lessons learned so far. It is noted that for realizing development impact, supplementary issues matters besides ICT provision, including policy and regulations, physical infrastructure and enabling environments for new businesses and innovation. The influence of socioeconomic and demographic factors is also mentioned: *[i]n designing ICT interventions, it is necessary to research and understand local information and communication practices, barriers to ICT-enabled empowerment, and priority information and communication needs of end users.* ICT availability does not guarantee participation by all social groups and social access should be taken into account for intervention (McNamara et al., 2011).

The second module focuses on ICT affordability and accessibility and notes that as provision of ICT infrastructure is relatively costly it tends to lag behind country averages for rural areas with low population-density. Partnerships (e.g. between public and private sector), (market) regulation, and geographical terrain and technology are deemed likely to matter for coverage of an area.

The third module is exclusively about mobile phones. References are provided on various occasions in this module, although evidence rigor is not explicitly discussed. In brief, mobiles are found to have the ability to be beneficial to farmers in various ways: *[m]obiles are being used to help raise farmers' incomes, making agricultural marketing more efficient, lowering information costs, reducing transport costs, and providing a platform to deliver services and innovate. Whether the potential of these trends can be realized more widely, especially in rural areas and in an equitable way, is uncertain* (Donovan, 2011). According to the study, mobile phone access can – in some instances – be associated with higher income for farmers, primarily to improved market positions. Mobile phones can also reduce information asymmetry in markets, leading to reduced price dispersion. Another impact mentioned is that of reduced transportation costs, as travel for obtaining information is substituted with for instance phone calls. In a summation, study states that mobiles *may help to increase income, improve the efficiency of markets, reduce waste, and improve welfare. They can reduce agriculture's significant transaction costs, displace costly and time-intensive travel, and facilitate innovative interventions, especially in service delivery* (Donovan, 2011). Some constraints and points of attention are also mentioned in that ICTs often require accompanying components in order to be effective: *shoddy roads—or no roads—limit farmers' ability to sell their grain in prime markets...[and]... [p]oor access to education can prevent many rural people from taking advantage of mobile phone services that depend on being able to read* (Donovan, 2011). Other issues mentioned are that a lack of financial access can constrain additional possibilities, and that mobile phones may reinforce existing asymmetrical social structures between for example large and small farmers or men and women (Donovan, 2011). Gender imbalances are more extensively discussed in the module four (Manfre, 2011).



The fifth module focuses on farm productivity enhancement through ICT. This is primarily based on illustrative examples. Geostationary information systems (GIS) and other soil related technologies – such as wireless sensor networks – form a major component in this module, while the rest focuses on agricultural information systems providing information on weather, irrigation, and crop diseases and pest control.

Module six focuses on *research and knowledge sharing systems, advisory services, and e-learning* (Rudgard et al., 2011). It is noted that 'the more complex ICTs' will require new technical and entrepreneurial skills from farmers and advisory providers. The use of radio and TV/video are illustrated and it is noted that a video involving women had a better reach to other women who were then more likely to learn from the video. It is remarked that challenges remain given cultural and socio-economic circumstances and that *[i]f the primary aim is to get information to farmers, then multiple channels and media should be used to reach many groups. The quality and relevance of the content/advice to be provided is also important, as is the level of community “connectivity” to the providers’ messages. Conversely, if the aim is to maximize farmer-to-farmer documentation and sharing, then the emphasis is likely to be much more on capacity building and issues of culture, language, and various forms of literacy* (Rudgard et al., 2011).

Module seven is about financial services, which – although possibly of high impact for certain developmental settings – do not constitute a core element of the research presented in this report, and are subsequently excluded. In brief, issues discussed are (among others) the provision of credit to farmers, the execution of electronic payments and the use of warehouse receipts as loan collateral.

The next module focuses on strengthening farmer organizations through ICT. Three categories for ICT impact on cooperatives are characterized: enhanced connection to members, improved accounting and administration and strengthening of the collective voice. With regard to inter-population disparities it is noted that younger people tend to access ICT more easily (although no direct evidence is provided for this in the module), and that technology acceptance is higher among the better-educated which increases the danger of a growing digital divide.

Module nine is about agricultural markets. This topic is relevant to for the research of the research presented to the reader here, and it is also the primary section referenced in (World Bank, 2012). It is noted that farmers producing different products in different countries have different information needs. *The primary message underlying these disparities appears to be that farmers require a package of information and that their needs and priorities change throughout the production cycle* (Dixie & Jayaraman, 2011). Also a table of evidence is featured which is represented below.

Table 2: primary studies in Dixie & Jayaraman (2011)

LOCATION, PRODUCT, MEDIUM (STUDY AUTHORS)	FARMER	TRADER	CONSUMER	COMMENTS
Uganda, maize, radio (Svensson and Yanagizawa 2009)	+ 15%			Increase in price paid to farmers considered to be due to farmers' improved bargaining power
Peru, range of enterprises, public phones (Chong, Galdo, and Torero 2005)	+ 13%			Increases in farm income, but higher for nonfarm enterprises
India (West Bengal), potatoes, SMS (M. Torero, IFPRI, pers. comm.)	+ 19%			Yet to be published, but showed information to be important both in the form of SMS and as a price ticker board in markets
Philippines, range of crops, mobile phones (Labonne and Chase 2009)	+ 11–17%			Effect on income among commercial as opposed to subsistence farmers, plus perceived increase in producers' trust of traders
India (Madhya Pradesh), soybeans, web-based e-Choupal (Goyal 2008)	+ 1–5% (average: 1.6%)			Transfer of margin from traders to farmers, effect seen shortly after e-Choupal established
Sri Lanka, vegetables, SMS (Lokanathan and de Silva, pers. comm.)	+ 23.4%			Appreciable price advantage over control over time, plus benefits such as increased interaction with traders and exploring alternative crop options
India (Maharashtra), range of products, SMS (Fatchamps and Minten n.d.)	No significant effect			In this one-year study, quantitative analysis did not show any overall price benefit, but this finding is thought to be due to sales in state by auction; price benefits of 9% were observed with farm-gate sales and younger farmers
Morocco, range of crops, mobile phone (Ilahiane 2007)	+ 21%			Small sample showed usual behavioral changes; higher-value enterprises took a more pro-active approach to marketing via mobile phone
India (Kerala), fisheries, mobile phones (Jensen 2007)	+ 8%		-4%	Outlier in the sense that fish catches are highly variable and fishermen have their own boat transport
Uganda, range of crops, SMS and radio (Ferris, Engoru, and Kaganzi 2008)	Bananas + 36% Beans + 16.5% Maize + 17% Coffee + 19%			Awareness of market conditions and prices offers more active farmers opportunities for economic gain
Niger, grains, mobile phones (Aker 2008)		+ 29%	-3 to -4.5%	Traders increased margin by securing higher prices through greater capacity to search out better opportunities
Ghana, traders, mobile phones (Egyir, Al-Hassan, and Abakah 2010)		+ 36		Traders using mobile phones tended to sell at higher prices but also tended to be larger-scale traders than nonusers
Kenya wholesale traders, mobile phones (Okello 2010)		+ 57%		Improved trader margin through combination of cheaper buying prices and higher sale price

Source: {Dixie, 2011 #102}

As noted, research results are *generally positive in terms of farmers' income and prices* (Dixie & Jayaraman, 2011). Other evidence indicates lower consumer prices and higher margins for traders using ICT. ICTs also seem to reduce transportation (as farmers can use phone calls instead of travel), improve negotiation power for farmers (through learning about pricing in multiple markets and avoiding intermediaries). Farmers can also *identify sources of inputs, obtain them more cheaply, and are better able to buy and apply them at the optimal times...* [and improve farm management]... *through better information about which inputs to use, new knowledge about grades and standards for produce, and increased interaction with corporations, traders, and other farmers* (Dixie & Jayaraman, 2011).

A note is that financial sustainability for market information services delivered by the private sector is unclear, while *a history of gathering inaccurate data and disseminating it badly* makes efficient and effective delivery by the public sector doubtful (Dixie & Jayaraman, 2011). The main conclusion if the section is that increased dissemination of mobile technology to areas currently lacking signal will yield significant benefits.

Module 10 is about including smallholder farmers in supply chains. This part is basically about connecting the developing world with the global food industry by integration of smallholders into commercial supply chains (involving the larger or multinational corporations). Although relatively little evidence is provided, the study theorizes that ICT can intervene in the supply chain by *reducing*

*costs of coordination (collection of production, distribution of inputs, and so on); increasing transparency in decision making between partners; reducing transaction costs; disseminating market demand and price information; disseminating weather, pest, and risk-management information; disseminating best practices to meet quality and certification standards; collecting management data from the field; and ensuring traceability* (S. Sen & Choudhary, 2011). In addition it is noted that ICT can (possibly) improve integration among supply chains otherwise characterised by a highly fragmented structure.

In module 11 the possible role of ICTs in risk management are discussed. In it, some categories of risk are identified (production risk, marketing risk and enabling environment risk) which subsequently are mapped against possible coping strategies (mitigation, transfer, and coping) for which then possible ICT impacts are discussed. Information concerning early warnings and advisory information was deemed the most important to risk management, and – as some most of the other topics mentioned such market information and logistics – had already been discussed in previous modules. Impact evidence is not often provided, but rather some currently running services are used to illustrate various strategies mentioned.

In the final module of relevance – the remaining ones are about public management – the role of ICT in improving food safety and traceability (of products along the value chain) is discussed. Some technological options are mentioned (e.g. RFID-tags, barcode scanners, nanotechnology), and a few examples provided. The remaining section (modules 13-15) is about public service provision and will be excluded from this summary.

### **Duncombe**

Duncombe (2012) also exclusively focused on the use of mobile phones; they are studied within the environment of agricultural and rural settings, and aims to *analyse and understand the potential and the limitations of mobile phones in the delivery of rural services for agricultural and rural development (ARD) in developing countries* (Duncombe, 2012). The study claims to use a systematic review approach, although not all components are equally well addressed. The study includes both quantitative as qualitative studies, and inclusion criteria are not explicitly specified. The review does however provide a table indicating various aspects of study quality such as the use of a baseline study, data collection methods, timing, whether the research is peer reviewed.

In its approach to framing the research, it specified a two-dimensional matrix. One dimension is based on a (mobile) technology evolution lifecycle specified by Heeks (2006), and Heeks and Molla (2009), the other is based on study methodology, spanning quantitative, mixed methods, qualitative and participatory approaches. The lifecycle dimension was chosen because it facilitates the consideration of a broad range of research, and comprises studies categorized in user needs, actual use, uptake and impact. The methodological dimension was chosen for its ease of identification in research retrieved (Duncombe, 2012). Categories were created based on study approach. One of the categories was comprised of studies employing quantitative methods for theory testing. Another category primarily set aims of explanatory nature, employing mixed methods and *deeper theory, and framework-based approaches* (Duncombe, 2012). A third category consisted of primarily qualitative studies using *frameworks, models (such as business models), single concepts or categories that are applied but which are not strongly grounded in theory* (Duncombe, 2012). Apart from the clustering, much synthesis is not provided, and rather individual study findings are provided narratively.

Regarding needs, transaction costs – including those related to the costs of searching for information – were a major focus. They can affect the value chain in the stages of gathering inputs, connecting to markets for final production sales and the consultation of experts and transaction oversight. It was found that information search costs constitute a large part (70 percent) of total transaction costs along the agricultural value chain when counting both direct financial expenditure and opportunity costs (e.g. time spent). In most studies search costs were seen as a large component in the informational barriers faced by agricultural producers. It was also found that information needs can differ extensively between various geographical, cultural and social settings. Regarding information provided it is noted that it should be 'actionable'; a term referring to the capital and social connections required to make of the information concerned. It was also found that many rural information systems are based on informal structures already in place.

In the category of adoption it was found that adopters were generally *better off with a high correlation between mobile ownership, use of a bank account and greater asset endowment.. and the constraints of ownership and use are exacerbated for the less well-off and the poor* (Duncombe, 2012), although in some studies high adoption rates were also found for poor farmers. Another study found that phone use was more intense for farmers living at a greater distance to markets. Regarding awareness and usage of (mobile) services, technological skills and experience were found to possibly be of influence as was the relevance of information provided to specific needs. Some studies reported voice as the dominant choice of communication, with formats such as SMS showing drastically lower rates of adoption.

Concerning impact it is noted that mobile phones are often passively diffused, which – according to theories of reasoned action – is driven by perceived benefits of ownership. Regarding impacts related to markets some evidence was found of mobile phones reducing price dispersion and product wastage. In the fishing industry, these benefits primarily fell to wealthier fishermen, although some spill-over effects were noted. In other agricultural sector some impact from mobile use on prices was also found. It was also mentioned that improved primary production technology, roads and transportation matter, and that a lack thereof might constrain mobile phone impacts. Regarding the value chain – instead of market access – it was found that phone use could improve speed of communication and save on expenses for time and transportation. Possibilities for strengthening network ties were also indicated, although not consisted in all related studies.

With regard to negative impacts, it was remarked – referring to a study by Qiang et al (2011), that the majority of projects using mobile phones for development impact are donor/government funded their evaluations are often not publically accessible.

In general it was found that *[g]reater connectivity and communication has led to significant improvements in coordination of supply and demand, coordination within value chains, communication and transparency of market prices, speeding up and facilitating of transactions, mobility of traders and personalised communication (i.e., less reliance on institutional mediation. ... The form, extent and distribution of benefits (such as between producers and traders, men and women) is contested and evidence highlights constraints on access and use such as the absence of trust where communication lacks face-to-face contact, inexperienced users and inefficient or incorrect use of the phone functionalities... Overall, the review suggests that as market information systems become more sophisticated their impact upon market efficiency is growing. The evidence from this*

review already suggests that new information technologies involving mobile communications and networks are realising significant benefits of speed, mobility and efficiency in information exchange creating new opportunities for arbitrage and making it easier for small producers and new entrants to participate and compete in markets (Duncombe, 2012).

Finally some gaps in the research were identified. As technology studied was limited to mobile phones, there is no information on *how mobile compares with other technologies as a means to deliver information-based services... The single technology focus combined with the narrow-empirical approach of research has caused lack of emphasis on service integration* (Duncombe, 2012). Another important gap was found in the limited understanding of contextual effects, as most research did not seek to understand the vulnerability contexts of rural producers (Duncombe, 2012). In the methodological dimension, an important gap was deemed the restrained use of participatory methods or action research.

### Patra

Patra et al. (2009) interviewed 50 ICT4D researchers and experts about their opinions on their assessment of past performance of the field and expectations for the future. Respondents were from a relatively wide range of domains and academic specializations. Regarding the agricultural domain, the following areas were deemed of highest future importance:

<b>Top 5 areas ranked by respondents</b>	<b>Percent Respondents</b>
Best practices and information sharing	56.7
Market access and information	51.3
Supply chain management	45.9
Sensors	21.6
Access to expert information	18.9

With regard to this (agricultural/rural) domain, some additional contextual factors emerge. Patra et al. (2009), in their survey, found longstanding concerns about *the incongruity of computers in the rural hinterland*. Efforts focusing on introducing ICTs to rural communities according to them have often focused on *providing information on agricultural practices, market prices and government schemes through telecenters*, albeit with limited success (ibid.). Besides telecenters they found projects using *cellphones and PDAs in organic certifications for farmers, sensor networks in helping water management for rural areas, livestock management, price information and farming extension and information sharing*, and recently a growing interest in microfinance operations (ibid.). Their survey among experts revealed the following priorities:

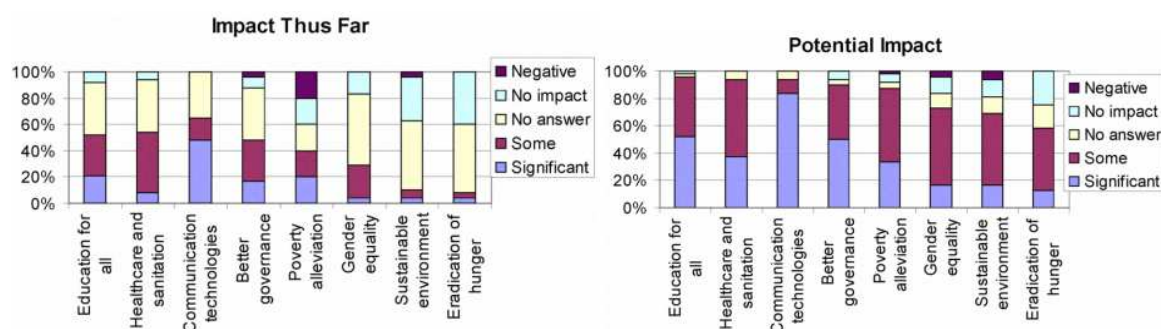
Regarding future design, expectations are that adaptation to local circumstances and general user-friendliness will be of the highest concern. With regard to technology, there was no clear winner, although low costs infrastructure and devices were mentioned most often, followed by mobile phones and community radio and tv (Patra et al., 2009).

Questions were also asked about the respondents' perspective on what the role of the government should be ICT4D. From the responses it was noted interesting that *very few of the experts felt that the government should be directly owning ICTD projects in agriculture, most respondents preferring a hybrid role instead. This is a fairly unexpected, because in the earlier days of ICTD, the government's*

role in e-agriculture was seen as very important. This could perhaps tie in with the experiences with telecenters and e-agriculture run by state agencies in the past decade, which have often suffered mixed fortunes, usually weak (Patra et al., 2009).

Regarding impact, opinions were asked on both past performance and future expectations. It was noted that most experts felt that ICTD projects generally had potential, but that it had a significant way to go in achieving it fully. This is reflected by the fact that a large number of respondents chose not to answer questions on the perceived impacts of ICTD thus far, but also by the fact that few respondents believed that existing ICTD work has made a significant impact (Patra et al., 2009). The highest negative assessment on impact thus far was on poverty alleviation, indicating a risk of ICT increasing inequalities.

Figure 4: estimated impact thus far and potential future impact



Source: (Patra et al., 2009)

## 2.5 ICT4D - Conclusion

In conclusion of this chapter, a few things deserve mention. Firstly, it was shown that the field of ICT is relatively broad in the technology used, the information communicated and the impacts related to poverty. Effects of ICT manifest through a range of pathways that are established in broad systems comprising of various interacting users and uses, interacting with a wider societal context. These characteristics render the field somewhat complex, and bear resemblance to what Craig et al. (2008), Petticrew (2011) – in the field of health care – denoted as 'complex interventions' (Craig et al., 2008), (Petticrew, 2011). Generally, this term refers to interventions that include multiple interacting components, targeting several groups or organizational levels and with varying outcomes (Craig et al., 2008), (Shepperd et al., 2009), (Ogilvie et al., 2011) (Petticrew, 2011). Other definitions mention the degree of flexibility and non-standardization as an indication of complexity, and often focus on multiple components and non-linear pathways (Petticrew, 2011). Researching such interventions, or reviewing research on them, is often difficult, and no standardized approach exists (Shepperd et al., 2009). As the above description fits the field of ICT4D relatively well, a standardized approach to reviewing evidence might not suffice.

Secondly, it was shown that the field of ICT4D has already been researched, that various primary studies exist, and systematic reviews thereof have already been conducted. However, the reviews identified so far did not present an overly systematic approach (Dixie & Jayaraman, 2011), (World Bank, 2012) or were limited to a specific technology (Duncombe, 2012).

Thirdly, conducting such broader oriented systematic review can be interesting as potential impacts indicated by experts might not yet have been realized (Patra et al., 2009). For improving understanding, theories of the middle-range would be highly useful (Donner & Toyama, 2009).

In brief, the review that will be conducted should take notice of the complexity of the field, refrain from focusing on too narrow a notion of poverty and cover sufficient ground in terms of technology and context involved. As it is unlikely that a standardized research approach will yield the desired results, the next two chapters will explore the dimensions respectively primary research and research reviews.

### 3 Chapter on science and evidence

The main interest of this research is in the aggregation of (scientific) research findings on ICTs in development settings. Before gathering such evidence, it is however useful to gain some understanding of what does and does not constitute scientific evidence, and what its dimensions are. This paragraph will therefore briefly look into the dimensions of science, evidence and impact evaluation. Noting that these topics can be of a rather philosophical nature, discussions will be kept brief as lengthy elaborations in that dimension are not strived for in this report.

#### 3.1 Introduction to science

Science is etymologically related to the Greek 'skhizein' (to split, rend, cleave,) and the Old English word 'sceadan' (to divide, separate) and the Dutch 'scheiden' (to separate). Similarly, analysis stems from Greek analuein, meaning as much as *dissolving, breaking up, loosening, releasing* (van Veen & van der Sijs, 2011). With some imagination, this matches the notion that science is about splitting up systems into individual components and looking at their interactions.

The main goal of science is basically to discover regularities (or patterns) within a certain domain, and formulate theories to account for them, worded by Rousseau, Manning, and Denyer (2008) as: *Science seeks general knowledge, explanations that make useful predictions about a common reality in a replicable fashion. It creates theories that explain regularities in our natural and human-made world.* The ultimate interest is in a rather straightforward objective: establishing causal conclusions beyond reasonable doubt (Mitchell, 2000), (Cook, Scriven, Coryn, & Evergreen, 2010). Once verified as real and meaningful, these theories can then be used to explain, predict and control items in a domain (Craver, 2008). In order to be able to make such predictions, discovered phenomena need to be generalized and applied to other situations than were they were discovered. As Feynman (1995, p. 164), quoted by Mitchell (2000), put it: *Science is only useful if it tells you about some experiment that has not been done; it is no good if it only tells you what just went on. It is necessary to extend the ideas beyond where they have been tested.* In brief, science tries to systematically observe a certain domain, identify regularities in these observations that allow identification of (theories about) causal mechanisms, and use these mechanisms to formulate predictions in other (albeit similar) contexts.

The process of scientific theory discovery can work both inductively and deductively, and often involves both types of thinking. Specific empirical observations can be inductively generalized into broader theories and such generic hypotheses can be deductively translated into empirically testable settings. Sometimes a distinction is made between empirical and non-empirical research methods in that that former rely on observations and data and aim at testing theories, while the latter focus on development of concepts and ideas (W. Chen & Hirschheim, 2004). As a research discipline grows, efforts might shift from generating and exploring theory to theory-testing. In that sense, the distribution of empirical and non-empirical studies in a field might indicate its progress (W. Chen & Hirschheim, 2004).

In the research process, it is possible to obtain somewhat 'intermediate' generalizations that hold under a relatively narrow set of circumstances, rather than over broad contexts. Reflecting (albeit perhaps somewhat semantically) on the applicability of the notion of scientific laws in biology, Mitchell (2000) provided a scale of generalizability (*a continuum of contingency*) between *accidental generalizations* at the bottom and *ideal laws* (that are contingent, universal and true) at the top of



generalizability. For this research, practical usability of identified results in a similar notion to what Merton termed 'theories of the middle range' (Merton, 1957) would be an attractive objective.

Methods for scientific enquiry are often divided in 'qualitative' and 'quantitative' approaches. Essentially, these terms refer to the type of data obtained in the research process with quantitative research generating data in the form of numbers, while qualitative research produces data in primarily in words (Garbarino & Holland, 2009). Qualitative methods are generally deemed to better suit development of concepts, theories, and hypothesis, while quantitative methods are more useful in testing theories (Sofaer, 1999). *Expressed simply, quantitative research seeks limited information from a large amount of people and qualitative research seeks detailed information from a small amount of people* (Gibbs, 2012). The difference between both method classes will be briefly discussed in the following paragraphs.

### 3.1.1 Qualitative methods

Qualitative research focuses predominantly on gaining understanding of the way systems operate and less on measuring effects (Adeya, 2002). They (often) seek an *in-depth understanding of the causal chain connecting observed outcomes to an intervention and explicitly set out to discover the causes of observed effects with the goal of establishing beyond reasonable doubt how an outcome or set of outcomes occurred* (H. White & Phillips, 2012). Qualitative methods allow for (among others) extensive descriptions of multifarious phenomena, illumination of various actor perspectives, theory development and hypothesis generation (Sofaer, 1999), and can help in investigation and explanation of relationships and contextual influences (Garbarino & Holland, 2009). According to Lorenc, Pearson, Jamal, Cooper, and Garside (2012), qualitative approaches can help in *understanding the barriers and facilitators of intervention effectiveness...[and]... 'open up the black box' of outcome evaluation*. In impact evaluation, this black box refers to the intervention logic: the transformation from input to expected outcome (Pedersen & Rieper, 2008). Qualitative research can help in discovering relationships by increasing understanding of both events themselves as their context, and *enhance peripheral vision* (Sofaer, 1999). In that sense, *[q]ualitative methods have the potential to contribute significantly to the development of meaningful "quantities"* (Sofaer, 1999). Qualitative methods can also be used when a quantitative approach is not possible, as can happen in macro-problems or other situations where quantitative data are lacking. In such a case, the main question is *how to find and/or develop the counterfactual, when statistical (experimental/quasi-experimental) designs are not possible* (Leeuw, 2012).

According to JBI (2011), qualitative approaches are often used for the analysis of phenomena related to the realm of human experience and social and cultural dynamics. Qualitative approaches include ethnography, phenomenology, action research, discourse analysis and grounded theory and data can be gathered through interview, observation and written material. Qualitative methodologies are often aimed at studying *things in their natural setting, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them* (JBI, 2011). Qualitative research is often used in domains where little initial knowledge is available and hypothesis generation is difficult (JBI, 2011).

Mays and Pope (1995) noted that the main criticisms on qualitative research are that it is *merely an assembly of anecdote and personal impressions, strongly subject to researcher bias*, that reproducibility is frequently lacking and that generalizability of outcomes is often low. According to

them, qualitative data is often gathered in a somewhat unstructured manner, leaving room for scientific reliability to be increased by carefully recording their research process (Mays & Pope, 1995).

### 3.1.2 Quantitative methods

Quantitative research is primarily focused on finding or confirming patterns in quantitative data (W. Chen & Hirschheim, 2004). By doing so, quantitative research provides a way to divide complex issues into manageable, discrete elements (Sofaer, 1999). These quantitative variables are often chosen (or presumed) to be independent, objective, generic entities (Kaplan & Maxwell, 2005). Quantitative evidence generally is numerical data generated by the 'traditional scientific methods', and is aimed at identification of relationships between variables. For assessing such relationships, often statistical methods are involved. Quantitative assessment is often deemed more objective, as it involves a transparent scale, and results are often similar in various replications (JBI, 2011). In social sciences such quantitative data is often obtained by using tools such as questionnaires. In such cases, phenomena are often divided into discrete elements in order for their quantification. As this requires more close-ended research questions, quantitative research is sometimes thought to be less suited for domain exploration and theory development.

Quantitative methods can be divided in three broad categories: (quasi-) experimental, observational and descriptive (JBI, 2011). In experimental approaches, a causal relationship is sought by actively changing one variable while controlling all others, and watching for a change in the outcome variable. If such a change is observed, it can be ascribed to the initial change brought about (H. White & Phillips, 2012). Quasi-experimental approaches seek to approach an experimental situation by statistical modelling (e.g. through regression analysis). Observational approaches aim to establish correlations, but are not 'strong' enough to establish the direction of the correlation (causation), if any. Descriptive studies basically provide rudimentary information, without aiming to establish any relationships (JBI, 2011).

As the main interest of the research at hand is in the exploration of the developmental effects of ICT use, there is an explicit interest in a specific instance of the application of scientific methods for establishing causation; that of impact evaluation.

## 3.2 Impact Evaluation

Impact evaluation is primarily interested in establishing the change resulting from specific programmes or interventions. In the words of Cook et al. (2010), *[I]legitimate knowledge claims about causation have been a central concern among evaluators and applied researchers for several decades and often have been the subject of heated debates* (Cook et al., 2010). There are various approaches to establishing such causation, and various main goals for doing so.

In their 'evaluation tree', Alkin and Christie (2004) define three main 'branches' of evaluation: methods, valuing and use, resting on a root of accountability and social inquiry. They define accountability *in the broadest way possible...[as] designed to improve and better programs and society* (Alkin & Christie, 2004). In a deeper notion they observed accountability of goals (indicating whether *reasonable and appropriate goals have been established* by e.g. upper management levels), accountability of process (indicating *whether reasonable and appropriate procedures for accomplishing those goals have been established and implemented*) and accountability of outcomes (indicating *the extent to which established goals have been achieved*) (Alkin & Christie, 2004). From

the three aforementioned branches, the methods branch is regarded as the 'main branch'. Continuing on the idea of accountability, this branch *deals with obtaining generalizability, or “knowledge construction”* and emphasizes *well-designed experimental studies and other controls* (Alkin & Christie, 2004). The 'valuing branch' is driven by the perspective that *placing value on data is perhaps the most essential component of the evaluator’s work*, while the 'use branch' is more aimed at assisting program stakeholders and informing decision making (Alkin & Christie, 2004). On a somewhat similar note, OECD (2010) stated that *a quality evaluation should provide credible and useful evidence to strengthen accountability for development results or contribute to learning processes, or both*.

Although perhaps jumping to conclusions, the aforementioned distinctions seem to differ primarily in the amount of focus placed on the proper identification of quantified effects, versus a somewhat broader approach aiming rather at understanding the internal workings of causal system for policy formulation and valuation of results. Generally the identification of intervention results seems dominant in evaluation approaches in the field of international development, as illustrated by the definitions of evaluation from NORAD (2012) defining evaluation as:

*Evaluation is a systematic collection and analysis of data in order to assess the strengths and weaknesses of programs, policies, and organizations to improve their effectiveness,*

and OECD (1991), whom described evaluation as:

*An evaluation is an assessment, as systematic and objective as possible, of an on-going or completed project, programme or policy, its design, implementation and results. The aim is to determine the relevance and fulfilment of objectives, developmental efficiency, effectiveness, impact and sustainability. An evaluation should provide information that is credible and useful, enabling the incorporation of lessons learned into the decision-making process of both recipients and donors (OECD, 1991).*

### **3.2.1 Research approaches for evaluation**

Leeuw and Vaessen (2009) outlined two generic premises for determining impact: attribution and counterfactual. Attribution means that rather than presenting observed changes, impact evaluations should attribute observed impacts to interventions. Counterfactual refers to the idea that a comparison between a situation where an intervention has actually been implemented and one where the intervention was absent produces the best knowledge about the impacts said intervention produced (Leeuw & Vaessen, 2009).

As with broader approaches to science, approaches to impact evaluation can vary. Not all evaluation designs have the same focus, and not all are equally suitable for inference of cause and effect relationships (van der Knaap, Leeuw, Bogaerts, & Nijssen, 2008). As indicated, when it comes to objective measurement of effects, often quantitative methods are given preference, as they are relatively well suited for identification of effects against objective, quantitative measurements. Quantitative approaches for impact evaluation can broadly be categorized in three groups: experimental, quasi-experimental, and regression-based techniques. These techniques generally aim at simulation of a counterfactual group, and – if properly executed – have the advantage of adequately addressing the attribution problem (Leeuw & Vaessen, 2009).

Although often aimed at determining the mechanisms involved in establishing intervention impact, non-quantitative approaches are often considered less successful in establishing attribution (Leeuw & Vaessen, 2009), and given their *inherent subjectivity and sampling restrictions*, views on their ability to provide generalizable conclusions differ (Gibbs, 2012). These differences in opinion are illustrated by the number of proposals on quality in qualitative research reaching well over one hundred (Dixon-Woods et al., 2006). As a result, qualitative methods are often considered to be better suited for situations where obtaining quantitative data is not possible, complex settings, and for providing additional insight in the mechanisms of change involved in interventions (Leeuw & Vaessen, 2009).

Theory based approaches aim at uncovering the phenomena and mechanisms behind an intervention (Astbury & Leeuw, 2010), and often primarily employ qualitative methods. Especially in social sciences, there is wide and growing interest in the this so called 'program theory' focusing on uncovering key program elements and how they relate (Cooksy, Gill, & Kelly, 2001). Such theory-based approaches generally aim at 'the black box problem', which denotes the tendency of many evaluations to focus primarily on the effects of (social) programs alone, while showing less interest in mechanisms producing those results (Rousseau et al., 2008), (Astbury & Leeuw, 2010).

Efforts aimed at uncovering the internal workings of interventions or programs can be recognized in the works of for instance H. T. Chen (1990) and Pawson and Tilley (1997). The latter notably focused on what Merton (1957) termed 'theories of the middle-range' (Astbury & Leeuw, 2010). Earlier examples were mentioned by Cooksy et al. (2001) and include Stake's (1967) model of antecedents (conditions necessary), transactions (activities and their outputs) and outcomes of a program, as well as Weiss (1972)'s proposed path diagrams for modelling the causal chain of events between an input and its desired outcomes.

As much as the suggested approaches to uncovering program logic vary, so do the terms used (Astbury & Leeuw, 2010). Donaldson and Lipsey (2006) indicated terms such as "theory-based evaluation," "theory-driven evaluation," "program theory," "theory of change," "logic models," "logical frameworks," and "intervention logic". Bickman (1987, p. 5), defined program theory as *a plausible and sensible model of how a program is supposed to work*. Program theory has been expressed in various ways, such as *a graphic display of boxes and arrows, a table, a narrative description, and so on* (Astbury & Leeuw, 2010).

**3.2.2 Levels of evaluation**

Evaluations can vary in their focus of both effects and population under investigation.

Figure 5: impact result chain

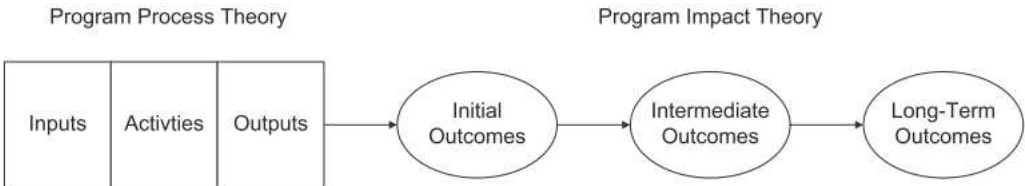


Figure 1. Linear program theory model. Source: Adapted from Donaldson, S. I. (2007). *Program theory-drive evaluation science*. New York, NY: Lawrence Erlbaum, p. 25.

Source: (Coryn, Noakes, Westine, & Schröter, 2011)

According to Duncombe (2009) impact assessment can focus on different geographical scopes: macro-level (country level); meso-level (impact on intermediary level organisations); or micro-level (individual). He also distinguished between outputs, outcomes and impacts. Duncombe (2009) also noted a difference in interest between audiences, with donors and public policy makers likely to be more interested in hard evidence and impact, while practitioners might be more interested outputs and outcomes. In this he noted a tension between *proving or improving impact*.

### 3.2.3 Evaluation in international development

The main concern of impact evaluation within the field of international development is with *the final results of interventions (programs, projects, policy measures, reforms) on the welfare of communities, households, and individuals, including taxpayers and voters. Impact evaluation is one tool within the larger toolkit of monitoring and evaluation* (Leeuw & Vaessen, 2009). Impact was described by OECD-DAC as *the positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended* (OECD-DAC, 2002). However, opinions on the scope of and methods within the field of impact evaluation differ broadly among practitioners (Leeuw & Vaessen, 2009). Regarding the specific field of ICT4D, quantifying ICT impact in a convincing and explanatory way is not simple (Taylor & Zhang, 2007), and a lot remains unknown regarding impact (James & Versteeg, 2007). To gain some insight in the span of methods used, the next paragraph will elaborate on approaches to impact assessment.

## 3.3 Research quality

When drawing scientific conclusions, the confidence that one can place in these findings is important. In this respect, the notions of objectivity, validity and bias are often mentioned (Bamberger, 2004). A distinction is however not always equally clear, and they often seem related to the same concept; that of strength of evidence or conclusions, as is indicated by the word validity – stemming from the Latin 'validus' which means 'strong' (van Veen & van der Sijs, 2011). Basically the notions referring to the quality of evidence denote the strength of conclusions in correspondence to the system of interest. This generally involves epistemological assumptions about reality and such paradigms may vary, especially in the softer (social) sciences (see e.g. Blaikie (2000) and Marsh and Furlong (2002)). Overlooking such philosophical differences for now, scientific validity can be categorized in four main categories (Maxwell & Delaney, 1999), (Shadish, Cook, & Campbell, 2002):

- *Statistical conclusion validity*, relating to the link between the dataset and drawn conclusions; this type of validity basically asks whether there is indeed a (statistical) difference in the outcome variable.
- *Internal validity*, relating to the validity of the postulated theory of change; the causal logic; this type of validity is about the direction of the relationship; what caused the difference?
- *Construct validity*, relating to the way constructs (from the causal theory) are operationalized (measured); this type of validity is about the relationship (generalizability) between what is measured and the underlying concepts. This type of validity is especially relevant in psychological research (Maxwell & Delaney, 1999, p. 26).
- *External validity*, relating to the extent in which findings from the study are applicable to other cases, in other places, on other times and with other subjects. *'What is true about behavior for one time and place may not be universally true'* (Maxwell & Delaney, 1999, p. 26).

These types of validity relate to the way initial empirical data is gathered, and the way it is translated into more generic ideas. Referring to Bamberger and Rugh (2008), Ton (2012) added:

- Objectivity, indicating whether conclusions are based on reliable evidence and *relatively free of researcher bias*;
- *Reliability: is the process of the study consistent, coherent and reasonably stable over time and across researchers and methods? If emergent designs are used, are the processes through which the design evolves clearly documented*;
- Utilisation, whether research results are useful to their intended audiences.

### 3.4 In brief

Science is about discovering regularities within a certain domain. Identification of such patterns helps in increasing systematic understanding, and once established such understanding can be used for deliberate manipulation. In a bold sketch, the process of establishing such patterns involves the exploration of a domain, the formulation of hypotheses and the testing thereof. Although this process is often iterative and clear boundaries are hard to identify, it can be argued that qualitative research methods are better suited for exploration, while hypothesis testing is better served by quantitative methods.

Impact evaluation is a specific application of the scientific method for identification of impact and relating it to specific interventions. In doing so, impact evaluation is primarily interested in effects, and aims to identify the difference in outcomes between a situation with, and one without a certain intervention. In controlled circumstances – e.g. laboratory settings – this is a relatively straightforward task, but in less controllable situations this becomes a more difficult task.

The research at hand is primarily interested in empirical evidence on the (hypothetical) relationship between ICT use and the alleviation of poverty. As indicated in the previous chapter, the domain of ICT4D is however relatively complex, and the range of potential impacts is relatively broad as poverty in itself was found to be a somewhat ambiguous notion. Therefore, the interest of this research is both in gaining theoretical understanding of the various relationships in the field of ICT4D as in the (quantitative) establishment of impact. In the previous chapter it was noted that the field is likely to benefit predominantly from the establishment of so called 'theories of the middle range'. This entails combining theory and empirical results, and hence involves both internal and external validity. Ideally, only experimental studies will be selected for the review, but given the relative immaturity of the research domain and the expected dearth of such findings, the research will include findings obtained through both (quasi-)experimental and observational methods. In order to combine both, the next chapter will explore the dimensions of systematically reviewing findings from primary research.

## 4 Systematic reviews

### 4.1 Introduction

As in primary research, systematic reviews are a means to an end; a method to achieve a goal.

#### 4.1.1 In brief

Systematic reviews are a form of research aimed at combining findings from primary research literature using clear and transparent methods (Gough, Thomas, & Oliver, 2012). Systematic reviews aim to provide an overview of the research relevant to a certain question in an unbiased way. Their main aim is to *reduce complexity and distil an essence of findings out of a universe of evidence* (Geldof et al., 2011), while minimizing influence of prejudice, cherry-picking and other types of distortion (Thomas & Harden, 2008), (Gough, Oliver, & Thomas, 2012). Systematic reviews can be used as a scientific tool for appraisal, summation, and communication of the findings of *otherwise unmanageable quantities of research* (Sally Green, 2005). Systematic denotes the *comprehensive accumulation, transparent analysis, and reflective interpretation of all empirical studies pertinent to a specific question* (Rousseau et al., 2008). By following explicit, pre-defined steps, improved transparency, replicability and ultimately reliability is aimed for (Sally Green et al., 2011). This is helpful, as individual studies can be biased, context dependent, methodologically flawed, and may disagree in findings (Tacconelli, 2010).

The term 'systematic' distinguishes them from reviews undertaken without clear and accountable methods (Gough, Thomas, et al., 2012); systematic reviews differ from 'conventional reviews' in the sense that the latter often provide no explicit description of the strategies followed and can tend to be position papers rather than providing a thorough overview of a field of knowledge (Rousseau et al., 2008). Regarding that difference, Hammersley (2002) remarked that the '*positive ring*' to the word systematic is not to be taken without caution, as a (conventional) review aimed at underpinning a predefined outcome can be systematic as well, if only in evading unwelcome evidence instead of providing an exhaustive overview of the field.

Besides providing an overview of the state of knowledge regarding a certain question, systematic reviews can be used to identify knowledge gaps, theory development, resolution of rival theories, and identification of active elements and weak links in interventions and their implementation (Sandelowski, Voils, Leeman, & Crandell, 2012). They can also aid in establishing to extent to which reported findings are consistent and generalizable across populations and context (Mulrow, 1994). As such, systematic reviews have gained popularity for policy makers, where they can fulfil a bridging role between areas of research and those of practice and policy making (Hammersley, 2002). All in all, systematic reviews do not differ all too much from primary research in that they too aim for the systematic obtainment of primary data in order to provide some sort of generalization of patterns observed.

*There are systematic reviews in such diverse topics as advertising, agriculture, archaeology, astronomy, biology, chemistry, criminology, ecology, education, entomology, law, manufacturing, parapsychology, psychology, public policy, and zoology. A recent paper even adopted systematic review methods to summarise eyewitness accounts of the Indian rope trick (Petticrew, 2001).*

### 4.1.2 Background

The history of developing methods for evidence synthesis date back over two hundred years (Egger, Smith, & O'Rourke, 2008), (Chalmers, Hedges, & Cooper, 2002). According to Bartholomew (2002) and Grant and Booth (2009) James Lind was the first to carry out systematic clinical trials, looking for a cure for scurvy – although it is argued that his efforts might not have been as systematic as they are sometimes presented nowadays (Bartholomew, 2002). According to Grant and Booth (2009), Lind is however likely to have been the first to describe the systematic review method in 1759, when he wrote: *'As it is no easy matter to root out prejudices ... it became requisite to exhibit a full and impartial view of what had hitherto been published on the scurvy ... by which the sources of these mistakes may be detected. Indeed, before the subject could be set in a clear and proper light, it was necessary to remove a great deal of rubbish'* (Lind, 1753).

According to Grant and Booth (2009), *[g]athering research, getting rid of rubbish and summarizing the best of what remains* encapsulates the nucleus of the systematic review method. Lind's position was reiterated in the 1980s, when the field of medicine increasingly noted that conventional reviews were flawed because reviewers, when encountering large amounts of evidence, tended to focus minor selection of studies without adequately communicating their basis of selection (Dixon-Woods et al., 2006).

Primary efforts in systematic reviewing were mostly focused on reducing statistical imprecision – see e.g. (Glass, 1976). An early set of review guidelines was provided by Cooper (1982) for what he referred to as 'integrative reviews': *the synthesis of separate empirical findings into a coherent whole, and inferring generalizations about substantive issues from a set of studies directly bearing on those issues*. Explicit methods for systematic reviews had however not been described until the 20<sup>th</sup> century (Chalmers et al., 2002), and these efforts have only recently aiming more explicitly at reducing bias (Valentine, Cooper, Patall, Tyson, & Robinson, 2010).

Initially, scientific reviews were especially popular in health care, but they have been gaining popularity and recently begun spreading to other disciplines such as international development (Snilstveit, 2012). Over the past two decades methods have been explicated into such as those outlined by the Cochrane Collaboration<sup>6</sup>, Campbell Collaboration<sup>7</sup>, EPPI-Centre<sup>8</sup>, Joanna Briggs Institute (JBI)<sup>9</sup> or the Centre for Reviews and Dissemination (CRD)<sup>10</sup>. Since the beginning of 2012 there even is a specialized, peer reviewed, open access, systematics review journal<sup>11</sup>.

Initially, systematic reviews were primarily aimed at answering questions concerning the impact of interventions by integrating quantitative findings from studies investigating homogeneous intervention with a similar design (Gough, Thomas, et al., 2012).

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<sup>6</sup> <http://www.cochrane.org/>

<sup>7</sup> <http://www.campbellcollaboration.org/>

<sup>8</sup> <http://eppi.ioe.ac.uk/cms/>

<sup>9</sup> <http://www.joannabriggs.edu.au/>

<sup>10</sup> <http://www.york.ac.uk/inst/crd/>

<sup>11</sup> <http://www.systematicreviewsjournal.com/>



## 4.2 Approaches

### 4.2.1 Aggregative versus integrative

Approaches used for systematic reviewing are not too different from the general scientific approaches as described in the previous chapter. Where primary research focuses on the systematic obtainment of data and the formulation and testing of general hypotheses, so do systematic reviews (Cooper, 1982). In doing so, systematic review approaches – similar to primary research methods - vary with the goals they set and the questions they aim to answer (Gough, Thomas, et al., 2012).

Traditionally, review questions have been about intervention effectiveness, which were answered by gathering and pooling quantitative evidence (JBI, 2011), (Gough, Thomas, et al., 2012). However, apart from aggregation of quantitative data, reviews can have a more theoretical focus or aim at understanding the social and paradigmatic surroundings of research (Gough, Thomas, et al., 2012). They can aim for instance on landscaping theory (proposed concepts and phenomena), development of interventions (generating theory) or testing intervention feasibility (Harden & Thomas, 2005).

Gough, Thomas, et al. (2012), following Sandelowski et al. (2012), discerned between reviews in the extent they intend to generate, explore, or test theory. Reviews focused on testing theory generally aim to statistically aggregate estimates of effects in order to find out whether an intervention works. Research aiming for theory exploration or generation is generally focused on examination of processes or meanings (Gough, Thomas, et al., 2012). In such studies it matters less to generate precise aggregated estimates, but rather to identify a range of varied concepts in order to gain understanding (Gough, Thomas, et al., 2012). Where primary research approaches can be organized in quantitative and qualitative methods, a similar categorization has been made for systematic reviews. Besides the differentiation in qualitative and quantitative approaches, a distinction is often made between aggregative and interpretative methods; a distinction that shares many dimensions with the quantitative-qualitative split.

Quantitatively focused reviews are basically aimed at aggregating findings (measurements) on highly similar concepts, while qualitative oriented reviews are oriented more towards translating differing concepts into each other (Sandelowski et al., 2012). According to JBI (2011), quantitative reviews (generally) focus on interventions, while qualitative reviews rather aim at 'phenomena of interest', which denote *the experience, event or process that is occurring, for example: response to pain or coping with breast cancer*. Gough, Oliver, et al. (2012) opined that quantitative research is primarily aimed at *quantitative properties of phenomena and their relationships*, while qualitative research is aimed more at the *meaning of phenomena and their relationships*. They distinguished between aggregative reviews – which aim at adding up data from primary studies to answer the review question, and configurative reviews – that aim more at organising data from primary studies for answering the review questions (Gough, Oliver, et al., 2012).

Noblit and Hare (1988) also distinguished between integrative and interpretive reviews. According to them, the former are aimed the combination or merging of data, while the latter are aimed more at interpretation and inductive reasoning (Noblit & Hare, 1988). Dixon-Woods, Agarwal, Jones, Young, and Sutton (2005) suggested that integrative synthesis aims at summarization of data for relatively well-defined and secure concepts, while interpretative synthesis is aimed more at the development

and specification of concepts. According to them, interpretative analysis is *conceptual in process and output, and the main product is not aggregations of data, but theory* (Dixon-Woods et al., 2005). They did however argue that both qualitative and quantitative evidence can be subjected to interpretive syntheses.

Dixon-Woods et al. (2005) scaled studies in a similar spectrum between what they termed integrative and interpretive. However, some (slight) variation can be found. Rousseau et al. (2008) for instance identified aggregation, integration, interpretation and explanation as focal points, while Okoli (2012) identified theory landscaping, theory building and theory testing as possible review orientations.

The table below is based on (Petticrew, 2001), (Rousseau et al., 2008), (Hannes & Harden, 2011), (Sandelowski et al., 2012) and (Gough, Thomas, et al., 2012), and depicts the main differences between aggregative and interpretative approaches.

**Table 3: reviewing approaches compared – aggregative versus interpretative**

	<b>Aggregative</b>	<b>Interpretative</b>
<b>Goal</b>	Confirmation More exact estimate than single study achieves	Exploration and summarization Synthesize and interpret research to build higher-order theoretical constructs
<b>Method</b>	Combine effects to increase sample size and reduce bias in answering specific questions	Create tentative theories of phenomena including patterns of social construction
<b>Focus</b>	Similar (quantitative) findings	Dissimilar (qualitative) findings
<b>Product</b>	Pooled summary Magnitude and precision	Theory, model (Emergent) concepts
<b>Connection of findings</b>	Confirmatory (replication of findings)	Complementary (coherent assembly between findings)
<b>Quality assessment</b>	Internal validity Avoid bias	External validity Value of contribution
<b>Strengths</b>	Minimal method bias Answers precise question Systematic, replicable Targeted audience Highly relevant (and specialized) advice Findings likely to be accepted	Synthesizes multiple qualitative studies Takes context into account Broad scope Works good for highly heterogeneous contexts
<b>Weakness</b>	Findings less transferable Only relevant within context Useful only for homogeneous studies	Might lack particular audience Findings might be too general Context might get lost in overall picture Replication difficult Coding relies on reviewer skills

Within the broad characterizations illustrated above, specific approaches can however vary extensively. Weed (2005) for instance listed eight approaches to synthesis of evidence. Hannes and Lockwood (2011) identified seven different methods of qualitative synthesis. Grant and Booth (2009) found 14 types of review and associated methodology and constructed a table denoting perceived

strengths and weaknesses for each type. According to Gough, Thomas, et al. (2012), there is no clear typology of reviews, while Gough, Thomas, et al. (2012) noticed a relatively large overlap between approaches, despite the variety in names, and argued for a more standardized lexicon on synthesis methodology.

#### 4.2.2 General review steps

Systematic reviews generally use an explicit protocol that describes the approach a review will take. By pre-defining objectives and methods of the review, this protocol increases transparency and adds rigor (JBI, 2011). Regardless of the ultimate goals, most reviews follow the same broad generic steps, although the actual implementation can vary (Oliver, 2005), (Gough, Oliver, et al., 2012). All reviews start with formulating a question. Subsequently a protocol for the review is formulated, followed by a search for primary studies over various bibliographic sources, and an ultimate selection of studies for inclusion in the review. Included studies are subsequently coded and relevant data is extracted. These data is subsequently analysed and synthesized followed by the communication of the final results.

##### *Question formation and protocol design*

The formulation of the review question should aim to translate the interest of the commissioner of the review to a workable basis for setting up a review protocol and actually conducting a review. In this process, the field of interest is explicated. Usually this is done by dividing it according to the various components of the population, intervention, comparator and outcome of interest. These components are also used for specification of the inclusion criteria for the review. Logically, reviews interested in estimating precise outcomes for a well-defined intervention formulate rigorous, precise criteria, while reviews aimed at theory exploration or generation tend to rather delimitate a broad field of interest and compose more iterative search processes in their (Gough, Thomas, et al., 2012).

##### *Search*

A thorough and systematic search protocol is one of the aspects that sets systematic reviews apart from 'normal literature studies' (Shaw et al., 2004). It helps in systematically guiding the research and improving reproducibility. In order to limit bias, ideally all relevant material related to the search questions is identified. However, given limitations on time and resources, this is often an unlikely goal (Shaw et al., 2004). Besides, a really exhaustive search is improbable since the total field of potentially relevant studies is unknown (Gough, Oliver, et al., 2012, p. 113).

For aggregative reviews, an exhaustive search process is of relatively high importance, as omitting study findings might introduce bias and skew the quantitative synthesis. For integrative reviews, the aim of the search process lies rather in finding sufficient cases for the exploration of concepts and patterns. For such reviews exhaustiveness is less relevant and often some notion of 'saturation' is adopted, halting the review when the marginal number of new concepts identified decreases (Barnett-Page & Thomas, 2009), (Gough, Oliver, et al., 2012).

In general, retrieval rates of studies are relatively low. For instance, Sutcliffe et al. (2011), using a broad search strategy, found a percentage of relevant articles of 1,8% of the initial studies retrieved from the search query. When consulted an expert (Giel Ton) confirmed a retrieval rate between 1 and 5% as not uncommon. Booth (2010) indicated that – regardless the aim of the search – it is generally wise to use some sort of heuristic to determine when additional searches stop yielding significant benefits compared to time required. He indicated that not all databases offer the same

chance of finding additional studies, and that a balance should be struck between resource consumption and likeliness of retrieving significant additional studies. Somewhat similarly, Bradford's law expects exponentially diminishing returns when extending a search for references in science journals (Black, 2004). According to the law, '*for a search on some specific topic, a large number of the relevant articles will be concentrated in a small number of journal titles*' (Drott, 1981). This heuristic was initially based on a study on geophysics bibliography, which found that a core of a few journals held about one-third of all articles, followed by a bigger but still relatively small periphery containing another third of all articles, with a wide range of remaining journals containing the rest of all articles. Although the law is not statistically significant, it is often used by librarians as a guideline (Black, 2004).

### *Selection*

In the selection phase, the studies that were retrieved in the search phase are critically appraised for inclusion. Inclusion is often based on both study relevance to the topic of interest and the (methodological) rigor of findings. The selection phase generally results in the discard of a large part of retrieved studies, which is predominantly based on irrelevance rather than study quality (Petticrew, 2003). Study relevance is determined by matching retrieved studies against the inclusion criteria.

Evidence trustworthiness can vary with the research methodology employed. Gough, Oliver, et al. (2012, p. 155) reported that various reviews had found that lower quality primary studies tend to overestimate the effect of interventions. A similar statement, albeit perhaps less empirically founded, was offered by Rossi (1987) a few decades earlier when he proposed his 'stainless steel law', stating that *the better designed the impact assessment of a social program, the more likely is the resulting estimate of net impact to be zero*.

For quantitative studies, the consensus is that properly executed randomized controlled trials yield the most reliable results. For additional study designs, often an established scale of study quality is used, such as the Maryland Scientific Methods Scale (van der Knaap et al., 2008).

For qualitative research, there is no broadly supported evidence hierarchy (JBI, 2011), although over a hundred have been proposed (Dixon-Woods et al., 2006). JBI (2011) proposed three broad levels, without much further specification:

- *Unequivocal - relates to evidence beyond reasonable doubt which may include findings that are matter of fact, directly reported/observed and not open to challenge*
- *Credible - relates to those findings that are, albeit interpretations, plausible in light of the data and theoretical framework. They can be logically inferred from the data. Because the findings are interpretive they can be challenged.*
- *Unsupported - is when the findings are not supported by the data*

### *Data extraction*

In the data-extraction phase the required information is extracted from the included studies. In general this includes bibliographical information and often information on the specific study settings (e.g. location, date of intervention, etc.). For quantitative oriented reviews, information on effect and sample size is also extracted for use in the meta-analysis. For more qualitative focused reviews aimed at theory exploration or formation, this entails information on concepts and themes. In such reviews,

data extraction (and synthesis) is often an iterative process, instead of the relatively straightforward, protocol-led approach of aggregative reviews.

### *Synthesis*

The synthesis of study findings can take many forms. For aggregative reviews a meta-analysis is often conducted where findings on effect sizes from primary studies are statistically integrated to a single measure. For interpretative reviews, synthesis is often done based on interpretation by the researcher. Often, various concepts that are deemed thematically congruent are clustered in order to identify generic concepts. Often a narrative synthesis is involved as well.

### *Communication of findings*

Study findings are often communicated in a report. Although content and organization may vary, a standard for reporting quality has been established: the PRISMA-statement<sup>12</sup> (Liberati et al., 2009) - Preferred Reporting Items for Systematic Reviews and Meta-Analyses. However, in a review on systematic reviews, general reporting quality was found to be low (Moher, Tetzlaff, Tricco, Sampson, & Altman, 2007).

## **4.3 Reviewing in international development**

Systematic reviews have recently started gaining some popularity in the field of international development, and are considered as a tool in the formation of evidence-informed policy (Mallett et al., 2012). Especially the UK Department for International Development (DFID) and the Australian Agency for International Development (AusAID) have started exploring the suitability of systematic reviews for comparing intervention effectiveness in the field of international development (Mallett et al., 2012). IOB has conducted several systematic reviews as well.

Some dimensions for consideration have been brought forward by Waddington, White, et al. (2012). The first concerns the focus of the research question, which they noted can be centered around an outcome (what are the effects on...), or focus on an intervention (what are the effects of), or a combination of both for further delimitation. Secondly, with regard to the breadth of the review question and the subsequent search for and selection of studies, they mentioned the dimension of *lumping versus splitting* (Waddington, White, et al., 2012). According to them, splitters argue that studies can only be compared when they are highly similar in terms of design, intervention, population etc, while lumpers argue that policy relevance is better served by broader reviews comparing various interventions to achieve a similar goal and that broad reviews allow for a wider range of contexts to be taken into account. According to Waddington, White, et al. (2012), rigorous evidence in the field of development is often (still) lacking, and reviews covering more ground can provide helpful by 'mapping the field'.

## **4.4 Conclusions**

Systematic reviews are aimed at systematic aggregation of findings of other research. In doing so, a protocol is employed for identification, selection, appraisal and synthesis of primary research findings. Depending on the research questions, reviews can aim either at systematic aggregation of quantitative findings, e.g. by performing a meta-analysis, or at theoretic enquiry. Reviews aimed at aggregation of findings tend to focus on a set of relatively homogeneous studies and focus the selection on the internal validity of the studies. Reviews focusing on a broader, more heterogeneous

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<sup>12</sup> <http://www.prisma-statement.org/>

field of primary studies are generally less quantitative, and aim for the interpretative synthesis of more qualitative components such as concepts and themes. The next chapter use the findings from the previous chapters (2 and 3) to select among the dimensions of this chapter (4) and devise a protocol for the actual review.

## 5 Protocol design

This chapter will outline the approach to the review. This approach will be based on a comparison between the objectives of the review, the characteristics of the ICT4D domain and the dimensions of systematic review.

As noted in the first chapter, the goal of the review is to increase insight in the field of ICT4D by finding comprising rigorous research efforts so far. As noted in the chapter 2, the field of ICT4D and its potential impacts (relating to various conceptions of poverty and the alleviation thereof), encompass a rather broad field of study. Such broad focus is – as noted in chapter 3 – generally best facilitated with a more explorative character of the review. This chapter will briefly look into the characteristics of the field of review (ICT4D), explore some reviewing approaches for areas with similar characteristics and ultimately design a review approach for the research at hand.

### 5.1 Complex interventions

Where systematic reviews initially focused on statistical integration of study results, they often concentrated on relatively straightforward and homogeneous interventions. In practice, interventions of interest can however be more diversified and less simple. Interest can for instance be in interventions that comprise of multiple steps taken, either in sequence or simultaneous. Effects can be less linear and occur at multiple levels. These types of interventions are sometimes recognized as 'complex interventions' (Craig et al., 2008), (Petticrew, 2011).

In chapter 2 it was found that the field of ICT4D comprises various technologies, actors and contextual factors in an interaction of which various outcomes evolve. Hence, ICT4D interventions can be characterized as (relatively) complex. Although lacking a clear definition, complex interventions were described by Campbell et al. (2000), as those comprising *a number of separate elements which seem essential to the proper functioning of the interventions although the 'active ingredient' of the intervention that is effective is difficult to specify*. A sharp boundary of complexity is however not generally assumed; rather the degree of complexity is perceived to vary between interventions (Craig et al., 2008), (Shepperd et al., 2009). Most interventions are seen to have some characteristics of complexity (Shepperd et al., 2009), and the amount of it taken into account varies with the perspective taken (Petticrew, 2011). This perspective varies with the initial research question and its focus or absence thereof on *components, systems, processes, outcomes or about simpler pathways and outcomes* (Petticrew, 2011).

In the chapter on evaluations, it was noted that complex interventions are generally well served by more theoretically oriented evaluations (Sofaer, 1999), (Leeuw, 2012). A similar reasoning might hold for more explorative oriented systematic reviews such as the one carried out in this research. A more explorative oriented aim involves reviewing various components and levels, thereby increasing complexity according to the aforementioned definition. As such interventions often lack an agreed definition or clear description, they could be described differently across studies and research perspectives adopted could vary. This can complicate the formation of criteria for inclusion, the search process for relevant studies and ultimately the integration of reported results (Shepperd et al., 2009). A unilateral quantitative perspective in such circumstances might miss nuance and even introduce bias. As noted by Craig et al. (2008), a key question in evaluation of complex interventions concerns their generalizability to regular practice. This requires understanding of all their effects and the variation therein. Understanding of the main mechanisms behind an intervention and the

interactions between its core components is essential in the evaluation of complex interventions. Ogilvie et al. (2011) argued that it would be helpful to gain understanding on complex interventions by aggregating evidence on their workings across a range of contexts. Logically, systematic reviews can assist in such goals.

For reviewing evidence on complex interventions, some limitations are noted by Shepperd et al. (2009). According to them, these limitations relate to the scope and definition of the intervention, the search process, the standardization of the selection process and the synthesis of results. For instance, improper or incomplete definitions of the various possible configurations of a complex intervention might lead to bias by missing studies in the search process. Similarly, difficulties can arise in the selection of studies, where unclear criteria increase the risk of rendering the process non-reproducible (Shepperd et al., 2009). Regarding the synthesis of results, gains are thus more likely to be found in improved understanding of the various impact pathways of intervention and the influence of its context rather than finding an overall summary of effect size through meta-analysis (Shepperd et al., 2009).

As noted by Craig et al. (2008), a key question in evaluation of complex interventions concerns their generalizability to regular practice. This requires understanding of all their effects and variation therein. Similarly, understanding of the mechanisms behind an intervention and its core components is essential in its evaluation. For policy makers, maximum efficiency of complex interventions can be achieved by tailoring them to local circumstances (Craig et al., 2008). Similarly, Ogilvie et al. (2011) argued that *evaluative research [in the area of complex interventions] should test more general theories about how interventions work by aggregating the evidence for and against such theories across a range of situations.*

Anderson et al. (2011) noted that for policy questions of a more complex nature, it is often difficult to communicate the dynamics of interventions that operate at various levels simultaneously. A possible way to soothe this is by moving toward a systems thinking perspective, as such perspective lays more focus on the workings (internal and external) of a system. According to Waddington, White, et al. (2012), such efforts are also likely to be helpful in the domain of international development. Therefore, the current research will also aim at providing increased insight in the various outcomes and their relations of ICT use in development settings.

## 5.2 Internal and external validity

As indicated in chapter 4, aggregative/quantitative systematic reviews are mainly concerned with summarizing (quantitative) findings that were generated by studies with high internal validity on highly homogeneous concepts. Interpretative studies are generally aimed at interpretatively combining (qualitative) study findings by assessing similarity of concepts from often heterogeneous primary studies. Criticism on aggregative studies often refers to low validity and difficulty of practical use for policy makers due to limited insight in underlying mechanisms, while criticism on interpretative studies generally concerns the lower internal validity and lack of hard evidence.

## 5.3 Combining review methods

As indicated, systematic reviews can have various main goals and employ various approaches in order to achieve those. Review approaches vary in a spectrum that primarily lies between the summation of quantitative findings for the testing of intervention effectiveness (or other



hypotheses), and the generation of theory by integration of qualitative findings bases on (interpreted) similarity between concepts or theme's. Review approaches are generally positioned towards one of the ends of the spectrum. However, some studies have tried to find a midway of some sort, by *exploring how best to develop the breadth, generalizability and policy relevance of aggregative reviews without losing their methodological protection against bias* (Gough, Thomas, et al., 2012). Apart from narrative descriptive reviews that summarize various primary studies individually, some studies are worth noting.

van der Knaap et al. (2008) tried to add context to a Campbell review by combining elements of realistic evaluation (Pawson & Tilley, 1997). Their reason for doing so was based on (Pawson, 2006) argument that 'normal reviews' (following the Campbell approach) are overly focused on internal validity, while paying only limited attention to external validity and practical use of results. A combination of both methods was deemed useful as *opening up the black box of an intervention under review* could help evaluators in *understanding why interventions have (no) effects and/or side effects*, while the realist approach could benefit from using a stricter filter on internal validity (van der Knaap et al., 2008). In their words, *knowledge that is to be generalized should be credible; internal validity is a prerequisite for external validity. Therefore, both approaches are combined in this article* (van der Knaap et al., 2008). The approach presented was to first follow the methodology of a Campbell review in devising the research question and searching and selecting studies. After doing so, information on elements of the realist review (context, mechanisms) was extracted from the studies. As the information required for this second step was not always present in selected studies, this part proved to be rather difficult, and often required assumptions to be made by the reviewers. The resulting mechanisms identified were listed narratively and three overarching mechanisms were distilled.

Greenhalgh et al. (2005) termed their approach a 'meta-narrative' review, and aimed at *extracting key meta-narratives* from a diverse body of literature. They noted that reviewing a range of diverse, complex literature is *particularly challenging methodologically* as it requires *repeated iterations of the research question, cover[s] large bodies of evidence, include[s] many different research designs and require[s] the judicious combination of qualitative and quantitative data* (Greenhalgh et al., 2005). In the review, defining components and setting inclusion criteria proved difficult, as the reviewers did not want set too narrow a focus thereby ruling out many studies, while at the same time the amount of studies retrieved needed to remain workable. According to the reviewers, *[a]n important early finding of our research was the impossibility of sorting the primary studies into a single theoretical taxonomy* (Greenhalgh et al., 2005). At a consultation session with fellow researchers and policy makers halfway in the review process the reviewers were criticised for being too radical in their aim for theoretical rigour. Session attendees preferred a *more pragmatic and descriptive approach that embraced—and explained—the diversity of the research field* (Greenhalgh et al., 2005). In reaction, the reviewers used for elements of the philosophical paradigm of primary studies (conceptual, theoretical, methodological and instrumental aspects) for data extraction, and built a narrative storyline for each primary study.

Ton (2012) proposed a three step process for mixing methods during impact evaluations themselves – as opposed to reviewing them – which was developed during review work on agricultural value chains. A main reason for seeking a combination of review approaches was found in the observation that *[v]alue chain-support interventions tend to be quite different from interventions where the*

*'treatment' is clearly specified* (Ton, 2012). A starting point for mixing methods of distant research traditions was found in the *emphasis on contextual configurations* present in the realist tradition. According to Ton (2012) variation in outcomes under different contextual conditions provides an indication that interventions are unlikely to *'always' and 'universally' work; and any 'average' measure of impact needs to be defended by a clear specification of the context in which these apply* (Ton, 2012). The first step in the proposed process is rephrasing the review question; the reason for which is that experience showed that 'did it work' kind of questions did not always yield informative results. Rather, the exact design of and intervention and the surrounding dynamics were found to often be of significant influence. For this step, a logic model of the intervention and its position in the related value chain is constructed in cooperation with the stakeholders involved in the assignment. In doing so the causal chain leading to the intended impact is explored and (theoretically) constructed. According to Ton (2012), *[t]his first step leads to a list of 'areas' where research on causality and attribution may help to reflect on the performance of the intervention and/or generate information on key assumptions about the way that activities translate in the desired outcomes*. The second step focuses on potential threats to validity. This step critically examines the (mix of) methods to be used and their fit to the research problem. For this steps guidance is found in the threats to validity listed by Shadish et al. (2002) – presented in chapter 3 of the research – combined with the three additional dimensions of objectivity, reliability and utilisation of Bamberger and Rugh (2008). Although dimensions for this step are mentioned, the exact process is not presented. In the third step the scope of the research is expanded in order to *generate a body of evidence for a wider group of stakeholders regarding the effectiveness of interventions* (Ton, 2012). For this, including comparative case studies is suggested, as well as the identification of contextual factors that facilitate or hinder the intended mechanisms creating outcomes.

## 5.4 Graphical approaches (pathway exploration)

Graphical modelling of (complex) processes has already been used regularly in various domains to improve interpretation. Examples can be found in the use flow charts, IDEF0 and other approaches in business process modelling (Aguilar-Savén, 2004), or the use of causal loop models in the system dynamics domain (Sterman, 2002). Comparable approaches have been used in evaluations for expressing program theory, focusing among others on path analysis and causal modelling (Astbury & Leeuw, 2010).

In some reviews, some form of theoretical model is presented (under varying names) as theoretical background. King, Samii, and Snilstveit (2010) for example presented an 'ideal theoretical' model from another study as background to their. On some occasions the model is used to further delimitate the scope of the actual review, such as e.g. in (IOB, 2011). In general, these models are hypothetical, and based on some previous study or expert informed.

*maps have three main purposes of: (i) describing the nature of a research field; (ii) to inform the conduct of a synthesis; and (iii) to interpret the findings of a synthesis* (Gough, Thomas, et al., 2012).

### 5.4.1 Logic models

A logic model is a way to systematically and visually organize information on relationships between the various elements in an intervention or program (W.K. Kellogg Foundation, 2004), and *depicts assumptions about the resources needed to support program activities and produce outputs, and the activities and outputs needed to realize the intended outcomes of a program* (Cooksy et al., 2001).

Logic models are related to what in evaluations is often described as 'program theory' or 'theory based evaluations' (McLaughlin & Jordan, 1999). They can help in untangling complex relationships between the various components of a program or intervention and can be understood as *a visual approach to the implicit maps we all carry in our minds about how the world does or should work* (Wyatt Knowlton & Phillips, 2013). As noted by Anderson et al. (2011), logic models have often been used to increase understanding on complex programs in social and health sciences, and according to Cooksy et al. (2001), logic models have considerable potential as an integrative framework. *In the field of research synthesis, conceptual models and causal diagrams are under-utilized. Yet, they have the potential to make systematic reviews more transparent and ultimately more cogent to decision-makers, by making explicit the underlying assumptions about causal relationships and program theory... Logic models promote systems thinking by illustrating the relationship of the parts to the whole and highlighting congruencies and inconsistencies. In doing so, they can draw attention to aspects of complex problems that might otherwise be overlooked* (Anderson et al., 2011).

#### 5.4.2 Pathways

Both primary evaluation research and systematic reviews generally focus on identifying the causal effects of some intervention. Absent from purely RCTs – a situation difficult to establish in practice oriented research – some identification of underlying causal mechanism is generally required, although the level of detail can vary. As this research adopts a relatively broad perspective, the intervention of interest can be characterized as relatively complex, as was discussed at the beginning of this chapter. For complex interventions quantitative methods are not always applicable (Leeuw & Vaessen, 2009). There is also a the 'lumping versus splitting' discussion regarding the breadth of the research question (Waddington, White, et al., 2012), indicating that the research question could be split into multiple ones with higher internal homogeneity. For this review interest is in a broader study as this allows for better comparison of the various interventions, and possibly more generalization. Therefore, a focus will be on identification of various pathways for ICT4D effects.

So far, some studies have adopted a somewhat similar approach. A notable example is (Webb, 2013). He studied causal pathways on improved nutrition and health. He noted that pathways of causal inference had been used in search efforts for evidence before, and himself built on various examples thereof (Webb, 2013). However, all studies he referenced either built on 'expert knowledge' or were lacking any verifiable empirical backup at all. Some of the studies did however try to populate evidence pathways after establishing them, such as (Gillespie, Harris, & Kadiyala, 2012), (Hawkes, Turner, & Waage, 2012) and – although not mentioned by Webb - (IOB, 2011). According to Webb, *[e]ach of the reviews of evidence of linkages of the past decade has concluded that too many studies rely on “simplistic associations” and too few “include all the necessary aspects of the research chain”* (Webb, 2013). He noted that intervention efficiency can only be compared with alternatives when the full pathway has empirically been identified (Webb, 2013). On a side note it was remarked that many previous reviews found that study designs in primary studies were frequently of relatively low quality and often failed to meet inclusion criteria; studies that did use control groups or otherwise reasonable quantitative approaches were also often found to lack statistical power for identification of the effects aimed for (Masset, Haddad, Cornelius, & Isaza-Castro, 2011).

An example of an more interpretative study focused on causal effects is (Baxter et al., 2010). In their research, they used qualitative studies from an unidentified 'previous review' to build a logic model from common elements. They did not use an extensive search methodology, and neither used quality

standards for inclusion criterion. Their analysis was based on an interpretative – and iterative – coding of common elements in qualitative analysis software (NVivo<sup>13</sup>). In this approach their analysis basically used interpretative synthesis.

Another example was provided by Lorenc et al. (2012), who investigated *links between crime and fear of crime, the social and built environment, and health and wellbeing*. In their study they drew from approaches such as realist review (Pawson, Greenhalgh, Harvey, & Walshe, 2005), critical interpretative synthesis (Dixon-Woods et al., 2006) and the above mentioned method of Baxter et al. (2010). For the review, an iterative process of search and selection was used, although explicit details were not provided. In their words: *the main foci in terms of data were theoretical literature and quantitative observational studies of associations between variables, although we also utilised qualitative evidence, outcome evaluations, policy papers and a range of other types of evidence* (Lorenc et al., 2012).

### 5.4.3 Systematic mapping

Sometimes an overview of a larger research domain is provided by means of a systematically constructed map. Such maps can be regarded a bibliographical tool that can inform research by describing and organising literature relevant to some question. Systematic mapping as an approach to chart a research domain was originally developed by the EPPI-Centre (Peersman, 1996), (Clapton, Rutter, & Sharif, 2009). In the approach, a (relatively) exhaustive search and selection process is carried out, after which included research is coded. The coding generally indicates some of main aspects of included studies, such as the focus of the report, the characteristics of the population, the geographical location where the study was carried out, the (type of) intervention studied, etc. Codes are often recorded in a way that allow for cross-tabulation of a number of selected questions/components. Such cross-tabulation can later help in establishing sub-sections in the literature and relationships between them.

## 5.5 Review protocol

As this research focuses on a relatively unexplored, young and dynamic domain, it will aim at improving (generic) understanding. Therefore, the approach will have a partly theoretic focus in uncovering various pathways of ICT effects in development setting on a generic level. In order to do so, no up-front efforts of formulating an explicit framework or pathway-model will be undertaken, but rather broad speculation about possible effects will be used for the search terms formation. A framework will be subsequently composed based on study results. In order to maintain empiric grounding, in- and exclusion criteria will aim for a minimum level of study quality. Standard will however not be set too high, as this might hamper explorative aspirations as was indicated in the previous chapter. The approach taken here differs somewhat from the usual approaches towards similar pathway or logic models as they generally explicitly specify the model up front while populating it later.

The approach taken aims to combine richness in breadth by including a relatively wide range of research while simultaneously minimizing the influence of bias by adopting quality criteria for evidence.

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<sup>13</sup> [www.qsrinternational.com/products\\_nvivo.aspx](http://www.qsrinternational.com/products_nvivo.aspx)

### 5.5.1 Scope

As indicated earlier, the review will adopt a relatively broad character in order to provide an overview of the field relevant for policy makers. Therefore a range of information technologies will be included, thereby focusing on the communicational aspect(s) of such technology. Similarly, a relatively wide context within which primary studies examine ICT use will be explored; basically the review will focus on the use of ICTs within rural areas within or directly related to the agricultural value chain. The scope of a review is often refined by explication of the various components forming the acronym PICO: population, intervention, comparator(s), outcomes (Tacconelli, 2010).

For this research the population will consist of inhabitants of rural, developing areas. The 'intervention' will be the use of ICTs for some form of communication or exchange of information. As comparators might be difficult to obtain, it is expected that many studies will be lacking any. Therefore, constraints on this component will be relatively lenient, and studies employing at least some (basic) form of quantitative, quasi-experimental analysis will be accepted. Ideally, possible outcomes for this review would be unspecified *ex ante*, but rather 'learned' from the literature identified. However, some form of specification is likely to be required in order to limit results to a workable number. Therefore a broad range of outcomes will be considered, relating to one or more of the following broad categories: market effects (e.g. prices), effects on financial well-being (e.g. income, wealth, savings),

#### *Inclusion criteria*

Inclusion criteria determine what (sort of) studies will be reviewed. In order to limit bias and improve transparency, such criteria are generally set *ex ante*. As noted, the review focuses on the (effects of the) use of ICTs in agricultural/rural settings developing countries. For finding inclusion and exclusion criteria, the agricultural focus has been further specified as being delimited by the 'agricultural value chain', which includes roughly anything from inputs for farming to the actual production process to the sales of the final product.

Inclusion criteria define the type of studies to be included. For this research, inclusion criteria should be sufficiently broad to incorporate a diverse range of studies relevant to the research goal and questions, but narrow enough for the selected studies to share at least some generic aspects that allow for synthesis and for the amount of selected studies to be workable. Included studies should hence fulfil the following requirements:

- Language – Given resource constraints, only studies written in English will be included. Although possibly introducing some bias, the effects of this decision are expected to be fairly small. The majority of research these days is published in English, especially on international topics as ICT. The choice of limiting inclusion to English material is a relatively common one in systematic reviews.
- Period – As the field of ICT is fairly dynamic and subjected to change, only recent developments will be considered. Therefore, inclusion will be limited to studies published in current century (after December 31<sup>st</sup> 1999).
- Type of publications (study quality) – For this research, only scientifically published material (peer reviewed articles and conference papers will be included). Where methodology is concerned, studies identifying correlations through quantitative methods will be included.

- Study setting – Included will be studies that were conducted in or on developing areas.
- Study focus – As the study focuses on ICT in developmental settings, only studies of developing nations will be included.  
Focus on activities within or directly related to the agricultural value chain and/or life in rural areas.

As indicated in, the method of analysis by which a pathway is investigated and the subsequent trustworthiness of the result, can vary. In health care reviews the search process often aims for identification of (only) the most reliable evidence, which is generally considered to be evidence gathered by means of RCTs. As such highly controlled, experimental settings are unlikely to be found in development settings – especially when concerning a relatively young field as ICT – other methodology are likely to provide viable information and should be included.

### *Exclusion criteria*

Studies focusing (primarily) one of the topics below will be excluded:

- Studies focused solely on non-developing nations or regions (as determined by the bank classification);
- Studies focusing on processes not primarily positioned within the farming value chain (e.g. education, biology, government, technology in itself, health care, chemistry, tourism, finance, telecommunication sector, etc.);
- Studies published before January 1<sup>st</sup> 2000;
- Studies adopting a purely qualitative approach;
- Studies using a small sample size ( $n < 100$ );

### **5.5.2 Search strategy**

The search strategy will focus on academic sources due to limitations in resources. Search queries will be developed during the execution of the review.

### **5.5.3 Study selection**

Selection will be done based on the inclusion criteria listed above. Generally, appraisal is done in teams in order to minimize bias. For this review, selection and appraisal was done by a single person (the author) due to resource constraints. This might introduce an element of bias.

#### 5.5.4 Data extraction

As this study is primarily interested in (quantitatively) established relations, the following data will be extracted:

- Bibliographical data (e.g. author, year, journal, date, etc.)
- Study method
- Geographical area
- Population (e.g. profession)
- Technology (e.g. radio, mobile phone)
- Sample size
- Data source (e.g. survey, external)
- Period of data collection
- Research method employed
- Possible weaknesses in study design
- Study results (established relationship(s))

#### 5.5.5 Synthesis

As indicated, this study is primarily interested in causal relationships stemming from ICT use. The effects (relationships) identified from primary studies will be combined in some sort of visual overview.

### 5.6 Conclusion

The field of ICT4D matches the characteristics of what are often termed 'complex interventions'. Contrary to the relatively well-defined interventions studied in most Cochrane-style reviews, complex interventions are comprised of multiple elements that interact on various levels producing multiple, sometimes non-linear effects. As complexity of the ICT4D field is not inviting for the construction or proposal of a broad, all-encompassing theory, more empirically grounded theories of the middle range are rather welcome. This requires the review approach to maintain focus on methodological rigor and protection against bias from primary studies, while at the same time aiming to increase breadth, generalizability and policy relevance of the results. In order to do so, an adapted version of a Cochrane-style protocol will be used for this review. The approach will aim at extracting multiple aspects related to ICT4D from primary research. In this protocol, some steps will undergo some minor changes to accommodate a broader scope, while especially the synthesis process will be considerably changed. The inclusion criteria will aim at a wider range of studies, and adopt a lower methodological threshold; the latter as it is expected (based on expert consultation) that relatively few high quality studies will be available. The search process will use a similar approach as other reviews, although a relatively broad array of topics is targeted. Study selection will be based on prespecified inclusion criteria as normally. Data extraction will also follow a pre-set protocol aimed at extracting researched causal relationships besides bibliographical data and some information context. For the synthesis, extracted relationships will be combined in a systemic overview.

# Part II – review execution

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## 6 Review execution

In this second part (B) of this research, the actual conduction of the proposed review will be described. The current chapter (six) will focus on the actual review process, while the next chapter (seven) will elaborate on its conclusions. The current chapter follows the review steps prescribed in the review protocol, beginning with the search.

### 6.1 Search

Leenaars et al. (2012) advised the following steps for conducting searches (in the field of animal studies): formulate research question, identify appropriate databases and sources of studies, transform research question into search strategy and collect search results and remove duplicates. After completion of the search process, retrieved studies will be matched against the inclusion in order to determine their ultimate selection. Basically, the search strategy consists of the resources to be search and the strategy by which to search them. As most information has been digitalized nowadays, search processes are often conducted electronically, which provides for increased speed over manual searches of non-digitized information. Given the limitation of the research at hand to recent information published from the start of the millennium, the expected loss and subsequent bias of excluding non-digitized information is limited. Therefore the search will focus exclusively on electronic sources in order to minimize time. The selected sources and accompanying search query design will be discussed in the following two paragraphs.

#### 6.1.1 Search sources

Due to the dynamic nature of the field and a relatively large involvement of the market-sector, ICT4D study is not an exclusive scholarly activity. Developmental organizations, governments and telecom-businesses take an interest in the field and partake in its research. Logically, evidence on ICT4D-related impact is likely to be present in both scientific publications and the so called 'grey literature'. The research at hand will however limit its focus to scientific research. This choice is based on two considerations. Firstly, constraints of time and resources required a relatively efficient search process, which favours the relatively well-indexed and easily searchable scientific databases over the often relatively limited, unstructured interfaces of grey literature. A second factor is that scientific databases and especially peer reviewed studies are more likely to offer methodological rigor and unbiased findings than grey literature.

Within the scientific literature the search will focus on broad portals aggregating a wide array of publications as well as more narrow-focused publications. Logically, searching a single database increases the risk of missing studies (Avenell, Handoll, & Grant, 2001), (Stevinson & Lawlor, 2004) and using additional specialist sources can add value (Stevinson & Lawlor, 2004). Additionally 'Bradford's law' – an heuristic indicating that for a specific topic a large amount of relevant material is likely to be found in a small set of journals (Drott, 1981) – supports the inclusion of a small amount of specialized sources. Based on size (and relevance to the research topic), the two largest relevant scientific databases – Elsevier's Scopus<sup>14</sup> and Reuters' Web of Knowledge<sup>15</sup> – will be selected for the

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<sup>14</sup> <http://www.scopus.com/>



search. For the more focused search, a number of journals selected based on table published online by ICT4D expert Heeks (2010b) and consultation with experts in the fields of international development and ICT4D<sup>15</sup>. The selected journals can be found in appendix I.

### 6.1.2 Search query design

The search query constitutes the interaction with the database; it basically tells the database what studies to look for, or in other words classifies studies in a database as relevant – a label which will result in their occurrence in the search results – or irrelevant. Although for some disciplines specific search approaches have been presented (e.g. (McGowan & Sampson, 2005), (Fehrmann & Thomas, 2011), (Agoritsas et al., 2012) for health care), specific guidelines for search query design do not exist. Ideally the search process would retrieve all and only relevant studies. However, in practice both relevant and irrelevant studies will be retrieved, leading to the existence of a general trade-off between exhaustiveness of the search and the time required for subsequent selection process (Furlan, Irvin, & Bombardier, 2006). This implies that on the one hand the search query should aim to retrieve as much (potentially) relevant studies as possible, while on the other there is an incentive to minimize the amount of studies for the selection process due to time and resource constraints. In machine learning, performance in such classification problems is often presented by means of a 'confusion matrix'; a table that presents statistics on true and false positives and negatives in four quadrants. The primary goal of a search algorithm is maximization of true positives while minimizing false negatives. False positives – often related to as type I errors – would mean inclusion of studies that will ultimately turn out irrelevant, increasing time required for selection. False negatives – also related as type II errors – would mean missing out on relevant studies, comprising search exhaustiveness. 'Search sensitivity' relates to percentage of relevant studies retrieved compared to all relevant studies in the total set (database), precision indicates the number of actual relevant studies in the set of retrieved studies, while 'specificity' of the search relates to the amount of studies that were wrongly ignored (type II errors). The ideal search would be highly sensitive and precise, but in practice sensitivity and specificity will need to be balanced. In this balance, it is safer to err on the side of sensitivity as it is easier to remove studies during the selection process, than it would be to make alterations to the search query should high specificity turn out to have overly impeded search exhaustiveness.

As it is easier to deselect some studies than it is to add additional topics (due to e.g. duplicates) while maintaining search integrity, it the search was aimed to be as broad as possible while remaining workable. For this research query design was therefore done through an iterative process aiming to retain a maximum workable amount of studies. As scientific literature is generally reasonably well-structured and often contains an abstract, it was estimated that study selection could proceed relatively rapidly. Therefore an initial amount of 5,000 to 6,000 studies was aimed for as a workable amount, based on protocols from other reviews.

For the design of the actual search query, three broad strategies can be identified (Shaw et al., 2004): using controlled keywords that are used for indexing studies (known as thesaurus terms or subject headings), using free-text terms for searching titles, abstracts and keywords, and using broad-based terms (generic, free-text terms). In an exploration of qualitative search strategies, Shaw et al. (2004) found that using controlled terms alone hampered study retrieval so that a combination of strategies

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<sup>15</sup> <http://www.webofknowledge.com/>

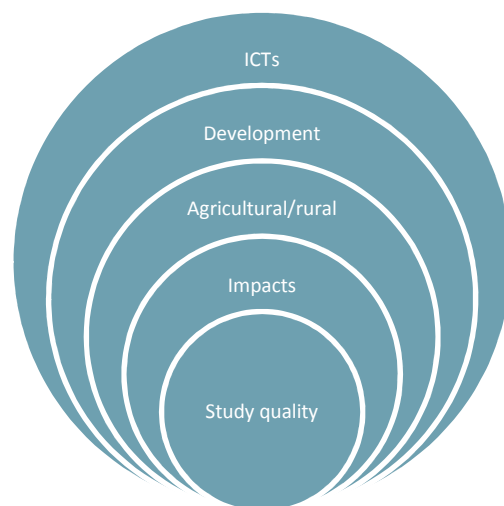
<sup>16</sup> Jeffrey James, Ruerd Ruben, Rob Kuipers

using free text as well was advised. Leenaars et al. (2012) advised splitting the research question into components and subsequently identifying relevant search terms for each component using both free text and controlled terms.

Search query components are often identified using the mnemonic PICO, which denotes population, intervention, comparator, outcome of intended studies. By specifying each component in synonyms connected by a Boolean 'OR' operator and subsequently linking the individual components by a Boolean 'AND' operator the full search query can be constructed. It is often advised to leave the two last PICO components (comparator and outcome) open, as study design is not always properly listed in titles and abstracts, and outcomes are not always known a priori.

In an initial run, the intervention (ICT) and population initially were specified in three components: ICT, development, and agricultural/rural settings, and trial searches were ran in the two major databases used (Elsevier's Scopus and Reuters' Web of Science). During this initial phase it turned out that the queries had a relatively unfocused nature and as a result high numbers of hits were returned (i.e. over 50,000). Therefore it was chosen to specify the components of study design (comparator) and results after all. The resulting query was specified as follows:

Figure 6: search query components



Synonyms for the various components were identified by using 'common knowledge' and dictionaries<sup>171819</sup>. Also search strategies from other systematic reviews were used:

- For ICT: (Geldof et al., 2011),
- For the international development: besides synonyms for 'development' a list of countries was used based on classification by the World Bank<sup>20</sup> (in order to account for changing statuses over the year, classifications up to 'upper-middle-income', resulting in a list of 144 countries).
- For agriculture: (Waddington, Snilstveit, et al., 2012)
- For study quality: xxx

<sup>17</sup> <http://www.thefreedictionary.com/>

<sup>18</sup> <http://www.synonym.com/>

<sup>19</sup> <http://thesaurus.com/>

<sup>20</sup> <http://data.worldbank.org/about/country-classifications/country-and-lending-groups>

### 6.1.3 Validation

#### *Search term validation*

V. J. White, Glanville, Lefebvre, and Sheldon (2001) noticed that subjectively gathered search terms do not tend to perform as well as those derived by a statistical approach. Although no extensive statistical approach was employed here, the most frequent terms were extracted from the abstracts of the papers from the reviews identified in Chapter 2 ((Duncombe, 2012); (Dixie & Jayaraman, 2011)) in order to check for missed search terms. This process is further described in appendix II. In it, no additional key words were identified, strengthening the belief that an adequate search query was devised.

#### *Validation of results*

Real validation is practically impossible as the size of the total research landscape is unknown. As noted above, a first indication of performance can be found in the relative low overlap between the focused searches and the generic search in portals. To get an additional impression, a sample of three journals was hand searched. The results are depicted below.

Publisher	Titel	Comp.	Hand	Dupl.	New
TandF	Inf. Technology for development	144	73	49	24
SAGE	Progress in Development studies	198	4	4	0
Wiley	Review of Development Economics	31	2	1	1

As can be seen, hand searching found no additional studies for the two journals oriented at international development in general (Progress in Development Studies, Review of Development Economics), while it did for the more ICT4D-oriented Information Technology for Development.

#### *Comparison with other reviews*

As noted in chapter 2, two other reviews were identified: (Duncombe, 2012) is a working paper focusing on mobile phones and (World Bank, 2012) is a study on ICT for agriculture from the World Bank. Both studies claim to have followed a systematic approach, although search criteria were only somewhat explicated. In order to gain an impression about the sensitivity of the search strategy employed in this paper, a comparison has been made between the studies retrieved in the two reviews mentioned above and the ones retrieved through the search criteria in this report. As the other reviews involved both grey literature and scientific research, both categories are listed explicitly.

Studies	Total	Scientific
# in other reviews	65	44
# retrieved	35	35
Percentage	54	80

As only 54 percent of the total of primary studies from the other reviews is retrieved, this can be regarded as relatively low, and far from being exhaustive. This low score is partly due to the choice of focusing only on the domain of scientific studies. As an aside it is interesting to notice how 21 (65 minus 44) out of 65 of the studies identified in other reviews are published outside of academic

sources. When limiting focus to scholarly publication, the search strategy performs better by retrieving 80 percent of the (academic) studies identified in the other reviews.

#### 6.1.4 Duplicate removal

The first step was the removal of duplicates. This was initially done in EndNote. The table below depicts the references retrieved per source and the duplicates with the existing set. Duplicates were filtered in EndNote by comparing references on author, and title, and manually removed based on other indicators such as year, doi and volume. For conference proceedings articles that had subsequently been published in journals, the journal reference was kept.

An interesting notice was that Scopus and Web of Science – two of the largest portals – show considerably little overlap, as only (a max of) 1091 duplicates were found between the two. Also interesting is the relatively large amount of 216 duplicates within the 3094 results retrieved through Scopus. Those duplicates consist of both double entries and conference proceedings that were later turned into articles. In addition, a relatively small overlap was found between the focused searches with specific publishers and journals and the broad searches in the portals. From this, it can be concluded that each source searched, added significantly and (almost) uniquely to the total set. As study quality has not been assessed it is at this point however unclear what the ultimate contribution of various sources will be.

Such recently large addition from the subsequent sources can have multiple causes. An influence can be found in the shorter search queries used for the more focused searches. If this was indeed the cause, this could be seen as an indication that the longer search queries used were not optimally composed (either to due specific issues, or due to their length in itself). A brief literature scan found that other authors reported similar results. Kloda (2007) in a comparison between Google Scholar, Web of Science and Scopus (on the topics of oncology and condensed matter physics), found a respective overlap in the results between 31 and 21 percent (for the study here, 20 percent was found). They found Web of Science to include the most unique references, followed by Google Scholar (Kloda, 2007).

After duplicate removal in EndNote, studies exported from EndNote and loaded into EPPI reviewer<sup>21</sup>. EPPI reviewer is an online software tool for systematic reviews created by the EPPI-centre. After studies were loaded into EPPI-reviewer, an additional 58 duplicates were identified and removed. As it turned out, EPPI-reviewer is better suited for duplicate identification than EndNote, as EPPI-reviewer uses percentage-wise matching instead of full-matching as does EndNote, and is therefore capable of identifying duplicates that exist with minor spelling variations.

## 6.2 Selection of primary studies

In the selection process, the studies informative to the research question are selected by comparing the studies identified during the search are compared against the criteria established in chapter 5 for inclusion. For doing this a software tool named EPPI-reviewer was used. This tool facilitates the import of bibliographic information such as author, study title and abstract and provides a practical, browsable overview thereof. For the selection process EPPI-reviewer allows for the labelling studies with various self-composed categories which can be used as a form of data extraction and/or record keeping.

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<sup>21</sup> <http://eppi.ioe.ac.uk/cms/Default.aspx?alias=eppi.ioe.ac.uk/cms/er4>

In the selection process, studies that did not match the inclusion criteria were removed. In order to provide some background information on the total set of selected studies, these exclusion rounds are briefly described below. It should be noted that categorization of excluded studies was done by assigning only a single category. As it is not unthinkable that studies fall in multiple categories, no exhaustive overview can be provided for excluded studies. Thus, although exclusion grounds can be informative to some extent, they should not be taken as a complete or extensive description of the studies removed.

All studies were selected and or removed based on the same selection criteria. This process was conducted over multiple rounds, with the first rounds aimed at rapid removal of clearly irrelevant studies, while later rounds examined retained studies with more scrutiny. The first three were broadly similar and focused on assessing subject relevance, while in the fourth round methodological quality was assessed. Studies for which exclusion was unclear were retained for further scrutiny in subsequent rounds.

The first round focused on quick detection of studies for which exclusion was relatively obvious. Study titles were searched for terms that were clearly unrelated to the inclusion criteria such as 'health care', 'teleostei', 'chemical', 'academic', 'library', 'HIV', 'government' etc. The titles brought up by the searches were quickly scanned for verification of exclusion and confirmed studies were deleted. Topics of dismissed studies were primarily related to biological, chemical, environmental, educational health care, water-management and governmental, issues. Also excluded were 84 book reviews. In total, around 1450 studies were excluded in this round.

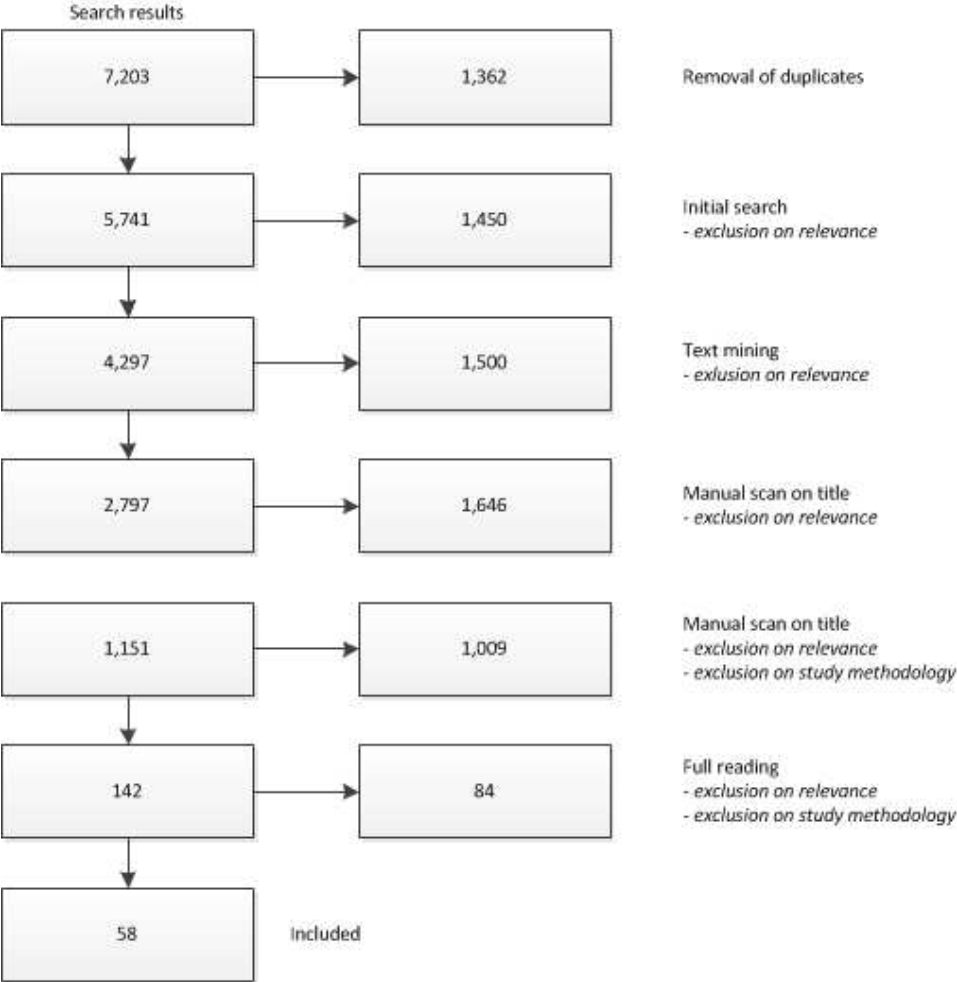
In a second round, a similar approach was used for fast identification of clearly unrelated studies. This was done by using the built in text-mining functionality of the EPPI reviewer, as no apparent keywords for direct exclusion were left. The text-mining function creates clusters based on study similarity related to a shared term. The terms identified in the text mining process were subsequently manually scanned for clear irrelevance to the inclusion criteria, and titles of related studies were scanned for verification of exclusion. Studies excluded related for instance to remote sensing, satellite technology (e.g. GPS, soil mapping), meteorological issues, robotics, banking, biology and water. This round led to the exclusion of roughly another 1500 studies.

In the next round the titles of the remaining studies were manually scanned for presence of clear reasons for exclusion. It was checked whether studies were clearly not related to development or ICT, or where unlikely to investigate a relationship (correlation). In this round excluded studies focused (among others) on large corporations, education, the financial sector, the telecom sector (by means of e.g. regulations, competition or price setting), governmental affairs, satellite technology (e.g. soil mapping), the ICT business sector, ICT design (instead of use), and urban settings (as opposed to rural environments). Studies were also excluded if they were not focused on developmental settings, the agricultural value chain, or lacked use of ICT. In this round it was also decided to exclude studies focusing (primarily) on (non-agriculture-related) small and medium enterprises (SMEs), resulting in the exclusion of (roughly) 300 studies. This decision was made as it seemed that the amount studies remaining would result in a sufficiently large set for further analysis. Ultimately, 1646 studies were excluded in this round, leaving 1151 for further scrutiny and analysis by full reading.

In the final round, the abstracts of the remaining 1151 were scanned for inclusion against the same criteria as used for the previous rounds, but focus on methodological quality (indicated by study design) was added. This means that studies that did not employ a quantitative (statistical) approach based on a sample size of 100 or greater for the assessment of studied correlations, were excluded. Studies for which inclusion was unclear were retained for full reading. This round led to the exclusion of an additional 1,009 studies, of which roughly a third did not match the methodological criteria, while two thirds turned out to be irrelevant to the field of interest on the same grounds as in the previous rounds. This left 142 studies for full reading.

For the final round, full texts for studies were retrieved for further analysis. For 16 potentially relevant studies the full paper could however not be retrieved, and subsequently no inclusion assessment and further analysis could be made. A list of these studies is provided in the bibliographic overview of this report. Of the remaining 126, an additional 68 studies turned out to match the inclusion criteria. This was mainly for methodological grounds. Roughly half of the studies turned out not to be quantitative after all, while in the other half no real correlation was identified as they were mainly descriptive. A minority of studies was excluded because their sample size fell below 100. Ultimately, this final round left 58 studies for inclusion. The selection process is illustrated in the graph below.

Figure 7: search and selection process - flowchart



As can be seen the amount of studies that were initially selected has been greatly reduced in the selection process. With a cutback from roughly 6,000 to nearly 60, this process rendered 99 percent of the studies initially retrieved useless. Although such substantial reduction might seem striking, it is not entirely uncommon. Giel Ton – an expert in the field of systematic reviewing – indicated for instance that selection percentages between 1 and 3 percent are not uncommon for reviews. Other sources indicated similar results. All in all, at the end of the selection process, 58 studies were retained, all of which matched the inclusion criteria set in chapter 5. Selected studies focus on the use ICT within the (broad) agricultural/rural value chain in developing areas, aim to identify aspects related to ICT use, employ a (partly) quantitative method for validation of such relations, draw from a minimum sample size of 100 observations and were published in the current millennium.

### 6.3 Data extraction

#### 6.3.1 Approach

In this step, the information relevant to the research at hand was extracted from the primary studies. Data extraction was initially done in excel as this provided an easy and relatively straightforward method of creating an initial overview of relevant issues such as study settings, research approach, participants, technology involved and study results, of which the latter constitute the primary interest for the research at hand. Other aspects extracted were bibliographical information, sample size, geographical focus, study design and potential weakness in its use (if applicable), and the period of data collection. An illustration of the initial data extraction sheet is provided below; a full overview is provided in appendix VI. The sheet also contained a column in which effects were narratively described, but as the use of this was primarily for scoping purposes and to provide guidance during the rest of the reviewing process, this was not done in a very rigorous format and will not be presented here. As a reminder for the reader, effects were only extracted if they matched the pre-set inclusion criteria and employed a statistical approach based on a sample size of at least 100 observations. Additionally, a narrative summary of primary studies was also created and is provided in appendix 124. In the extraction phase, relevant sections of the pdf-files were also marked using PDF-XChange Viewer<sup>22</sup> (packages such as Adobe offer a similar functionality).

Table 4: illustration of data extraction table

Author	Year	Sample	Area	Participants	Technology	Collection	Method	Weakness
Aker, J. C.	2010	415	Niger	Traders	Mobile	1996-2006	DiD	none
Alampay, E. A.	2006	515	Phillipines	Villagers	Various	2004	Statistical	-
Aminuzzaman, S.	2003	350	Bangladesh	Rural pop.	Mobile	1999-2000	Statistical	Self reported
Armstrong, L. J.	2012	100	India	Farmers	Broad	-	Statistical	-

Reported results from primary studies were the main interest for extraction, as these results constitute the relationships required for the synthesis phase. Results were only extracted if they matched the pre-set inclusion criteria: they had to involve some form of ICT, be based on a minimum sample size, and be assessed by quantitative methods. All outcomes matching these criteria were extracted, regardless of the direction or significance found.

As expected, the primary studies differed in terms of population, technology, setting and relationships studied. Populations studied for instance included traders, farmers and rural villagers, while for among other technology radio, mobile phones and internet were studied. As the goal of the

<sup>22</sup> PDF-Xchange viewer (Version 2.5): <http://www.tracker-software.com/product/pdf-xchange-viewer>

study was to examine a relatively broad field of interventions, settings and results, this posed no additional issues for data extraction. With regard to geographic focus, a difference was noted between studies focusing on regional or sometimes national areas within a single country, and those analysing relationships in a group of multiple countries simultaneously. The former tend to make somewhat more use of comparative analysis involving a counterfactual, while the latter made relatively more use of regression analysis. However, these differences posed no direct dilemma's for the data extraction, and no additional decision were made.

Where methodological strength is concerned, required levels for methodological quality for the research at hand were lowered somewhat in comparison to the more strict Cochrane-type systematic reviews. As a result, there was some variation in methodological quality of primary studies. Some studies were organized as randomized controlled trials, others followed a difference-in-difference approach or employed another quasi-experimental design, but a majority used fairly straightforward statistical methods; especially those exploring factors determining ICT use. Quality of implementation of study design in studies was also found to vary, which did result in an additional decision during the data extraction process. As noted in the methodological chapter, it is (sometimes) assumed that less rigorous studies might lead to an overestimation of effects (Rossi, 1987), (Gough, Oliver, et al., 2012, p. 155), which might lead to unreliable conclusions. Major weaknesses include the reliance on self-reported estimates of use, possible omitted variable bias in regressions (primarily in the studies adopting a multinational focus), and failure of randomization. This where a practical problem of the approach comes forward: on one hand there is an interest in exploring a broad range of plausible relationships, while on the other, the research aims to maintain empirical grounding in order to assure reliability of results. As self-reported results can suffer from bias, it was chosen not to include relationships based on abstract self-assed notions such as 'usable', 'functional' etc. However, issues such as potential omitted variable bias are more difficult to judge by means of a general guideline as potential problems can vary due to local circumstances. Therefore, potential weaknesses in study design were noted, but effects were extracted nonetheless.

### 6.3.2 Identified relationships

The relationships identified from the primary studies are briefly described over the next pages. For convenience this summary is formatted in accordance with the subsequent interpretative analysis. An initial classification is between factors relating to ICT use, and those stemming from such use. These effects are subsequently ordered in sub-categories.

#### *Use*

Alampay (2006) found that some less densely populated areas with geophysical barriers tended to have less access to ICTs due to infrastructural problems. Overall significant factors for ICT use were the level of education, age, and income of the respondents. Regarding gender, he found difference only on one location, where women were more capable than men in the use of cell phone and computers, although he noted that this might be related to higher education levels of the women.

Adopting a more specific technological focus, Aminuzzaman et al. (2003) found that mobile phone users were generally from the younger generation, mostly male (while lessees were generally female) and had an above average education.

Armstrong et al. (2012) in their study on broad ICT use among farmers in India found no clear relationship between age and ICT use, nor for education and ICT use. Income was however found to significantly correlate with use of ICTs.



Blumenstock and Eagle (2010) studied mobile use in Rwanda by comparing mobile phone users to the population at large. They found that phone users tended to be male, better educated, and wealthier than the population at large, and that richer phone owners generally used their phone more. Additionally, they noted that mobile phones are often shared, as individuals sometimes only buy a simcard at a cost of US\$ 1 and use it with phones from other people. Therefore actual phone ownership was deemed not (all too) important for use. Similarly, Zanello (2012) found that access to ICTs rather than ownership was relevant for effects.

Regarding internet use, H. H. Chang and Just (2009) found that it was higher among households with higher income and educational achievements. It was also found that age was positively correlated with internet use, while the presence of elderly (65+) was related to a decrease. Also internet use was found to be higher in urban locations compared to rural ones.

W. I. Chang and Tuan (2011) studied various technologies, and found some differences between their users. Radio was used more by older individuals with a lower educational level that were often members of a (farmer) association. Gender was not found relevant. TV users were found to be younger and more often of female gender. Telephone (landline) was found to be used by a younger, higher educated public generally outside of associations, while gender was not found very significant. For telecentres issues such as age, gender and education was not found to be very significant, local ethnic minority group membership was.

Chong et al. (2009) noticed that Peruvian households with higher incomes made more phone calls and had higher public phone expenditures.

In the research of Hassan et al. (2009), it was found that older respondents (especially those older than 51) experienced more ICT-related difficulties. Respondent education achievement was also found to be of influence, with better education related to less barriers and higher ICT usage. Similarly, a higher income could be related to higher ICT use.

Islam and Grönlund (2011) studied mobile phone use among farmers in rural Bangladesh and found no statistically significant relationship between income or land size and mobile phone ownership, noting that even the poorest people had mobile phones. Education was also found an insignificant predictor. Age was however found to be a strong indicator of phone ownerships, with younger people significantly more likely to have one, as were families with more children. Regarding actual use, they found that *[m]obile phones are used mainly for voice communication. Only 20% use SMS, and even among them use is quite sparse – only 5% are daily users. However, the number is up from 8% in 2006 potentially indicating a trend that mobile phone users over time become more sophisticated* (Islam & Grönlund, 2011).

Jiang et al. (2010) found that farmers with a higher education were more willing to pay for the service. Such positive relationship was also found for farmer income, agricultural production and land holdings.

Kiiza and Pederson (2012) found that adoption of market information systems was higher for farmers that sold their products through markets versus those selling at the farm-gate. Adoption was also found more likely for farmers with access to (micro-) finance, those with higher household wealth, and those participating in farmer groups or cooperatives. Education was not found to be significant for adoption, while higher age was linked negatively to adoption.

Muto (2012) found possession of mobile phones was to be related to education level and asset value. Muto and Yamano (2009) found household assets and education levels to be significantly related to mobile phone possession, while age was negatively related.

Ommani (2011) found positive correlations between ICT use and respondent income and education level, as well as with self-reported ICT skills and social participation.

Agüero et al. (2011) analysed mobile phone expenditures in six Asian countries (Bangladesh, Pakistan, India, Sri Lanka, the Philippines, and Thailand). They found that the poorest quintile of each country spent over 20% of their income on mobile services. Using Engel curves to estimate income elasticity of mobile services it was concluded that expenditures on these services are highly inelastic to income and therefore constitute a necessity.

Bakay et al. (2011) investigated what factors drove ICT diffusion in Latin America between 2004 and 2008. Using the ICT readiness index as a proxy for ICT diffusion (which could be considered a debatable choice), they found IT expenditure and age dependency ratio to be statistically significant for ICT diffusion. Additionally literacy rate and urbanization were found to be of relevance.

Chabossou et al. (2009) found income and education to be of significant influence, while no such relationship was found for gender, age and social network membership. Mobile expenditure was however found to be relatively inelastic to income.

Gomez (2013) reported that telecenter users generally are relatively young (hardly any elderly were found to use the facilities), medium educated (illiteracy and absence of education hardly occur in the data), and have moderate incomes (higher incomes probably buy their own equipment instead of using public access facilities).

May (2012) studied ICT access in four East African countries (Kenya, Rwanda, Tanzania and Uganda). According to them, *[w]hen looking at the full sample, households without ICT are poorer in all dimensions than those with ICT, particularly in respect of education, services and economic assets... When only households below an income poverty line are considered, these gaps disappear, leaving only education as the major difference between those with ICT and those without.*

Močnik (2010) found that for low income countries, the factors most significant for internet use were found to be literacy rate, age, schooling and the number of telephone lines. For lower middle income countries the same factors were found of significance, supplemented by the number of computers and income. Population density, unemployment and usage costs were found not to be of relevance. As the number of phone lines was already included, it is not greatly surprising that population density was (no longer) found relevant as this factor likely covariates with the number of phone lines in an area.

Silva et al. (2009) found that mobile phone adapters (owners –instead of use or users) at the BoP are more likely to be younger (although the age effect was not enormous), male, have a higher relative income and usually at least secondary education. Non-adapters were found to be *mainly younger females with relatively lower incomes and only a primary education living somewhat further away from town.*

Zainudeen (2011) studied the adoption of 'more-than-voice' services among 'bottom-of-the-pyramid' mobile phone users in six countries in emerging Asia. According to the authors, more-than-voice refers to services and applications accessible through mobile phones beyond voice and peer-to-peer SMS. It was found that those that did use the designated services were generally younger, better educated, had more contacts and had been using mobile phones for a longer period than non-users, while females had a slightly lower chance of using such services than males.

## Effects

### Network effects

The notion of network effects or network externalities refers to the phenomenon that the value of a product or service increases with the number of people using it. This concept is fairly well known in the world of ICT (Katz & Shapiro, 1985). For example, a telephone has significantly more value if it allows you to get in touch with all your friends and relatives than when there is no one to call. This phenomenon of network effects was identified in various studies. Aker (2010) for instance found that the primary effect of reduced price dispersion across markets stemming from mobile phone use only became significant after a market coverage of 30 percent. Similarly Bagchi et al. (2003) found what they termed 'diffusion effects', who found a somewhat exponential growth in cell phone adoption. Levendis and Lee (2012) found the impact of telecom on economic growth in Asia increased with the level of telephone penetration, suggesting that *"more phones, more growth" should actually state "more phones, even higher growth"*. A more specific instantiation of network effects were found by Silva et al. (2009) who noticed that mobile phone adoption was significantly higher among people of whom most of the closest contacts also had mobile phones of their own – although this could also indicate social pressure of some sort.

Some weaker circumstantial evidence of potential network effects was offered by Beuermann et al. (2012), who found aggregate village cell phone expenditures to rise steadily over time from the moment network coverage was first provided up to a level of 7 times the initial sum. Chavula (2012) ascribed the absence of significant impact from internet use on economic growth in Africa to a failure in reaching critical mass (yet). A potential lack of critical mass was also offered as explanation for the absence of various significant ICT use related effects by Badran and Badran (2011) and Ghosh and Prasad (2012), although it should be noted that the offering of hypothetical explanations does not equal evidence of anything.

### Markets

#### *Price dispersion/market integration*

One observed effect of mobile phone use is the integration of various markets, which is indicated by a reduction in price differences. It is expected that when markets become more integrated, information from various local markets will be combined, resulting in more products being allocated to higher priced markets thereby in turn reducing prices through greater supply while increasing prices in markets where supply is withheld. Ultimately this mechanism is thought to establish a 'law of one price' (Jensen, 2007). Effects of better market integration through ICT use were found in various studies. Aker (2010) perform rigorous difference-in-difference analysis and found that mobile phone introduction led to a reduction in price dispersion across markets of somewhere between 10 and 16 percent. The effects found were stronger for markets linked by unpaved roads (as opposed to paved ones) and markets with higher distance between them. Jensen (2007) concerned himself with the impacts of mobile phone introduction among fishers in India (Kerala). In a rigorous analysis based on micro-level data from a survey, he found that the use of mobile phones led fishers to sell at other (less local) markets, resulting in reduced price dispersion across markets. He also noted that *that the perishability of fish is an important reason why there was so much waste and inefficiency*, and argued that it is generally market integration is lower for perishable goods, for which spot markets often are cleared only locally. Katengeza et al. (2011) investigated the effect of market information systems (MIS) on market integration in rice markets in Malawi, and found that the introduction of the Malawi

agricultural commodity exchange in 2004 resulted in better integration of spatially distanced markets when measured by price movements between markets. They noted that *key intervening factors (that caused high variation in results) were the distance of markets from other markets and poor transport links, which impeded trade* (Katengeza et al., 2011). However, despite effects being higher in more spatially distance and less connected markets, Kiiza and Pederson (2012) found that adoption of a market information system for farmers in Uganda was negatively correlated to market distance, although the reason for this is unclear. It is possible that these farmers are more self-sustainable and less inclined to trade, or perhaps potential benefits are unclear to them. Muto and Yamano (2009) found positive effects on market participation at the community level for banana producing households in rural areas living at greater distance to markets. For maize – which is less perishable than bananas, no effects were found. The authors concluded that overall effects are more significant for producers of perishable crops in more remote areas. Svensson and Yanagizawa (2009) studied the effect of a radio based market information system in Uganda, by exploiting variations between households with and without radio access, based on a household surveys. They found a positive effect of the service (proxied by radio access) of 15% on farm-gate prices for maize, which was ascribed to better bargaining positions for the respective farmers. However, not all studies reported equally positive effects. Fafchamps and Minten (2012) studied Reuters Market Light; an SMS-based agricultural information service. They found no significant effects on market price variation, but farmers were found *10 percentage points more likely to add a new sales location* (Fafchamps & Minten, 2012).

### *Market participation*

Slightly different from market integration, some studies investigated market access and participation by study participants. Chowdhury (2006) found that telephone access led to an 8 percent increase in participation in land and labour markets in rural Bangladesh. Hashim and Zaman (2010) studied ICT investment effects in Pakistan using time series data over the period 1950-2007. The study is not the strongest of its kind as telecommunication investment is proxied by investment in the "transport and communication sector" and there is a significant risk of omitted variable bias. The study did however claim to have found a significant effect of ICT investment on domestic trade and an even stronger one on foreign trade. Zanella (2012) studied effects of mobile phone and radio use on market participation and transaction costs in northern Ghana. The study found that receiving price information generally increased market participation for buyers and sellers. However, using mobile phones was related to increases in market intensity while quantity traded was reduced. Radio use was related to an increase in quantity traded. Clarke and Wallsten (2006) examined the effect of internet penetration on international trade for developing countries. Testing for causality, they found that increased penetration could be related to higher exports to developed countries, but found no such effect on trade between developing countries.

### *Market Prices*

In studying the Grameen Bank's Village Phone in Rwanda, Futch and McIntosh (2009) reported positive difference-in-difference point estimates for trade volume and price, but these did not prove to be statistically significant. It was noted that the lack of effects might be caused by interlinkage of credit provision by established buyers whom presented sellers from realizing higher prices elsewhere, and the presence of a similar product (Tuvugane) potentially having already realised the expected benefits. Similarly, Fafchamps and Minten (2012) failed to find a significant effect on general prices received by Indian farmers after the introduction of Reuters Market Light, although

evidence did suggest that young farmers did receive slightly better prices after the introduction of the service.

### Income/economic growth

Income is a variable for which combined study results indicate a bidirectional relation with ICT use. On one hand, higher income was often found to correlate with higher mobile phone use. On the other hand, some studies found ICT to be related to higher income. Beuermann et al. (2012) studied the effects of cell phone coverage in Peru. Using expenditures as a proxy for wellbeing (consumption), they found significant effects on general household consumption and additionally a measured a reduction in poverty incidence. Chong et al. (2009) made use of a natural experiment in Peru as well, and found significant positive effects from landline phone use on both farm and non-farm income of over 15 percent (after propensity score matching results increased to 32% for total household income). Ghosh and Prasad (2012) analysed annual data on telephone connections and economic activity from India for cointegration and Granger causality. The study found no long term relationships, but did discover a short-term (i.e. four years) Granger causality from telephone connections to economic growth. Zhang et al. (2009) studied the effects of internet permeability (the ratio of internet users in the total population) in China by means of econometric modelling. By testing data from the China Internet Development Statistical Report 2004 for Granger causality, they found positive effects from internet use (and education) on GDP, and vice versa. Badran and Badran (2011) found a positive effect from broadband penetration on economic growth (10% increase in broadband penetration would lead to a growth rate increase of 0.05 %), while telecom investment was not found to be significant. The latter was explained by a possible lag for effects to show, or a lack of critical mass. Balamoune-Lutz (2003) found a bidirectional relationship between ICT use and economic development. Bankole et al. (2011) studied the effect of ICT investments on the human development index in 51 low, middle and high income countries using structural equation modelling on longitudinal data. Although suffering from potential omitted variable bias, the authors established significant effects of ICT investment on GDP across all country types, as well as on education. Bollou (2006) researched total factor productivity in the ICT sector in West Africa between 1995 and 2002. They found a connection between ICT investment and total factor productivity (the ratio of aggregate output to aggregate input), but noted that its progress was on decline, possibly due to exogenous factors such as education not keeping up. Chavula (2012) studied the effects of internet use on per capita income in 49 African countries. He found significant impact on economic growth of fixed telephony and internet usage for upper-middle-income countries, and an even stronger growth effect from mobile telephone use for both upper-middle, upper-low, and low-income countries. According to him, *mobile telephony has a higher growth impact on per capita income in Africa relative to the other communication technologies, while Internet usage seems not to have a statistically significant contribution to economic growth among African countries* (Chavula, 2012). However, a lack of additional variable in the analysis makes the findings somewhat susceptible to the risk of omitted variable bias. Dimelis and Papaioannou (2010) compared 42 developing and developed countries over the 1993-2001 period. They found a positive effect of ICT on economic growth for all country groups, although the effect was stronger for developing countries.

Djiofack-Zebaze and Keck (2009) conducted regressions over a panelled dataset of 177 countries over a 7-year period starting in 1997 to study the effects of mobile phone use. They found that increased access to mobile networks resulted in significant increases in GDP (1% increase in access on average resulted in 0.5% in GDP per capita), and additionally noted that ICT costs are relatively high in Africa

when compared to the rest of the world. Dutta (2001) examined the direction of causality between telecommunications infrastructure and GDP growth for thirty developing and developed countries over a 24-year period. Reasonable evidence was found for an influence from telecom infrastructure to economic activity, while for a reversed relationship only limited evidence was identified. These findings were found to hold for both industrialized and developing countries. Although not directly income related, Gholami et al. (2009) found that ICT spill-over effects from developed to developing countries are higher for recipient countries with a higher internet penetration rate. This means that developing countries can benefit from ICT capital of developed ones, and more so when internet use in the country is higher. Hosman et al. (2008) used generalized method of moment estimates to investigate the effects of ICT expenditure on GDP growth in 42 developing countries. They found a relatively low but significant exogenous effect of ICT investment on the GDP growth rate, controlling for inflation, education and openness of trade. According to them, *a 100% increase of ICT expenditure per capita produces an additional 9% increase in the growth rate*. Levendis and Lee (2012) studied the impact of mobile and fixed telephones on economic growth in 29 Asian countries for 1981 to 2006 by estimating regression models while paying particular attention to endogeneity of variables. They found significant positive impact from telecom on economic growth. Effects were found to be stronger for richer countries than for poorer countries, indicating a 'digital divide'. Morawczynski and Ngwenyama (2007) found ICT investment to be a significant predictor of GDP growth, with education and health care investment as a mitigating factor. Samoilenko (2013) found evidence suggesting that regardless of the level of economic development, investments in telecoms tend to decrease prices of telecom products, and that the reduction in purchase prices leads to a reduction in the cost of usage of telecom products. The lower usage costs were in turn found to increase levels of international trade participation, disposable income, and labor market participation. Shamim (2007) in an analysis over the period 1990-2002 in 61 developed, emerging and developing countries found that ICT use – especially internet and mobile phone use – significantly enhanced financial depth (the ratio of financial sector liquid liabilities to GDP; thus credit), and through that channel stimulated economic growth.

Less confirmative results were brought up by (Seo & Lee, 2006) who studied the relationship between ICT investment and total factor. For non-OECD countries, no significant relation was found between ICT investment and total factor productivity. This might be related to the relatively early period of analysis, where investments did not reach a threshold level required for effects, or lack of complementary factors such as human capital.

### Agricultural growth

He et al. (2011) researched the effects of ICT on agricultural growth in China using panel data for 1999-2006 to correlate ICT investment and physical and social capital with the agricultural component of GDP. Despite a risk of omitted variable bias (which was not noted), the study claimed significant impact of ICT on agricultural growth. Jensen (2007) found a reduction in waste in the fishing sector by almost 5 percent, which led to an increase in welfare of both producers (due to higher turnovers) and consumers (due to lower prices). Kiiza and Pederson (2012) found that adoption of an FM radio based market information system led to significantly higher use of improved seeds, and through that on higher farm returns. Kuppusamy et al. (2009) looked at effects of ICT investment (as proxy for ICT use) in Malaysia. Despite finding significant effects in the manufacturing and wholesale sectors over both long and short run, no significant impact was found for the agricultural and governmental sector. They saw the lack of agricultural impact as an indication of a

digital divide between the rural, agricultural states with a relatively low ICT adoption and urban states where adoption is higher. Nazari and Hassan (2011) investigated the educational role of television in improving farmers' knowledge in Iran and found significant effects from agricultural TV broadcasts. Lio and Liu (2006) found that ICT matters in explaining the differences in agricultural productivity across countries. According to them, the *result implies that a smaller amount of labor, livestock, machinery, and fertilizer can produce the same level of agricultural output if these inputs are used within a better information and communication infrastructure*. Additionally, they noted that agricultural production returns from ICT were about twice as high for richer countries than they were for poorer ones. Regarding the uptake of agricultural techniques, Moussa et al. (2011) found that radio augmenting village demonstrations by radio broadcasting significantly improved uptake of improved agricultural techniques for cowpea storage.

#### Additional issues

Muto (2012) studied the effect of mobile phones on rural-to-urban migration (n=856). He found a significant increase in the chance of job oriented rural-to-urban migration when related to the possession of a mobile phone. According to him, an increase in non-agricultural employment could be considered beneficial in poverty reduction.

Indicating a potential lag for ICT effects, Soper et al. (2006) studied the effect of ICT expenditures on institutionalized democracy and foreign direct investment over a five year period (1998-2003). Although potentially suffering from omitted variable bias, the study indicated significant effects from ICT expenditures on both dependent variables starting after a 1-year incubation period, indicating a relatively small lag.

Regarding additional technological matters, Ghosh and Prasad (2012) noted that more phone coverage would be likely to increase diesel consumption in India due to electricity demand, and noted potential difficulties regarding the diesel and road network. Other studies also noted access levels and effects of ICT to be higher in more urban areas, possibly due to better electricity access. Additionally – although not brought forward in any of the studies, it should be noted that higher electricity consumption is likely to result in increased pollution of some sort. Regarding the latter, higher ICT use is not unlikely to increase problems with electronic waste (e.g. heavy metal pollution).

Futch and McIntosh (2009) found that increased phone access led to a (self-reported) improvement in the arrangement of transportation to markets and reduction in travel time and distance in Rwanda.

## 6.4 Synthesis

The step of synthesis is a major step in the systematic review process, as this is where the data extracted from the included study is interpreted and integrated and ultimately a conclusion is drawn. The main goal that was set for this study was to create an overview of ICT related aspects and the nature of their relations to ICT. The creation of this picture will be based on the relationships that were extracted from the primary studies in the previous step provide. This paragraph will describe the analysis and synthesis of these relationships.

Based on the extracted data on study design, data collection and geographical focus, it was decided to initially separate outcomes between studies analysing at the national level or smaller and those exploring multiple countries. Although perhaps a somewhat arbitrary distinction, it was based on the

observation that studies analysing on a supranational level generally made more use of regression methods and data was obtained from external sources and collected over an earlier period than most studies with a national or more local perspective. Also, studies analysing at the supranational level were often less specifically focused on rural areas or the agricultural value chain.

For the first step of the synthesis the NVivo<sup>23</sup> software tool was used, which was originally developed for qualitative research. The use qualitative software was based on the relatively interpretative character of the synthesis, which is shared by studies with a more qualitative orientation. Although other software packages such as ATLAS.ti<sup>24</sup>, MAXQDA<sup>25</sup>, Dedoose<sup>26</sup>, QDA Miner<sup>27</sup> were explored, NVivo was chosen for its superior graphical mapping feature. Another feature is the possibility to construct an array of primary components as labels, subsequently linking them to form relationships and labelling relevant sections of primary studies with those labels (components and relationships). This allows for the creation of a database of relationships identified in the primary studies with attached links to their related sections in those studies. NVivo was primary helpful in constructing and storing an overview of relationships and their appearance in the primary studies, and creating an initial map. However, as graphical options were limited, the software from NVivo transposed to Microsoft Visio in order to create the ultimate overviews.

#### 6.4.1 Initial maps

For the initial analysis and synthesis both the excel table with extracted data and an NVivo database containing the primary studies in pdf-format with relevant sections marked was created. Based on the excel table, extracted relationships were attached to the relevant sections of the primary studies in NVivo. As with the data extraction, all 'rigorously studied' relationships were identified, and their direction and (in-) significance noted. Once this process was completed, maps were created for both levels of analysis (sub- and supranational). The initial creation of maps was done by NVivo. However, as the software positions relationship components in alphabetic order, and does not take much concern for graphical clarity, these maps were not too useful. Therefore, ordering components was done interpretatively, without the use of formal rules. As the synthesis process concerns relationships between and across individual studies, no explicit support is provided by the (individual) studies themselves. However, as one of the two components of each relationship was always some form of ICT, and the direction of the relationship was indicated by primary studies, there was some guidance for the process. Factors related to ICT use were depicted on the left, ICT in the middle and (correlated) outcomes on the right. In evaluations, effects are often classified according to sustainability and 'depth' of impact; direct effects are termed output, deeper changes become outcomes, and lasting effects are seen as impact. As there are no explicit rules for such classification, this would imply adding an additional interpretative step, and it was chosen not to do so in order to refrain from potential bias. Both maps resulting from this initial step will be discussed below.

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<sup>23</sup> NVivo version 10, see: [http://www.qsrinternational.com/products\\_nvivo.aspx](http://www.qsrinternational.com/products_nvivo.aspx)

<sup>24</sup> <http://www.atlasti.com/index.html>

<sup>25</sup> <http://www.maxqda.com/>

<sup>26</sup> <http://app.dedoose.com/>

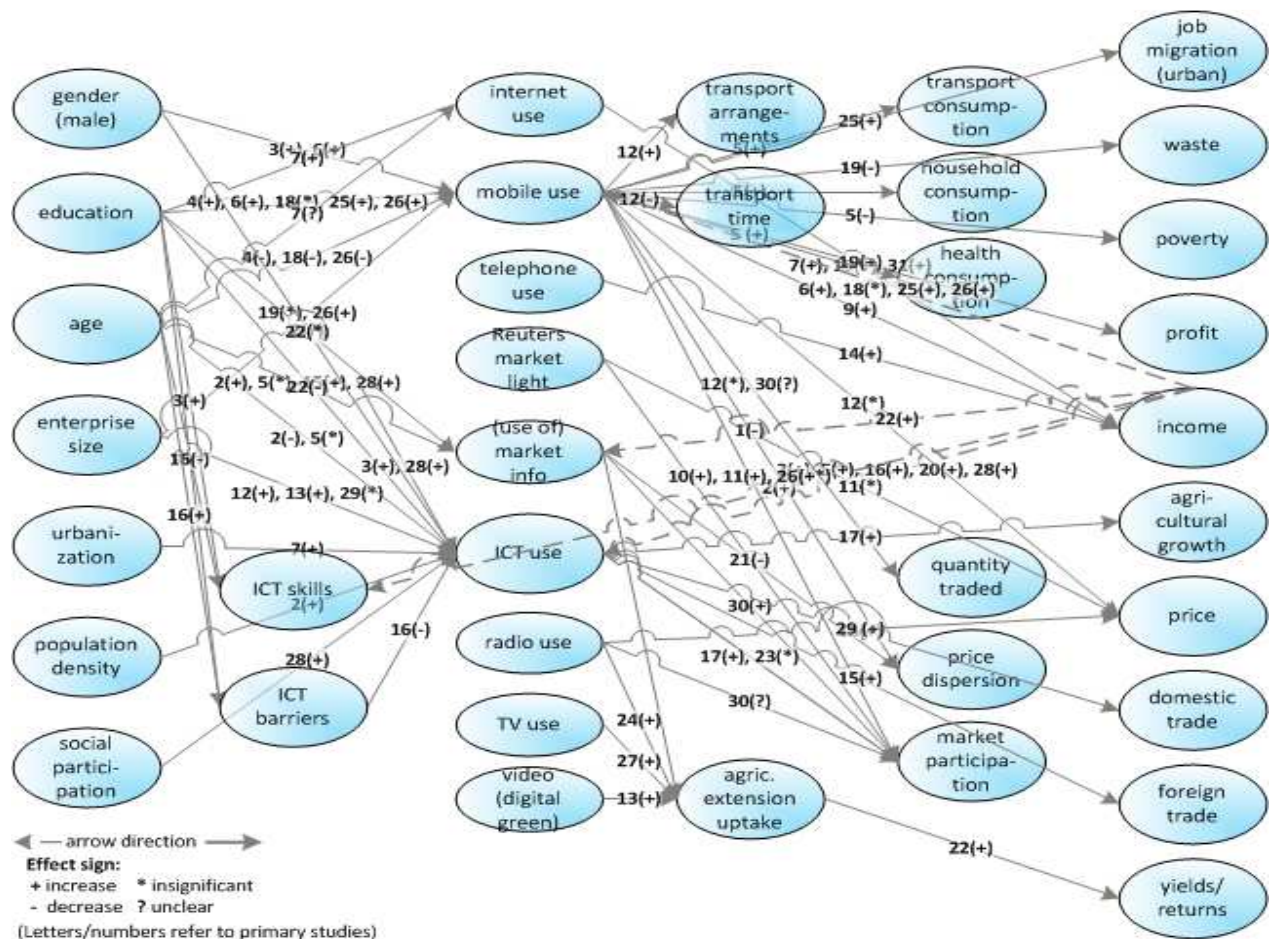
<sup>27</sup> <http://provalisresearch.com/products/qualitative-data-analysis-software/>



### Local focus

The research selection with a more narrow geographical focus (sub-national level) included 28 studies, a list of which can be found in the bibliographical references of this report. The majority focused on farmers, but other studies focused on fishermen, agro-entrepreneurs, (grain) traders, and rural villagers in general. Technology included internet, mobile phones, landline phone and radio. Additionally some more specific services were studied. These were Reuters market light (an information service for farmers), village phone (a way of providing phone services to poor villages), and digital green video (a service aimed at spreading agricultural information through video. An initial overview is provided in figure below. In the figure, arrows indicate the direction of the relationships as mentioned by the studies, although it should be noted that not all studies did perform sufficient quantitative testing or provide adequate theoretical backing to support the claimed directionality. Primary studied related to the depicted relationships are indicated by a numbers, with the sign of the effect noted in braces. A table connecting the numbers used to the primary studies is provided in appendix V.I.

Figure 8: overview of relationships from sub-nationally focused studies



As can be seen, factors influencing adoption primarily are age, education and income. Although not all relationships were equally consistent, the general image is that ICT uptake is higher among the younger, somewhat better off population that has attained at least some minimal standard of education. On these latter two factors it should be noted that they may be related, as wealthier families are more likely be able to bear schooling expenses, should they exist.



Factors influencing adoption are age, education and income. Although not all relationships were equally consistent, the general image is that ICT uptake is higher among the younger, somewhat better off population that has attained at least some minimal standard of education. On these latter two factors it should be noted that they may be related, as wealthier families are more likely to be able to bear schooling expenses, should they exist. Additionally, the relationship with income seems to be a reinforcing one, as ICT use in itself was also found to improve income. Other factors that studies related to for adoption are access to electricity, and the number of users. The former basically speaks for itself, while the latter indicates so called network externalities. Another factor found was openness of trade, the volume of foreign trade. A relationship between gender and adoption was also investigated, but results were mixed. Sometimes no significant relationship was found, while another study did find a significant influence. Gender patterns can vary significantly between cultures, and therefore issuing a generic statement cannot be vindicated by the data. It should also be noted that studies focusing primarily on gender relationships were excluded during the selection. Although the all studies in this set adopted a relatively broad (multi-country) level of analysis, effect of ICT vary in level of abstraction.

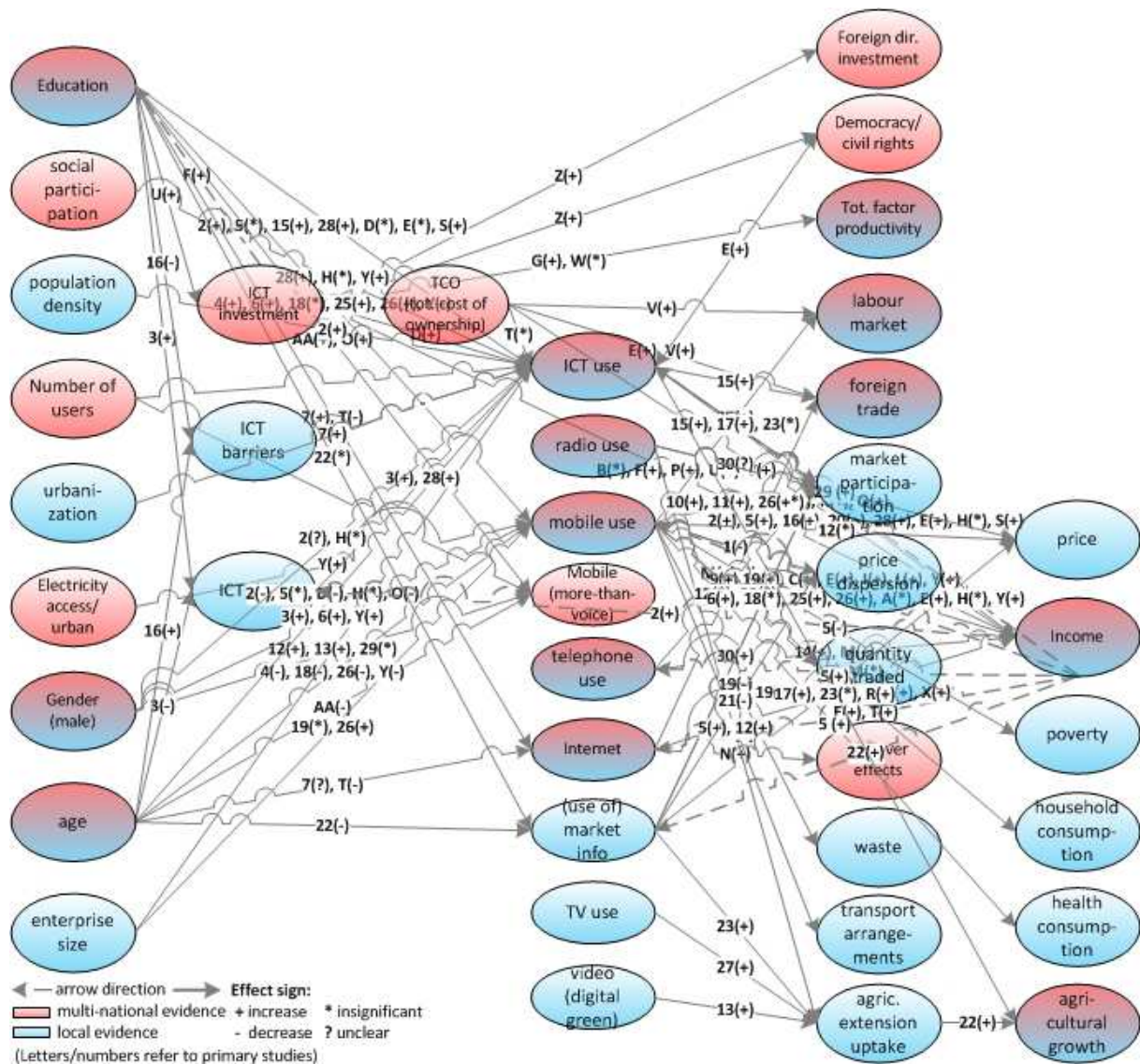
## 6.4.2 Integration

### *Combination*

In the previous part 'reliably proven' connections (as defined by the inclusion standards) between the use of ICT and related aspects were integrated in two separate maps. The relationships that were extracted from the primary studies were graphically depicted and synthesized into a graph. For this initial analysis, a distinction in primary studies was made based on their geographical scope of analysis; studies employing a (sub-) national perspective were analysed separately from those employing a supranational perspective. In this paragraph both maps will be combined into a single overview. The initial composition was relatively straightforward and is depicted below. Again, relationships between components are represented by arrows, and the studies from which the relationships were extracted are represented by the numbers and letters along the arrows (numbers for subnational and letters for supranational level of analysis).

For the combination of both previous figures, some components with a fairly high similarity were integrated: 'Reuters Market Light' was added to 'price info', 'yields' was added to 'agricultural growth' and 'job migration' was 'added to labour market'. As can be seen from the figure, roughly half of the components was studied by both sets of studies, while the other half was examined in only a singly group. Most of the ICTs featured were studied on various levels, with the exception of TV and video, which were studied only on a local level. More than voice-use of mobile telephony and the use of market information were also explicitly mentioned in only one of both groups, but are not specific types of ICTs. Regarding outcomes and factors influencing ICT use, no explicit conclusion can be drawn based on this figure, which puts forward the question whether the initial distinction was useful, and whether another would have been more informative. Perhaps an initial distinction based on methodological strength of primary studies would have been of greater value.

Figure 10: relationships from all primary studies combined

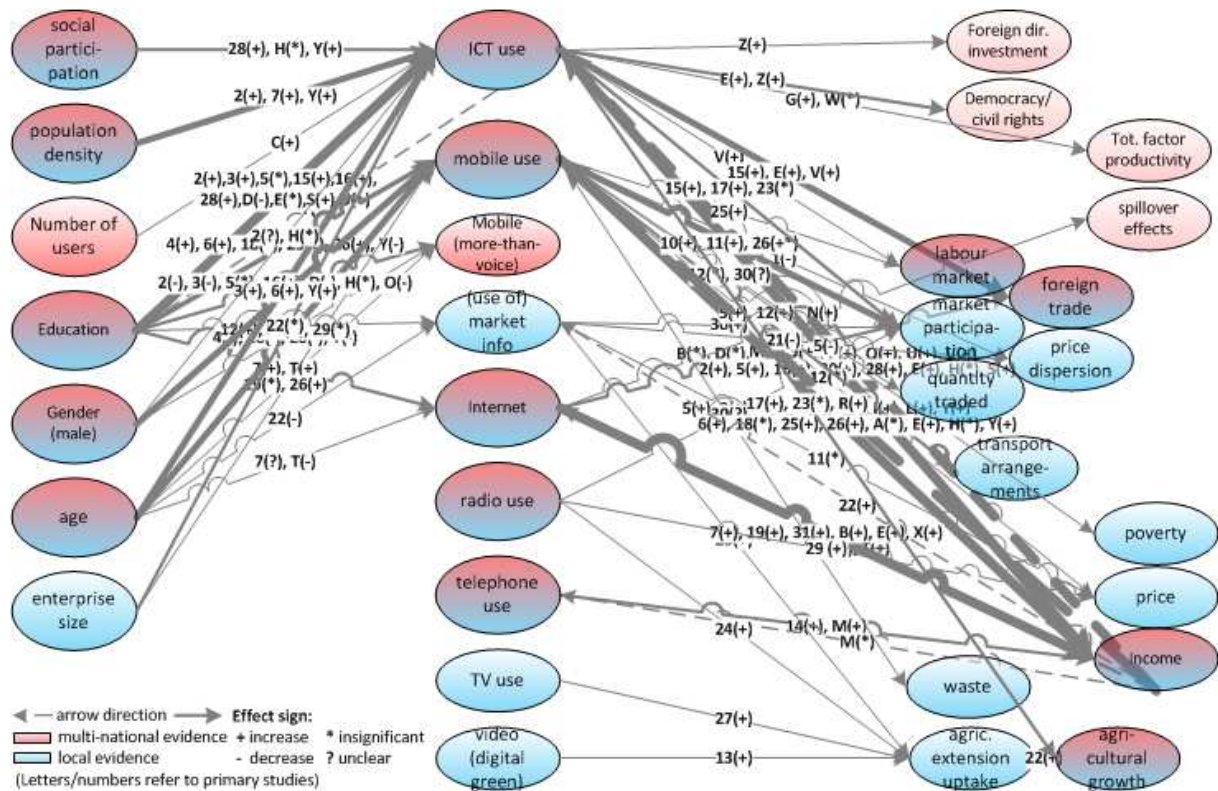


### Further aggregation

Now that the full integration of both sets of studies is completed, the next step will focus on the interpretative aggregation. In this step, components deemed (highly) similar will be merged in order to provide more clarity and a higher level of abstraction. Factors merged will be described below. Initially, the following concepts were merged:

- 'GDP', 'profit' and 'income' all relate to income and were clustered under 'income';
- 'Reuters Market Light' and 'more than voice use' both denote a mobile phone internet application and were clustered under 'internet';
- 'transport time' and 'transport consumption' were added under 'transport arrangements';
- 'exports (to developing countries)', 'international trade' and 'foreign trade' are all international trade related and were merged into 'foreign trade';
- 'domestic trade' was added to 'market participation';

Figure 11: relationships from primary studies integrated

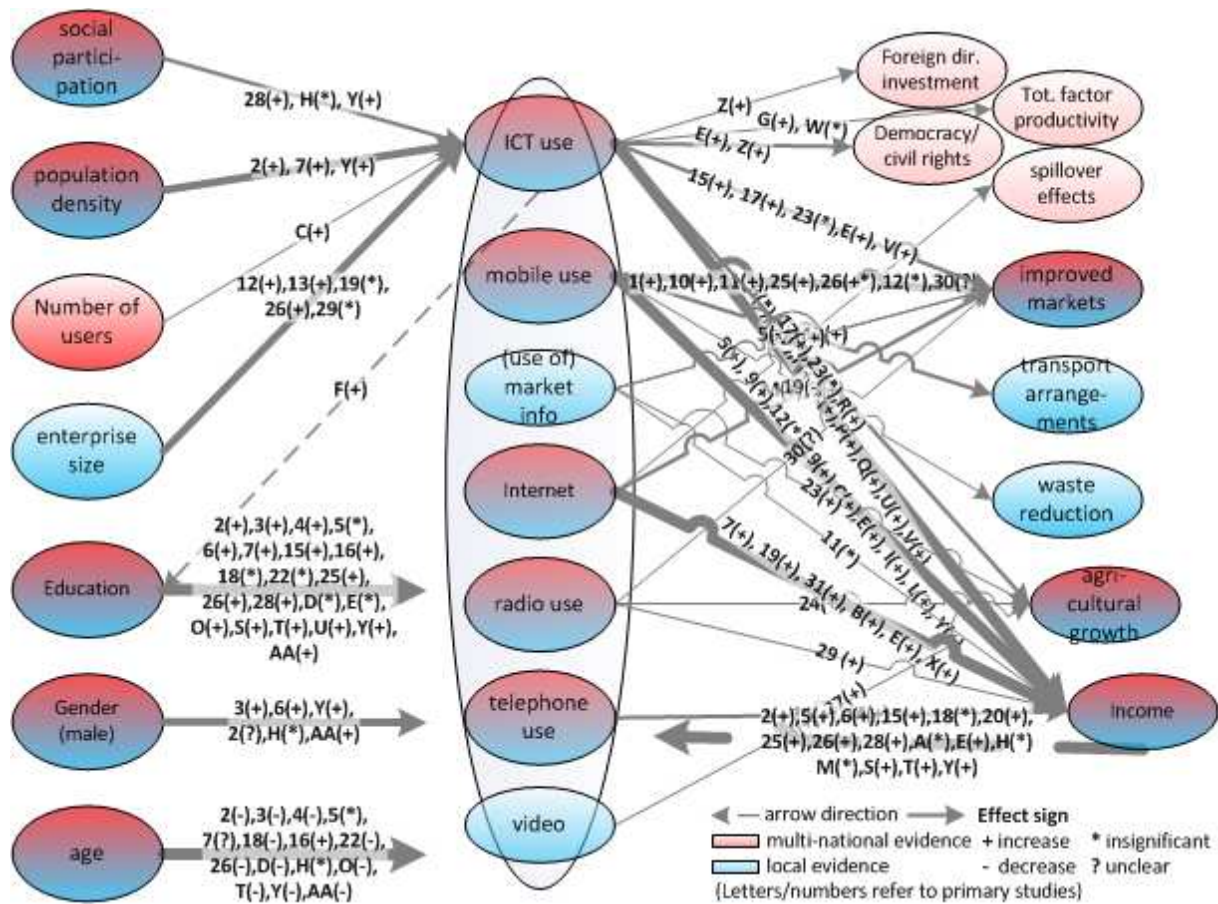


In order to increase aggregation further, and improve the clarity of the resulting figure, some concepts were combined in an initial aggregative step:

- 'Household consumption' and 'health consumption' are both related to consumption and can hence be regarded some form of income; they were added as such (income);
- 'Urbanization' and 'electricity access' were added to 'population density';
- ICT barriers and ICT skills were removed, as they were already specified by their ingoing connections (e.g. 'education'). The in- and outgoing connections were combined into direct connections between ICT and related prior factors;
- 'ICT investment' was added to 'ICT use' (as it can be seen as a reasonable proxy);
- 'price' (the product prices for farmers) and 'poverty' were added under 'income';
- 'labour market', 'market participation', 'price dispersion', 'foreign trade' and 'quantity traded' were grouped under 'market improvement';
- TV and video were combined under video;

The resulting figure is depicted on the next page. The thickness of the arrows was based on the net number of confirmative relationships found in primary studies.

Figure 12: final integration of relationships



## 6.5 Resulting observations

The analysis identified both effects from and factors related to ICT use. Positive effects on income (in a broad, aggregative definition) were reported from unspecified or general ICT use (Bankole et al, 2011; Dimelis & Papaioannou, 2010; Hosman et al, 2008; Levendis & Lee, 2012; Morawczynski & Ngwenyama, 2007; Samoilenko, 2013), but also from the use of mobile phones (Beuermann et al, 2012; Chong et al, 2009; Jensen, 2007; Bagchi et al, 2003; Balamoune-Lutz, 2003; Chavula, 2012; Djiofack-Zebaze & Keck, 2009; Silva et al, 2009), internet (Chang & Just, 2009; Zhang et al, 2009; Badran & Badran, 2011; Balamoune-Lutz, 2003; Shamim, 2007), telephone (Ghosh & Prasad, 2012); Dutta, 2001) and radio (Svensson & Yanagizawa, 2009). Negative income effects were not reported in the included studies, but some were however unable to confirm significant positive effects (Badran & Badran, 2011; Bakay et al, 2011; Futch & McIntosh, 2009).

Significant market enhancing effects were also found from the use of various technologies. These effects included labour market enhancement (Muto, 2012; Samoilenko, 2013) market integration (Aker, 2010; Katengeza, Kiiza, & Okello, 2011), market participation (Hashim & Zaman, 2010; He et al, 2011; Chowdhury, 2006; Fafchamps & Minten, 2012) and foreign trade (Hashim & Zaman, 2010; Balamoune-Lutz, 2003; Samoilenko, 2013; Dutta, 2001; Clarke & Wallsten, 2006). However, reported effects were not always unanimous as some failed to find a significant effect on market participation (Kuppusamy, Raman, & Lee, 2009; Megumi Muto & Yamano, 2009). Also, improved markets did not always result in higher prices or higher quantities traded.

Another effect is that of uptake of agricultural extension and thereby agricultural sector growth. For this research, the category of agricultural extension was the only one showing positive impact from TV use (Nazari & Hassan, 2011) and video broadcasting (Gandhi et al., 2007), and in that sense bears some resemblance to the more propagandistic ICT4D efforts of the previous century. However, as other studies found the use of general ICT (He et al, 2011; Lio & Liu, 2006) and market price info (Muto & Yamano, 2009) to be of influence, there certainly seems room for broad improvement of the agricultural sector through ICT use in this category, although it should be noted that Kuppusamy et al. (2009) could not find significant agricultural growth impact.

Finally some effects were identified less broadly over the included studies, such as improved transportation arrangements from mobile use (Beuermann et al, 2012; Futch & McIntosh, 2009) and some more abstract effects in the multi-country oriented studies including improvement in foreign direct investments (Soper et al., 2006), democracy and civil rights (Bali moune-Lutz, 2003; Soper et al, 2006), and total factor productivity (Bollou, 2006) – although Seo and Lee (2006) failed to confirm the influence on the latter.

Concerning factors likely of influence to ICT use, it is interesting to notice that income seems to have a relatively large effect (Blumenstock & Eagle, 2010; Muto, 2012; Muto & Yamano, 2009; Bali moune-Lutz, 2003; Silva et al, 2009; Alampay, 2006; Beuermann et al, 2012; Hassan et al, 2009; Jiang et al, 2010; Ommani, 2011; May, 2012, Močnik, 2010; Kiiza & Pederson, 2012), which was confirmed by similar relationship with company size (Futch & McIntosh, 2009; Gandhi et al., 2007; Muto & Yamano, 2009). However, not all findings were congruent as some studies did not find a significant connection (Islam & Grönlund, 2011; Agüero et al, 2011; Chabossou et al, 2009, Dutta, 2001). In this regard it is interesting to note that Agüero et al. (2011) found that even the poorest quintile of the studied population spent over a fifth of their income on mobile phone services, which led them to conclude that mobile phones are a necessity.

Age (Alampay, 2006; Aminuzzaman et al., 2003; Armstrong et al., 2012; Bakay et al., 2011; Gomez, 2013; Islam & Grönlund, 2011; Kiiza & Pederson, 2012; Močnik, 2010; Muto & Yamano, 2009; Shamim, 2007; Zainudeen, 2011) and education (Alampay, 2006; Aminuzzaman, Baldersheim, & Jamil, 2003; Armstrong, Gandhi, & Lanjekar, 2012; Blumenstock & Eagle, 2010; Chang & Just, 2009; Gomez, 2013; Hashim & Zaman, 2010; Hassan, Hassan, Shaffril, & d'Silva, 2009; May, 2012; Močnik, 2010; Morawczynski & Ngwenyama, 2007; Muto, 2012; Muto & Yamano, 2009; Ommani, 2011; Silva et al., 2009, Zainudeen, 2011) were also found to be related to ICT use. Generally, ICT-users were found to be better educated and somewhat younger than their peers. However, not all findings were alike. For education some studies found no significant relation (Bali moune-Lutz, Bakay et al., 2011, 2003; Beuermann et al., 2012; Islam & Grönlund, 2011; Kiiza & Pederson, 2012), as for age (Beuermann et al., 2012; Chabossou et al., 2009; Chang & Just, 2009). Regarding gender relationships were less clear. Some studies found ICT users to be predominantly male (Aminuzzaman et al., 2003; Blumenstock & Eagle, 2010; Silva et al., 2009; Zainudeen, 2011), but this was not unanimous (Alampay, 2006; Chabossou et al., 2009). This factor is likely to be highly dependent on local context, where cultural factors might be of influence directly for ICT use, but also indirectly through education.

Finally, other factors that were found of influence were social participation (Ommani, 2011; Silva et al., 2009), population density (Alampay, 2006; Chang & Just, 2009; Silva et al., 2009) and the total

number of users of ICT (Bagchi et al., 2003). Although not exactly the same, these factors seem to hint to the existence of network externalities, a phenomenon established for ICT already some decades ago (Katz & Shapiro, 1985). This seems to work in two ways; on the one side a higher population density brings economies of scale for infrastructure, while on the other hand the number of (close) contacts in a network increases its value.



## 7 Conclusion

In this study, a systematic review was conducted to learn about the use of ICT in rural areas in developing nations and its effects. In the first part of the research, the field of ICT4D was identified as complex, and subsequently a fitting review protocol was designed. This protocol involved the collection of rigorously studied – by adoption of a statistical research method based on at least 100 observations – relationships involving ICT. Based on inclusion criteria specified for the research 58 relevant primary studies were identified and the components and relationships they studied were extracted, regardless of their outcome. Subsequently, extracted components and relationships were combined into a systemic overview, the results of which will be interpreted in this chapter.

### 7.1 Research outcomes

#### 7.1.1 General outcomes

This research set out to gain understanding on the use and impacts of ICT in developing areas. In order to accommodate time and resource constraints, attention was primarily focused on the agricultural value and rural areas. With the relevant studies retrieved, this research found a substantial base of evidence for positive impact from the use of ICT, gathered in various regions across the world and under varying local circumstances. Primary impacts with ample support were found in the facilitation of agricultural growth, market improvements and (ultimately) income growth. Additionally a lesser amount of studies found positive influences on the arrangement of transportation (and even its replacement by communication), reduction of agricultural waste, and total factor productivity, foreign direct investment, and democracy and civil rights. However, primary study findings were not unanimous concerning effects. Contrary results were not found, but some studies failed to confirm a significant correlation. Overall, the reasons for these differences did not directly jump out, but local circumstances are likely to be of influence. In the case of market effectiveness, some studies found for example that a monopolistic position in credit provision for local market traders hindered farmers in obtaining better prices in adjacent markets.

Regarding factors affecting the use of ICT, studies focused primarily on socio-demographic factors; in particular age, education and income (or enterprise size) of ICT users. It was generally found that ICT users were better educated, wealthier and younger than the average population of comparison. However, findings on these factors varied considerably more between primary studies than results on impacts. This could be seen as an indication that local context – e.g. cultural and socio-economic factors – are of more influence to ICT use than they are to ultimate impact if used. Other factors of relevance to ICT use were found to be social participation, population density and the number of users. Population density might be regarded a proxy for underlying infrastructural factors which are generally better in higher populated areas due to economies of scale. However a common theme across the three might also be found in the existence of network externalities, a well-known aspect of communication related technologies and services. Finally, it was found that ICT use was generally higher among males. However, not all studies confirmed this, and it was not investigated in all primary studies.

There was also variation in the type of technologies researched in primary studies. A relatively large part of the studies did not explicitly specify or target a particular type of ICT, but rather focus on a generic indicator of ICT use, such as ICT expenditures. For the studies that did specify a technology, the majority focused on mobile phones and, to a slightly lesser extent, (broadband) internet.

Additionally, a minority of the studied focused on radio, landline telephony, and TV/video. Landline telephony was primarily studied by studies using older (e.g. pre 2000) datasets, TV/video was mainly found to be effective for spreading improved agricultural practices, while radio was found to aid in the dissemination both agricultural practices and price information. In general, access to the latter group of technologies was found to be relatively widespread under poor populations, but a relatively small range of effects was reported (and studied). In somewhat of a contrast, the former group of, mobile phones and internet was found to have a slightly more distinctive user group and a broader range of reported effects.

### 7.1.2 For development practitioners

This study was primary focused on gathering insight on the use of ICT and the effects thereof. No systematic effort was undertaken in researching the best way for design and implementation of (local) ICT-based interventions. Also, no explicit account was taken of funding sources for the projects studied and hence a comparison between market-led projects and those supported by development efforts was not made. As such, the research cannot conclude much about possible development-led efforts aimed at IT use. It can however be concluded – as was above – that ICTs can significantly contribute to goals adopted by many developmental efforts, such as increased income or improved livelihoods. Should any efforts be made of incorporating ICT use in developmental undertakings, the pathway model might provide guidance for identification of both potential results and possible barriers.

Where potential results are concerned, various pathways have been identified that could be related against local problems to provide potential solutions. For doing so, it should be noted that the current study has identified the existence of certain effects under various circumstances, but provides no universal guarantee for them to always occur. Similarly, no analysis was made of the formation and implementation of actual ICT-related projects or risks for their failure. The results of the study hand hence provide a number of convincingly established directions for potential impact, but for application of ICT under local circumstances a thorough analysis of any problems at hand and local context is required.

Efforts aimed at increasing ICT use could be focused on reducing barriers of language and education by translating content to local languages or using local translators. Potential financial barriers could also be reduced, although this unlikely to be of much help without addressing barriers of language and education if present.

## 7.2 Review methodology

### 7.2.1 Comparison against other reviews

The reviewing method employed resulted in a systemic overview of the most significant relationships identified from the included literature. It might be interesting to compare the relationships this study identified against the reviews identified in chapter 2, as they employed a (somewhat) comparable focus.

Regarding impact, the World Bank study noted that *[m]obiles are being used to help raise farmers' incomes, making agricultural marketing more efficient, lowering information costs, reducing transport costs, and providing a platform to deliver services and innovate. Whether the potential of these trends can be realized more widely, especially in rural areas and in an equitable way, is*

*uncertain* (Donovan, 2011). The study at hand largely found similar results. Significant positive income effects were found in various primary studies (although not all studies returned significant effects). Markets were also found to have improved from ICT use, particularly by increased market participation and improved market integration (indicated by reduced price dispersion). Specific instances of local-led service delivery and innovation were however not directly found.

Patra et al. (2009), who interviewed 50 experts in the field of ICT4D about their opinions on future impact noted that impact expectations were highest for the following areas respectively: best practices and information sharing, market access and information, supply chain management, sensors, and access to expert information. Of those areas, the research conducted in this report most clearly indicated the use of ICT for market access and information. The topic of sensors was explicitly placed outside of the scope of the current report, and the other three areas were only sporadically mentioned; with perhaps the sharing of best practices for agricultural activities most brought up. As Patra's expert consultation was oriented at future expectations the lack of those effects in the study at hand does not directly invalidate the results, but is rather likely to indicate that these expectations remain yet to be fulfilled.

Compared to the study by Duncombe (2012), the current research firstly generalized results over a broader range of technologies. Where specific effects are concerned, several findings from the Duncombe study were repeated here. These include decreases in price dispersion across markets, reduction of (agricultural) waste and better organizations of transportation and the replacement of travel by distant communication. No striking differences or otherwise conflicting evidence was identified. However, the present study does provide a better overview of interrelations between the variables identified.

In general, an important difference between the present research and the other reviews identified is in the clarity and transparency of the research process. No major differences were found in the search process, although the current approach does seem to facilitate a broader initial scope through its more systemic subsequent analysis. In its analysis, the present study does seem to improve insight in the relatively strong presence of factors determining ICT use such as education, income and age. Additionally, it is interesting to notice the bi-directionality of the relationship between ICTs and income, with income positively related to ICT use and vice versa. Although this was the only analysis of such nature in the current review, it is possible that the approach can add additional value in other domains where more complex relationships have been identified.

### **7.2.2 Comparison to other approaches**

The review approach adopted in this research was geared towards exploring a relatively complex domain of interest, while maintaining methodological rigor. In doing so, a balance was sought between relatively narrow focus, but rigorous 'aggregative reviews' and broader oriented, but less transparent 'interpretative approaches'. The starting point of the approach is in identifying 'regularities' in a universe of evidence, and subsequently comparing and integrating these them. For the identification of these relationships, the adoption of a predetermined 'standard of evidence' allows for a more systematic and rigorous exploration of a domain of interest. Such rigor thus far seemed preserved to more narrowly focused reviews, while broader oriented reviews seem to rely more on (tacit) researcher interpretation. In its approach, the current review thus allows for the use of a predetermined level of methodological rigor, while covering a relatively broad domain of

interest. The synthesis allows for a more systematic comparison of convincingly established relationships, thereby 'growing' and evidence-based systems perspective. This systematic and transparent approach to combining relationships that were convincingly established in various primary studies seems to improve the validity of results, something that seems lacking in the other reviews.

### **7.3 Recommendations**

This study has systematically reviewed primary research in the field of ICT4D in order to provide an overview of empirically grounded effects. In doing so, a broader systemic picture emerged, and various contextual factors and reverse relationships have been identified. However, no (specific) attention was given to financial backgrounds and viability of the services included. The majority of the services studied were relatively simple and involved only the use of a mobile phone or radio for orally or textually spreading information. In such cases, only network coverage and electricity are required, which - highly remote or sparsely populated areas aside – are relatively well provided by the market. In the case of more specific content requirements (such as specific information systems on agricultural techniques or market prices) this might be less likely. For such more complex services, a review of currently existing market operated initiatives and their business models might provide information about their feasibility for more generic use.

For the research, relatively generic form of ICT use and usage have been studied, with a primary interest in related socio-economic factors and outcomes. The types of information used has been less systematically studied, and for practical use – e.g. intervention design – such information would be welcome. These would however have local characteristics.

## 8 Reflection

As always, the method should follow the research goal, and a systematic review is no different. For this research, a modified version of existing review approaches was used. In doing so, it was sought to strike a balance between an aggregative and interpretative approach in order to allow for the exploration and integration of relatively broad field of interventions, while maintaining some standard of methodological rigor in order to minimize bias. The approach adopted facilitates the construction of empirically grounded, interpretative pathway model. In this chapter, a brief reflection on this methodology and the study outcomes will be provided.

### 8.1 Study results

Although the research aimed to collect and integrate high quality evidence, the approach adopted has some limitations. The following paragraph will discuss the these for each of the research steps.

#### 8.1.1 Limitations

##### *General*

##### *Focus*

First of all, the study has a specific focus on the use of ICTs within rural areas for agricultural value chain related effects. That means that many application domains of ICT have been left out, such as those of finance, health care, education and governmental services. Within finance ICT might for instance add value as a means of payment, or in collecting information for facilitating matters such as micro-credits. For health care ICTs can be used for medical consult or providing patient status updates. Similarly ICT could be used in the educational sector for distributing study material or to facilitate in data collection. Although the above are only some untested examples, further study might possibly reveal many proven effects of ICTs beyond the scope of the research at hand.

Additionally, the research focused explicitly on actual use of ICT and outcomes thereof. Issues related to (technical) availability of ICTs, such as market regulation and competition were not studied. Information needs of potential users were also outside of the scope of the research.

##### *Quantitative approach*

For the relationships that did fall within the domain of interest, this research required quantitatively established backing. In the chapter about science and evidence, some general dimensions of science and evidence were briefly explored. It was noted that one of the goals of science is the identification of regularities which subsequently can be used to formulate broader hypotheses (or even scientific laws) that can be used as a basis for prediction. In order to reliably identify any associations, trustworthy methods are required, and for such observations to be deemed 'regular', repetition is required. As noted in the related chapter, research methods can employ both a qualitative and quantitative focus. Quantitatively oriented methods have the advantage that they can more easily process repetition and provide more reliable estimations of average effects, while a more qualitative orientation might allow for more flexibility and nuance. Additionally, a (potential) disadvantage of a more quantitative perspective is that certain aspects are difficult to quantify and might therefore be overlooked. These less quantifiable aspects are likely to involve (among others) softer social and cultural dimensions such as feelings of trust, safety and comfort, local cultural identity and social cohesion. It is not unlikely that ICT use can be of effect (both positively and negatively) in these dimensions.

### (Absence of) negative effects

Additionally, it should be noted that although negative effects were hardly identified, that does not necessarily mean that they have been totally absent. First of all, no explicit search for negative effects has been carried out. Secondly, as negative results are less likely to be of widespread interest to researchers, most enquiry has likely been focused on positive outcomes. Thirdly, if any negative results have been established, it is even less likely that they have been quantitatively identified on a reasonable scale. Such effects are for instance likely to be of a more qualitative or psychological nature (such as a lack of trust in new technology, or the feeling of local culture being evaded upon by 'Western' values and technology), and additionally, the (hypothesized) low interest from the general research community makes larger scale efforts of quantification less likely. Another issue related to the use of ICT is that of so called 'electronic waste'. Electronic products often contain many hazardous substances such as heavy metals, which if dumped in regular wastage channels might potentially cause significant environmental and health related problems – see e.g. Wang et al. (2005) or Huo et al. (2007).

Additionally, it should be noted that apart from potential negative impact – which as deliberated above was not found in this research – ICT-related projects themselves can fail due to a broad range of reasons such as mismanagement or inadequate adaptation to local context. With regard to project failure, substantial examples can be found (Heeks, 2008). As an illustration, the World Bank's Evaluation Group noted that *[r]egarding efforts to promote universal access, targeted World Bank ICT projects with the objective to directly promote access for the underserved and the poor had limited success; only 30 percent have achieved their objectives of implementing universal access policies or increasing ICT access for the poor or to underserved areas* (World Bank, 2011, p. 8). However, failure or success in project realization is a different dimension from impact from realized projects. As an illustration it should be noted that the current research did find evidence of (positive) impact, but did not (nor aim to) identify common factors of project success or failure.

### Opportunity costs

With regard to the topic of interest, the study identified a reasonable amount of convincing evidence of positive results stemming from the use of ICT in developing countries. However, these results lack foundation for comparing them against other uses of capacity invested – the so called opportunity costs. In other words, based on this research it can only be concluded that certain ICT related interventions stand a fair chance of leading to positive results, but not that dedication of resources to such project will lead to better results than other projects focused on e.g. education or road capacity.

### Conflicting results

Study results were sometimes conflictive; certain outcomes were identified as significant in a number of studies, while others found no significant relationship with ICT use. Such conflicting findings are always an interesting lead for further research. Some reasons for the differences might be lie in study approaches, factors included and contextual issues. For instance, potential confounding variables might have been neglected in some included studies (omitted variable bias). These variable could related to climate factors such as rainfall, agricultural and human diseases, other 'shocks' encountered by the population (such as monetary issues as e.g. high inflation), land rights or unrest and so on.

## *Protocol execution*

### *Inclusion criteria and search*

Due to the multidisciplinary nature of the field and the variety in information technologies, their uses and outcomes, no broadly shared terminology or framework to start from were found. This makes it hard to assess the exhaustiveness of the focus chosen for the research. This implies that although efforts were made to create an exhaustive list of search terms, relevant terms might have been overlooked. Additionally, the choice to incorporate potential outcomes in the search query in order to limit results to a workable amount might have further hampered exhaustiveness, as specifying potential outcomes up-front is a daring task. Although efforts were made to minimize the effect of this – e.g. through including more generic terms such as 'outcome' and 'impact' and expert consults – a potential risk to exhaustiveness remains. Similarly – as clearly noticed – the limited focus on scientific literature implies that non-scientific publications have been excluded. As ICT is as much a field of practice as it is of science, it is not unlikely that some interesting information has been overlooked as a result of this decision. Finally, the focus on quantitatively established results is likely to have a twofold impact. On the one hand, the included studies can be deemed reliable, while on the other, it might have led to the exclusion of aspects less easily quantifiable. These are likely to include 'softer' cultural dimensions and failed projects, as for the latter a quantitative assessment (other than perhaps financial) is generally not feasible.

### *Selection*

The selection criteria for the study were clear, and the potential impact of these criteria was discussed above. During the process of actual selection, two potentially limiting aspects were identified. Of relatively minor influence was the decision to exclude small and medium enterprises, which led to a minor redefinition of research scope. A potentially larger limitation is that a number of possibly relevant studies could not be retrieved.

### *Data extraction*

Data extraction primarily aimed at 'rigorously proven' relationships. This step was fairly straightforward since these relationships are generally well described in primary studies. However, some difficulty was found in the practical implementation of criteria for selection as some studies theoretically satisfied methodological criteria, while in practice research methods were not always implemented rigorously. As this latter is difficult to categorise, for this research it was chosen to note potential weakness in primary studies.

### *Synthesis*

In the syntheses, the identified relationships were combined to a causal model. This step is the most differentiating factor compared to other methodologies. As there is no explicit guidance for this step, it is also the most interpretative one, which therefore holds the highest risk of introducing bias. As all extracted relations contained ICT as a component, it was logically to place ICT in the middle, factors related to its use and uptake on the left and effects on the right. In itself this does not seem to be a major source of bias. Somewhat more interpretative, was the integration of components present in various studies. Although many of those factors – such as age or income – are of relatively universal nature, their examination in primary studies is bound to local circumstances. Although the goal of the research is to transcend these local limitations by integration of results gathered over various contexts, it should be noted that such integration holds interpretative elements not directly warranted by primary studies. Additionally, it should be noted that although most relationships

present in the final synthesis have been empirically identified in multiple settings, the generalized figure in itself has not. It should hence not be seen as a conclusive system, but perhaps rather as an informative hypothesis. Additionally, this research focused on studies investigating ICT. As a result, ICT became a central element in the resulting system as created in the synthesis. It is however not unthinkable that various components are connected beyond ICT, indicating that exhaustiveness of the overview is not guaranteed.

### 8.1.2 Validity

In chapter 3, various indications for research quality were presented; four types of validity and the three other aspects of objectivity, reliability and utilisation. Validity was operationalized in statistical conclusion validity (relating to the dataset and conclusions drawn from it), internal validity (relating to causal logic), construct validity (referring to the operationalization of constructs) and external validity (indicating the extent to which study findings are generalizable).

#### *Statistical conclusion validity*

Statistical conclusion validity relates to the strength of covariation of the alleged cause and effect; whether there is indeed a statistical difference in the outcome variable of interest. This type of validity hence relates to the heterogeneity of studied variables, the extent to which assumptions underlying a certain type of analysis are fulfilled and whether the statistical power of the analysis performed is in correspondence to the effect size the analysis aims to identify (Shadish, Cook, & Campbell, 2002). For the current research, this type of validity is primarily applicable to the primary studies, as no statistical analysis was performed for the ultimate synthesis of the current report. Statistical validity was not addressed specifically for each individual primary study, although it attended to in the selection process.

A relevant element for statistical conclusion validity is the sample size required to attain the power required to test the purported hypothesis (MacCallum, Browne, & Sugawara, 1996). Despite its relevance, this aspect is often overlooked. In a review on agricultural interventions Masset, Haddad, Cornelius, and Isaza-Castro (2011) for example found that sample sizes chosen in primary studies were often inadequate and calculations related to the determination of sample sizes were often lacking. The appropriateness of a chosen sample size depends (among others) on the expected size of the effect of interest, the degrees of freedom in the analysis, the type of analysis employed and the (expected) distribution of the variables involved (Krejcie & Morgan, 1970). For the research at hand sample size calculations were not performed explicitly. A generic minimum level was however set to 100 observations in order to prevent the most extreme threats, although this level can be considered too small for certain types of analysis (Masset et al., 2011). Additionally, it should be noted that for many of the multiple-country focussed studies external (nation-wide) data was used and sample sizes were not given. However, as these studies often used data collected by national governments or specialized institutions it seems fairly safe to assume that sample sizes were adequate for their intended goals, and generally contained more than 100 observations. Ultimately, 28 included studies did not elaborate on sample size, while 30 did. Studies not reporting sample sizes often employed time series analysis techniques. The median sample size for the studies that did report on it was 483; a number which on itself does not seem highly inadequate for most types of analyses. Ultimately statistical conclusion validity was not extensively addresses in this research, although minimum thresholds were set in order to mitigate the most extreme risks.



### *Internal validity*

Internal validity basically relates to whether conclusions drawn on causal relations are valid. It is about the postulated theory of change, the causal logic; what caused the difference? For food internal validity it should be established that the identified cause and effect are related, that the cause preceded the effect, and that no alternative explanations for the effect relation are possible; i.e. relationships identified should not be spurious (Shadish et al., 2002).

The internal validity of the analysis conducted in the current research is dependent on two aspects: the internal validity of selected primary studies and the internal validity of the subsequent analysis of these studies. As indicated, a minimum level for the internal validity of primary studies was set by selection on research design (it had to follow at least a quasi-experimental design). However, as indicated during their analysis, some primary studies seem to be at risk of omitted variable bias (e.g. potentially relevant factors such as rainfall, inflation, agricultural/human diseases, or other 'shocks' where often not included), which means that potential confounding cannot be ruled out for all primary studies. Additionally, some other primary studies did not explicitly test for directionality of effects. These issues seem somewhat stronger for the multi-country analyses – which often involved time series data – than for those with a more local perspective.

Where the analysis and synthesis of the primary studies are concerned, relationships or directions were all based on primary studies; no hypotheses or expectations were added. In that regard major threats to internal validity do not seem present. Some additional strength can be found in the comparison of results from multiple studies and the use of both cross-sectional and longitudinal approaches in selected primary studies. A potential threat can however be found in the aggregation of findings obtain from multiple primary studies with a diverse technological and geographical focus.

### *Construct validity*

Construct validity relates to the way constructs (from the causal theory) are operationalized; this type of validity is about the relationship between what is measured and the underlying concepts. Although this type of validity is often related to psychological research, it is applicable to the study presented here. In the primary studies most constructs (e.g. age, income, market prices) were reasonable clear. A somewhat softer construct is that of education, but even there it can be regarded a relatively objective – and thus valid – construct. However, validity might be comprised in two aspects in the analysis performed in the present research. Firstly, constructs deemed similar over various primary studies were aggregated, but they might have differed somewhat between various primary studies. As this type of combination is however not uncommon even in more narrowly focused reviews, and especially given the goals presenting generic directional relationships (rather than precise estimates), it is not expected that the trustworthiness of findings is significantly put at stake. A second issue is that concepts within the final analysis were subsequently integrated further in an interpretative manner. This integration might have combined some (slightly) different constructs, thereby potentially compromising validity, although in these steps maximum transparency was aimed for.

### *External validity*

External validity is about the generalizability of findings; whether findings from one study are applicable to other situations, in other places, on other times and with other subjects. This aspect is

relevant for policy makers (among others), as they are often interested in using insights from research for future policy actions.

With regard to the primary studies that were ultimately included in this research, external validity is difficult to assess, although it can be assumed that findings from the studies that adopted a multi-national focus are more generalizable than those with a sub-national focus.

Where the findings of the study at hand are concerned, those that have been repeated over multiple studies (the thicker arrows in final integration) are more likely to be generalizable than those that were identified in a single study only.

### 8.1.3 Interpretation

Overall, the results presented in this study seem fairly trustworthy as all primary studies adopted a minimum standard of methodological quality. The combination of results obtained in various contexts strengthens the assumption of general applicability of the results (external validity). However, some limitations should be noted. Firstly, as the search was limited to scientifically published material, the results presented should not be seen as an exhaustive description of available knowledge. Additionally, it should be noted that not all potentially relevant scientific material could be retrieved, posing additional risk to validity. Secondly, the methodological standards adopted for primary studies led to the exclusion of more qualitative research. As failed projects generally do not result in much impact, and reasons for failure are often described qualitatively, it is likely that failures are under-represented in the studies that were included for this research. It is also not unthinkable that the contextual factors identified through this research are not exhaustive, and that a richer, more qualitative description would be valuable for actual project design. In general, it can be assumed that this study paints a relatively reliable, but potentially incomplete picture of the ICT4D result chain.

## 8.2 Method design

As this research can be regarded as a case study for the application of the method design, this paragraph will briefly describe the experiences of its application. In general, no major problems were experienced during the execution of the research. However, some aspects might be interesting to notice for future application of the method. It should be stressed that any research approach is a means to an end. Hence, having a clear perspective on research goals and the rough dimensions of the research field is important. For this research, the method was directed at combining insights from rigorous research in the field of ICT4D, in order to create a systemic overview. Contrary to some other reviews, this systems perspective was based on empirical research, rather than on researcher or expert expectations/opinions. However, in some expectations on the amount and quality of research available, and of potential factors involved are likely to be of help for informing the search process and data extraction. Should such insights not be available, an efficient approach is likely to be found in hand searching specialized journals for the topic of consideration.

Regarding the synthesis, it is interesting to note that for the research conducted here, one factor (ICT) was central in the systems overview ultimately constructed. Such perspective might be relevant in the investigation of a particular issue, but in reality, components in complex systems are likely to be interconnected to higher extent (i.e. beyond the relations to the central component).

Concerning the usability of the method results, the method seems particularly suited to interventions – or general research issues – at the complex end of the spectrum, composing of multiple interrelated elements. Additionally, outcomes obtained by this method could be used to assess general congruence of findings from primary studies, and potential discrepancy could become a starting point for additional research on important contextual factors.

Ultimately, the approach followed here is a rather experimental one that allows for adaptation. In other research the standard of evidence for inclusion can for instance be varied in concordance with the research goal and questions. For this research, the approach seems to have matched its goals: allowing for a more explorative focus of what might be termed 'complex interventions'. It allowed for the interpretative integration of empirically grounded results. By doing so, allows for the validation and comparison of results from multiple studies against one another, highlights contrasting outcomes, allows for the (re-)construction of longer impact pathways and identifies potential feedback loops. However, more potential for identification of relevant contextual factors seems possible by further exploration (initially in primary studies) of discordant findings – a potential that was not taken advantage of in this research because of time constraints.

## Literature

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#### General Bibliography

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- Samoilenko, S. V., & Weistroffer, H. R. (2010). Improving the relative efficiency of revenue generation from ICT in transition economies: a product life cycle approach. *Information Technology for Development*, 16(4), 279-303. doi: 10.1080/02681102.2010.510461
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- Soriano, C. R. R. (2007). Exploring the ICT and rural poverty reduction link: Community telecenters and rural livelihoods in Wu'an, China. *The Electronic Journal of Information Systems in Developing Countries*, 1-15.

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- Thadaboina, V. (2009). ICT and rural development: A study of Warana Wired Village Project in India. *Transition Studies Review*, 16(2), 560-570. doi: 10.1007/s11300-009-0092-z
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# Appendices

## I. Journal sources

The journals for the focused search were conducted using an online published table (Heeks, 2010b) by an ICT4D expert<sup>28</sup> and consultation of other experts in the field of development studies<sup>29</sup>. The following journals were searched (the number is the e-ISSN number). Most journals were searched in batch through the portal of their (shared) publisher, while a small group of journals from more exotic publishers was searched by hand.

Journal	Publisher	(e)ISSN
<b>Publishers</b>		
Asian Journal of Communication	Taylor and Francis	1742-0911
Canadian Journal of Development Studies	Taylor and Francis	2158-9100
Development in Practice	Taylor and Francis	1364-9213
Forum for Development Studies	Taylor and Francis	1891-1765
Human-Computer Interaction	Taylor and Francis	1532-7051
Journal of Development Studies	Taylor and Francis	1743-9140
Journal of Human Development and Capabilities	Taylor and Francis	1945-2837
Oxford Development Studies	Taylor and Francis	1469-9966
Third World Quarterly	Taylor and Francis	1360-2241
Information Technology for Development (ITD)	TandF (/Wiley)	1554-0170
African Development Review	Wiley	1467-8268
Developing Economies (the)	Wiley	1746-1049
Development and Change	Wiley	1467-7660
Development Policy Review	Wiley	1467-7679
Journal of International Development	Wiley	1099-1328
Review of Development Economics	Wiley	1467-9361
Sustainable Development	Wiley	1099-1719
Information Technology for Development	TandF (Wiley)	1554-0170
Information Development	Sage	0266-6669
Journal of Developing Societies	Sage	0169-796X
Journal of South Asian Development	Sage	0973-1741
Progress in Development Studies	Sage	1464-9934
Development	Palgrave	1011-6370
European Journal of Development Research	Palgrave	0960-085X
Journal of International Relations and Development	Palgrave	1408-6980
Economic Development and Cultural Change	Jstor	1539-2988
Journal of Development Economics	Elsevier	0304-3878
World Development	Elsevier	0305-750X
<b>Hand search</b>		
African Journal of Information and Communication	LINK centre	2077-7213
International Journal of ICT Research and Development in Africa (IJICTRDA)	IGI Global	1947-3427
Information Technologies and Int. Development	Annenberg USC	1544-7529
International Journal of Information Communication Technologies and Human Development (IJICTHD)	IGI Global	1935-567X
International Journal on Advances in ICT for Emerging Regions (ICTer)	Sri Lanka Journals OnLine	1800-4156
The Electronic Journal of Information Systems in Developing Countries (EJISDC)	City University of Hong Kong	1681-4835

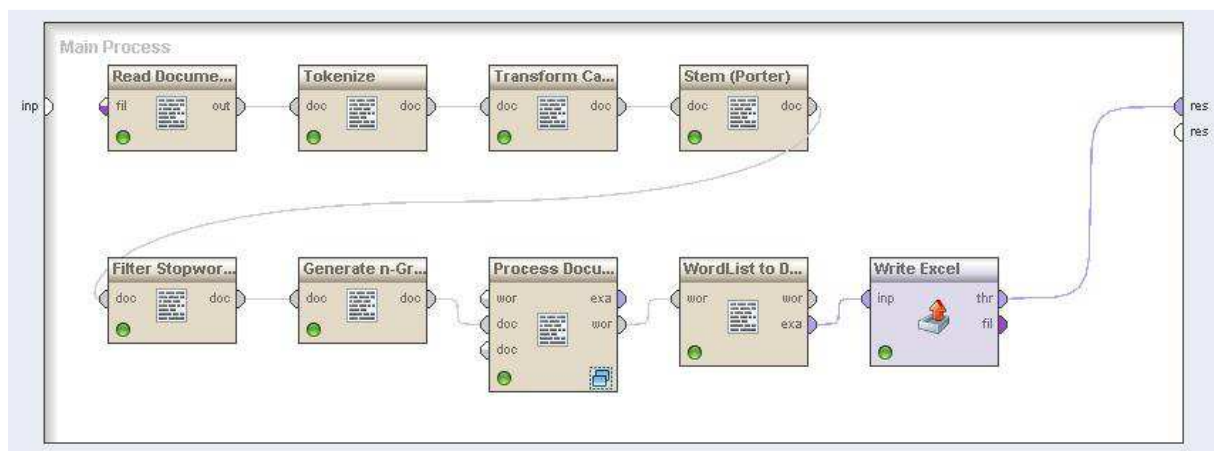
<sup>28</sup> Jeffrey James

<sup>29</sup> Ruerd Ruben, Rob Kuipers

## II. Term extraction from other reviews

As a validation and possible addition, keywords were also extracted from titles of studies found in other reviews: (Dixie & Jayaraman, 2011) and (Duncombe, 2012). The respective titles were extracted into Microsoft Notepad, and read into RapidMiner<sup>30</sup>. An alternative to rapid miner – besides any other text mining application – would be a visual representation of word frequencies in a word cloud through an application such as Wordle<sup>31</sup>. However, these programs generally do not seem to use a proper stemming algorithm, and hence singular and plural forms of the same term treated as separate terms and are counted individually, leading to a biased outcome.

In the RapidMiner process, words were transformed to lower case, stemmed using the Porter stemming algorithm, then stopwords were filtered, and n-grams were generated (3-grams). A graphical overview of the setup is depicted below, followed by the results of the process:



<sup>30</sup> <http://rapid-i.com/content/view/181/190/>

<sup>31</sup> <http://wordle.net>

Term	Freq	Term	Freq	Term	Freq
mobil	25	impact_mobil	5	micro	4
phone	21	livelihood	5	project	4
mobil_phone	19	market_inform	5	rural_uganda	4
agricultur	18	mobil_phone_rural	5	us_mobil_phone	4
rural	18	phone_rural	5	agricultur_extens	3
us	17	studi	5	agricultur_market	3
inform	16	us_mobil	5	econom	3
market	16	digit	4	effect	3
impact	12	enterpris	4	extens	3
servic	10	evid	4	kenya	3
farmer	9	ghana	4	micro_enterpris	3
ict	9	ict_base	4	mobil_telephoni	3
uganda	9	impact_mobil_phone	4	perform	3
case	8	india	4	role	3
commun	8	indian	4	rural_livelihood	3
technolog	8	inform_commun	4	south	3
base	7	inform_servic	4	tanzania	3
develop	7	market_inform_servic	4	telephoni	3

The n-grams (e.g. 'mobile phones') are compound terms, based on words occurring together. As can be seen, the words 'phone' was preceded by the word 'mobile' 19 out of 25 times. As most of the terms in the table had already been identified, the additional benefits of this text mining effort are relatively low, although they do provide some validation of the search strategy. The only search term previously unidentified is 'telephony', represented in stemmed form as 'telephoni' in the table. Furthermore, an interesting observation is the relatively high scores of the geographical terms 'uganda' and 'ghana' and 'india'. Apparently these countries have been popular for mobile phone impact research.

Other noticeable aspects: service as broad concept, technology, market information (this one could be added to the ict concept) – although market information service (containing the already listed information service) occurs almost as wide.

In a similar effort, the most important terms were retrieved for titles and abstracts together, as presented in the table below.

Term	Freq	Term	Freq	Term	Freq
inform	115	result	21	smallhold	14
mobil	112	ict_base	20	social	14
phone	109	system	20	commun_technolog	13
market	104	us_mobil_phone	20	farm	13
farmer	93	livelihood	19	inform_commun_technolog	13
us	89	paper	19	network	13
mobil_phone	87	reduc	18	agricultur_market	12
agricultur	79	cost	17	enhanc	12
commun	51	data	17	household	12
servic	50	effect	16	market_inform_servic	12
studi	48	inform_commun	16	time	12
ict	47	inform_servic	16	valu	12
rural	45	product	16	base_market	11
base	42	provid	16	base_market_inform	11
access	41	adopt	15	chang	11
improv	37	busi	15	district	11
technolog	33	contribut	15	group	11
develop	31	incom	15	ict_base_market	11
price	31	poor	15	india	11
impact	30	uganda	15	poverti	11
find	29	case	14	reduct	11
market_inform	27	chain	14	smallhold_farmer	11
abstract	25	develop_countri	14	suggest	11
increas	25	digit	14	telephoni	11
project	25	effici	14	trader	11
countri	24	enabl	14	villag	11
us_mobil	22	input	14		

### III. Search terms

As search options offered varied per publisher, various queries were used. Where possible, full text

#### III.I. Focused searches

##### III.I.I. Wiley

The Wiley online library<sup>32</sup> was searched using the 'advanced search' option. Date of search was February 2<sup>nd</sup>, 2013. Two search components were combined. The ICT component was searched for in abstracts, while the broader agricultural/rural focus was searched in full texts. The search yielded 303 results.

Final query:

Search in full text:

C4D OR "development informatics" OR ict4d OR ict4p OR ict4rd OR ictd OR it4d OR m4d OR \*phone OR broadband OR "cellular telephone" OR comput\* OR digital OR e\*mail OR e\*service OR e-business OR e-commerce OR e-development OR "electronic access\*" OR "electronic mail" OR "electronic messag\*" OR "electronic web" OR e-service OR "global positioning system" OR GPS OR GSM OR HCI4D OR ICT OR "information access\*" OR "Information and communication technology" OR "information device" OR "information exchang\*" OR "information infrastructure" OR "information system" OR "information technology" OR "instant messaging" OR internet OR laptop OR microcomput\* OR mobile OR PDA OR phone OR radio OR satellite OR SMS OR tele\* OR "text messag\*" OR web\*based OR web\*delivered OR wireless OR "world wide web" in Abstract AND 1099-1328 OR 1099-1719 OR 1467-7660 OR 1467-7679 OR 1467-8268 OR 1467-9361 OR 1554-0170 OR 1746-1049 in ISSN AND agri\* OR agro\* OR animal OR "aqua-culture" OR aquafarm\* OR "aqua-farm\*" OR \*bean OR bean\* OR camel\* OR cattle OR chicken\* OR commerc\* OR commodit\* OR corn OR cow\* OR credit OR \*crop OR crop\* OR cultivat\* OR dairy\* OR farm\* OR feed\* OR financ\* OR \*fish OR fish\* OR \*food OR food\* OR fruit\* OR goat\* OR grain\* OR horti\* OR land OR livelihood\* OR livestock\* OR meat OR maize OR mari\*culture OR market\* OR "micro-enterpr\*" OR olive OR organic OR pastoral\* OR \*pond OR potato OR poultr\* OR protein OR \*seed OR seed\* OR sheep\* OR "small-enterpr\*" OR smallhold\* OR "small-hold\*" OR soil OR sugar\* OR "supply chain\*" OR trade\* OR \*trading OR transaction OR tomat\* OR "value chain\*" OR value\* OR valuechain\* OR vegetab\* OR wheat

Daterange: between 2000 and 2013

This search yielded 303 results

##### III.I.II. Taylor and Francis

Taylor and Francis online<sup>33</sup> was used for this search. The search engine provides automatic stemming and spelling variations. ICT terms were combined with the ISSN numbers of selected journals and with 'stemming' enabled. As an initial search with the ICT terms in 'everything' yielded 5,466 results, the search was limited to abstract or titles in two separate rounds of searching.

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<sup>32</sup> <http://onlinelibrary.wiley.com/>

<sup>33</sup> <http://www.tandfonline.com/search/advanced>

In: abstract

C4D OR "development informatics" OR ICT4D OR ICT4P OR ICT4rD OR ICTD OR IT4D OR M4D OR broadband OR "cellular telephone" OR computer\* OR digital OR e?mail OR e?service OR e-business OR e-commerce OR e-development OR "electronic access" OR "electronic mail" OR "electronic message" OR "electronic web" OR e-service OR "global positioning system" OR GPS OR GSM OR "handheld device" OR handset OR HCI4D OR ICT OR "information access" OR "Information and communication technology" OR "information device" OR "information exchange" OR "information infrastructure" OR "information system" OR "information technology" OR "instant messaging" OR internet OR laptop OR microcomputer OR mobile OR PDA OR phone\* OR radio OR satellite OR SMS OR tele\* OR "text message" OR web?based OR web?delivered OR wireless OR "world wide web"

AND (1360-2241 OR 1364-9213 OR 1469-9966 OR 1532-7051 OR 1554-0170 OR 1742-0911 OR 1743-9140 OR 1891-1765 OR 1945-2837 OR 2158-9100) in ISSN

This search yielded 410 results.

### III.I.III. Elsevier

Elsevier published journals were searched using the Science Direct database<sup>34</sup>. The following query was used in the 'expert search' field for journals:

pub-date > 1999 and TITLE-ABSTR-KEY(C4D OR "development informatics" OR ICT4D OR ICT4P OR ICT4rD OR ICTD OR IT4D OR M4D OR broadband OR "cellular telephone" OR comput\* OR digital OR "e\*mail" OR "e\*service" OR "e-business" OR "e\*commerce" OR "e\*development" OR "electronic access\*" OR "electronic mail" OR "electronic messag\*" OR "electronic web" OR "e\*service" OR "global positioning system" OR GPS OR GSM OR HCI4D OR ICT OR "information access\*" OR "Information and communication technology" OR "information device" OR "information exchang\*" OR "information infrastructure" OR "information service" OR "information system" OR "information technology" OR "instant messaging" OR internet OR laptop OR microcomput\* OR mobile OR PDA OR \*phone OR phone\* OR radio OR satellite OR SMS OR tele\* OR "text messag\*" OR "web\*based" OR "web\*delivered" OR wireless OR "world wide web") and ISSN(0304-3878 OR 0305-750X)

This search yielded 51 results.

### III.I.IV. Palgrave

Searched through EBSCO<sup>35</sup>.

C4D OR "development informatics" OR ICT4D OR ICT4P OR ICT4RD OR ICTD OR IT4D OR M4D OR broadband OR "cellular telephone" OR computer OR digital OR "e-mail" OR "e-service" OR "e-business" OR "e-commerce" OR "e-development" OR "electronic access" OR "electronic mail" OR "electronic message" OR "electronic web" OR "global positioning system" OR GPS OR GSM OR HCI4D OR ICT OR "information access" OR "Information and communication technology" OR "information device" OR "information exchange" OR "information

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<sup>34</sup> <http://www.sciencedirect.com>

<sup>35</sup> <http://web.ebscohost.com>

infrastructure" OR "information system" OR "information technology" OR "instant messaging" OR internet OR laptop OR microcomputer OR mobile OR PDA OR phone OR radio OR satellite OR SMS OR "text message" OR "web-based" OR "web-delivered" OR "wireless" OR "world wide web"

AND 10116370 OR 0960085X OR 14086980 in ISSN

#### **III.IV. SAGE publications**

The selected journals from SAGE were searched with the publisher's search engine<sup>36</sup> using the following query:

In: All Text (TX):

C4D OR "development informatics" OR ICT4D OR ICT4P OR ICT4RD OR ICTD OR IT4D OR M4D OR broadband OR "cellular telephone" OR computer OR digital OR "e-mail" OR "e-service" OR "e-business" OR "e-commerce" OR "e-development" OR "electronic access" OR "electronic mail" OR "electronic message" OR "electronic web" OR "global positioning system" OR GPS OR GSM OR HCI4D OR ICT OR "information access" OR "Information and communication technology" OR "information device" OR "information exchange" OR "information infrastructure" OR "information system" OR "information technology" OR "instant messaging" OR internet OR laptop OR microcomputer OR mobile OR PDA OR phone OR radio OR satellite OR SMS OR "text message" OR "web-based" OR "web-delivered" OR "wireless" OR "world wide web"

AND (02666669 OR 0169796X OR 09731741 OR 14649934) in ISSN

#### **III.IV. JSTOR**

Limited search options. Therefore the ICT component was search in full-text, and references were subsequently selected by hand, based on title browsing for relevance. Initially 146 references were returned, of which 12+2=14 articles were exported.

ISSN: 15392988

Fulltext: M4D OR broadband OR "cellular telephone" OR computer OR digital OR e-mail OR e-service OR e-business OR e-commerce OR e-development OR "electronic access" OR "electronic mail" OR "electronic message" OR "electronic web" OR e-service OR "global positioning system" OR GPS OR GSM OR "handheld device" OR handset OR HCI4D OR ICT OR "information access" OR "Information and communication technology" OR "information device" OR "information exchange" OR "information infrastructure" OR "information system" OR "information technology" OR "instant messaging" OR internet OR laptop OR microcomputer OR mobile OR PDA OR phone OR radio OR satellite OR SMS OR tele\* OR "text message" OR web-based OR web-delivered OR wireless OR "world wide web"

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<sup>36</sup> <http://www.sagepub.com/journals.nav>

### III.II. Search terms broad searches

This search was done in Scopus using following syntax below. The search was conducted on February 5<sup>th</sup>, 2013.

#### Initial setup

##### III.II.I. In scopus

TITLE-ABS-KEY

```
(
  (
    (
      (
        (
          electronic OR mobile OR information
        )
      )
    )
  )
  PRE/2
  (
    access* OR applica* OR communicat* OR device* OR exchang* OR
    messag* OR mail OR service* OR techn* OR web*
  )
)
OR
(
  "development informatics" OR ICT4D OR ICT4P OR ICT4RD OR ICTD OR IT4D
  OR M4D OR C4D OR apps OR cellular* OR comput* OR connecti* OR
  desktop OR digital OR e*mail OR e*service OR "global positioning system*"
  OR GPS OR GSM OR ICT OR "information servic*" OR internet OR "land lin*"
  OR laptop OR microcomp* OR pc* OR PDA OR *phone OR phone* OR radio
  OR satellit* OR SMS OR tele* OR "text messag*" OR web*based OR
  web*delivered OR wireless
)
)
AND
(
  (
    (
      (
        (
          developing OR disadvantaged OR emerging OR impoverished OR
          lami OR "less* develop*" OR "low* develop*" OR "low* income"
          OR "middle income" OR poor* OR remote OR rural OR transitional
          OR "under*developed" OR "under*served"
        )
      )
    )
  )
  PRE/2
  (
    area* OR countr* OR econom* OR nation* OR people OR place*
    OR population* OR region* OR world*
  )
)
)
OR
(
  depriv* OR destitute OR "develop* aid" OR "development goal*" OR
  "economic development" OR famin* OR "low gross national" OR lmic* OR
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"low\* GDP" OR "low\* income" OR minorit\* OR penurious OR poverty\* OR "third world" OR Afric\* OR Asi\* OR Caribb\* OR "Central Americ\*" OR "Latin Americ\*" OR Sahara\* OR "South Americ\*" OR "south\*country" OR "West Indi\*"

)  
**OR**

(  
Afghanistan OR Bangladesh OR Benin OR Burkina Faso OR Burundi OR Cambodia OR "Central African Republic" OR Chad OR Comoros OR Congo OR Eritrea OR Ethiopia OR Gambia OR Guinea OR Guinea Bissau OR Haiti OR Kenya OR Korea OR "Kyrgyz Republic" OR Liberia OR Madagascar OR Malawi OR Mali OR Mauritania OR Mozambique OR Myanmar OR Nepal OR Niger OR Rwanda OR "Sierra Leone" OR Somalia OR Tajikistan OR Tanzania OR Togo OR Uganda OR Zimbabwe OR Albania OR Armenia OR Belize OR Bhutan OR Bolivia OR Cameroon OR "Cape Verde" OR Congo OR "Côte d'Ivoire" OR Djibouti OR Egypt OR Salvador OR Fiji OR Georgia OR Ghana OR Guatemala OR Guyana OR Honduras OR Indonesia OR India OR Iraq OR Kiribati OR Kosovo OR Lao OR Lesotho OR Marshall OR Islands OR Micronesia OR Moldova OR Mongolia OR Morocco OR Nicaragua OR Nigeria OR Pakistan OR "Papua New Guinea" OR Paraguay OR Philippines OR Samoa OR "São Tomé and Príncipe" OR Senegal OR "Solomon Islands" OR "Sri Lanka" OR Sudan OR Swaziland OR Syria OR Timor-Leste OR Tonga OR Ukraine OR Uzbekistan OR Vanuatu OR Vietnam OR "West Bank" OR Gaza OR Yemen OR Zambia OR Angola OR Algeria OR Samoa OR Antigua OR Barbuda OR Argentina OR Azerbaijan OR Belarus OR Bosnia OR Herzegovina OR Botswana OR Brazil OR Bulgaria OR Chile OR China OR Colombia OR "Costa Rica" OR Cuba OR Dominica OR "Dominican Republic" OR Ecuador OR Gabon OR Grenada OR Iran OR Jamaica OR Jordan OR Kazakhstan OR Latvia OR Lebanon OR Libya OR Lithuania OR Macedonia OR Malaysia OR Maldives OR Mauritius OR Mexico OR Montenegro OR Namibia OR Palau OR Panama OR Peru OR Romania OR Russia\* OR Serbia OR Seychelles OR "South Africa" OR "St. Lucia" OR "St. Vincent" OR Suriname OR Thailand OR Tunisia OR Turkey OR Turkmenistan OR Tuvalu OR Uruguay OR Venezuela

)

**AND**

(  
agri\* OR agro\* OR animal\* OR "aqua-culture\*" OR aquafarm\* OR "aqua-farm\*" OR \*bean OR bean\* OR camel\* OR cattle OR chicken\* OR commerc\* OR commodit\* OR corn OR cow\* OR credit OR \*crop OR crop\* OR cultivat\* OR dairy\* OR farm\* OR feed\* OR financ\* OR \*fish OR fish\* OR \*food OR food\* OR fruit\* OR goat\* OR grain\* OR horti\* OR land OR livestock\* OR meat OR maize OR mari\*culture OR market\* OR "micro-enterpr\*" OR olive OR organic OR pastoral\* OR \*pond OR potato OR poultr\* OR protein OR \*seed OR seed\* OR sheep\* OR SME? OR "small-enterpr\*" OR smallhold\* OR "small-hold\*" OR soil OR sugar\* OR "supply chain\*" OR trade\* OR \*traders OR \*trading OR transaction OR tomat\* OR "value chain\*" OR value\* OR vegetab\* OR wheat

)

**AND**

(

asset\* OR benefit\* OR capital OR consume\* OR consumption OR earning\* OR employ\* OR empower\* OR expenditure\* OR food\* OR hous\* OR income\* OR inequal\* OR job\* OR "labour supply" OR livelihood\* OR "living standard\*" OR nutrition\* OR perform\* OR price\* OR productiv\* OR profit\* OR revenue\* OR salar\* OR "transaction costs" OR utility OR wage\* OR wealth OR welfare OR well\*being OR yield\* OR success OR fail\* OR "lesson\* learned" OR apprais\* OR apprais\* OR assess\* OR baseline OR "before and after" OR coefficient\* OR "co-efficient\*" OR "cohort analy\*" OR "comparative analys\*" OR "comparative design\*" OR "comparative stud\*" OR comparison OR control\* OR counterfactual\* OR covariate OR demonstrat\* OR difference OR econometr\* OR "economic research" OR effect\* OR efficacy OR "equivalent group\*" OR estimat\* OR evaluat\* OR evidence OR experiment\* OR "Heckman model\*" OR impact\* OR "instrumental variable\*" OR intervention\* OR investigat\* OR "kernel matching" OR "least squares" OR "linear probability" OR "log linear" OR "match\* group" OR "matching on observable\*" OR "matching with replacement\*" OR measur\* OR multivariate OR "multi-variate" OR "nearest neighbo\*" OR "non random\*" OR "non-comparison" OR "observational stud\*" OR outcome\* OR panel\* OR placebo OR "post test\*" OR "post-intervention" OR posttest\* OR "pre and post" OR "pre post" OR "pre test\*" OR "pre-intervention" OR pretest\* OR "Probit model\*" OR proof OR "propensity score\*" OR "prospective allocation" OR proven OR proving OR PSM OR quantitative OR random\* OR RCT\* OR regression\* OR result\* OR "retrospective allocation" OR review OR statistic\* OR stratification OR "stratified matching" OR survey\* OR "time series" OR "Tobit model\*" OR "treatment group\*" OR trial OR "two group\*" )

AND

PUBYEAR > 1999

This search yielded 61,816 results, which is an unmanageable amount. Subsequently the various components were tested for their contribution, as depicted in the table below:

Component	#Results
Total search	61,816
ICT component	5,095,950
Development component	914,574
Agricultural component	8,689,151
Effects component	19,208,155

The respective syntaxes can be found below:

**Component: ICT**

TITLE-ABS-KEY(((electronic OR mobile OR information) PRE/2 (access\* OR applica\* OR communicat\* OR device\* OR exchang\* OR messag\* OR mail OR service\* OR techn\* OR web\*)) OR ("development informatics" OR ict4d OR ict4p OR ict4rd OR ictd OR it4d OR m4d OR c4d OR apps OR cellular\* OR comput\* OR connecti\* OR desktop OR digital OR e\*mail OR e\*service OR "global positioning system\*" OR gps OR gsm OR ict OR "information servic\*" OR internet OR "land lin\*" OR laptop OR microcomp\* OR pc\* OR pda OR \*phone OR phone\* OR radio OR satellit\* OR sms OR tele\* OR "text messag\*" OR web\*based OR web\*delivered OR wireless)) AND PUBYEAR > 1999

### *Component: Development*

TITLE-ABS-KEY((((developing OR disadvantaged OR emerging OR impoverished OR lami OR "less\* develop\*" OR "low\* develop\*" OR "low\* income" OR "middle income" OR poor\* OR remote OR rural OR transitional OR "under\*developed" OR "under\*served") PRE/2 (area\* OR countr\* OR econom\* OR nation\* OR people OR place\* OR population\* OR region\* OR world\*)) OR (depriv\* OR destitute OR "develop\* aid" OR "development goal\*" OR "economic development" OR famin\* OR "low gross national" OR lmic\* OR "low\* GDP" OR "low\* income" OR minorit\* OR penurious OR poverty\* OR "third world" OR afric\* OR asi\* OR caribb\* OR "Central Americ\*" OR "Latin Americ\*" OR sahara\* OR "South Americ\*" OR "south\*country" OR "West Indi\*") OR (afghanistan OR bangladesh OR benin OR burkina faso OR burundi OR cambodia OR "Central African Republic" OR chad OR comoros OR congo OR eritrea OR ethiopia OR gambia OR guinea OR guinea bissau OR haiti OR kenya OR korea OR "Kyrgyz Republic" OR liberia OR madagascar OR malawi OR mali OR mauritania OR mozambique OR myanmar OR nepal OR niger OR rwanada OR "Sierra Leone" OR somalia OR tajikistan OR tanzania OR togo OR uganda OR zimbabwe OR albania OR armenia OR belize OR bhutan OR bolivia OR cameroon OR "Cape Verde" OR congo OR "Côte d'Ivoire" OR djibouti OR egypt OR salvador OR fiji OR georgia OR ghana OR guatemala OR guyana OR honduras OR indonesia OR india OR iraq OR kiribati OR kosovo OR lao OR lesotho OR marshall OR islands OR micronesia OR moldova OR mongolia OR morocco OR nicaragua OR nigeria OR pakistan OR "Papua New Guinea" OR paraguay OR philippines OR samoa OR "São Tomé and Príncipe" OR senegal OR "Solomon Islands" OR "Sri Lanka" OR sudan OR swaziland OR syria OR timor-leste OR tonga OR ukraine OR uzbekistan OR vanuatu OR vietnam OR "West Bank" OR gaza OR yemen OR zambia OR angola OR algeria OR samoa OR antigua OR barbuda OR argentina OR azerbaijan OR belarus OR bosnia OR herzegovina OR botswana OR brazil OR bulgaria OR chile OR china OR colombia OR "Costa Rica" OR cuba OR dominica OR "Dominican Republic" OR ecuador OR gabon OR grenada OR iran OR jamaica OR jordan OR kazakhstan OR latvia OR lebanon OR libya OR lithuania OR macedonia OR malaysia OR maldives OR mauritius OR mexico OR montenegro OR namibia OR palau OR panama OR peru OR romania OR russia\* OR serbia OR seychelles OR "South Africa" OR "St. Lucia" OR "St. Vincent" OR suriname OR thailand OR tunisia OR turkey OR turkmenistan OR tuvalu OR uruguay OR venezuela))) AND PUBYEAR > 1999

### *Component: Value Chain*

TITLE-ABS-KEY((agri\* OR agro\* OR animal\* OR "aqua-culture\*" OR aquafarm\* OR "aqua-farm\*" OR \*bean OR bean\* OR camel\* OR cattle OR chicken\* OR commerc\* OR commodit\* OR corn OR cow\* OR credit OR \*crop OR crop\* OR cultivat\* OR dairy\* OR farm\* OR feed\* OR financ\* OR \*fish OR fish\* OR \*food OR food\* OR fruit\* OR goat\* OR grain\* OR horti\* OR land OR livestock\* OR meat OR maize OR mari\*culture OR market\* OR "micro-enterpr\*" OR olive OR organic OR pastoral\* OR \*pond OR potato OR poultr\* OR protein OR \*seed OR seed\* OR sheep\* OR sme? OR "small-enterpr\*" OR smallhold\* OR "small-hold\*" OR soil OR sugar\* OR "supply chain\*" OR trade\* OR \*traders OR \*trading OR transaction OR tomat\* OR "value chain\*" OR value\* OR vegetab\* OR wheat)) AND PUBYEAR > 1999

### *Component: Results*

TITLE-ABS-KEY(asset\* OR benefit\* OR capital OR consume\* OR consumption OR earning\* OR employ\* OR empower\* OR expenditure\* OR food\* OR hous\* OR income\* OR inequal\* OR job\* OR "labour supply" OR livelihood\* OR "living standard\*" OR nutrition\* OR perform\* OR price\* OR productiv\* OR profit\* OR revenue\* OR salar\* OR "transaction costs" OR utility OR wage\* OR wealth OR welfare OR well\*being OR yield\* OR success OR fail\* OR "lesson\* learned" OR apprais\* OR

apprais\* OR assess\* OR baseline OR "before and after" OR coefficient\* OR "co-efficient\*" OR "cohort analy\*" OR "comparative analys\*" OR "comparative design\*" OR "comparative stud\*" OR comparison OR control\* OR counterfactual\* OR covariate OR demonstrat\* OR difference OR econometr\* OR "economic research" OR effect\* OR efficacy OR "equivalent group\*" OR estimat\* OR evaluat\* OR evidence OR experiment\* OR "Heckman model\*" OR impact\* OR "instrumental variable\*" OR intervention\* OR investigat\* OR "kernel matching" OR "least squares" OR "linear probability" OR "log linear" OR "match\* group" OR "matching on observable\*" OR "matching with replacement\*" OR measur\* OR multivariate OR "multi-variate" OR "nearest neighbo\*" OR "non random\*" OR "non-comparison" OR "observational stud\*" OR outcome\* OR panel\* OR placebo OR "post test\*" OR "post-intervention" OR posttest\* OR "pre and post" OR "pre post" OR "pre test\*" OR "pre-intervention" OR pretest\* OR "Probit model\*" OR proof OR "propensity score\*" OR "prospective allocation" OR proven OR proving OR psm OR quantitative OR random\* OR rct\* OR regression\* OR result\* OR "retrospective allocation" OR review OR statistic\* OR stratification OR "stratified matching" OR survey\* OR "time series" OR "Tobit model\*" OR "treatment group\*" OR trial OR "two group\*") AND PUBYEAR > 1999

### III.II.II. Final version Scopus

Combining the refined queries still yielded too many results (5,055). Therefore the ICT component was further refined to in-title only. Based on the results from the other reviews that seemed a safe choice, although it should be noted that these reviews did not specify search strategies (and henceforth could themselves have been limited to in-title searches for the ICT component).

The final query was composed of a combination from the queries below, using Boolean 'AND' (apostrophes not included), resulting in the query below.

Results: 2,892

Due to an extraction limit in Scopus of 2,000 references, the query was split up and imported from two subsequent searches. The split was made in the ICT component between PDA and \*phone. The first part yielded 1,673 results, while the second gave an amount of 1,421. This adds up to 3094, which is 202 more than the former total of 2892. The difference is most likely due to some overlap in the results caused by studies scoring on multiple search synonyms.

(TITLE("electronic access\*" OR "electronic applica\*" OR "electronic communicat\*" OR "electronic exchang\*" OR "electronic messag\*" OR "electronic mail" OR "electronic service\*" OR "electronic web\*" OR mobile\* OR "information access\*" OR "information applica\*" OR "information communicat\*" OR "information device\*" OR "information exchang\*" OR "information messag\*" OR "information mail" OR "information service\*" OR "information techn\*" OR "information web\*" OR c4d OR "development informatics" OR "e-development" OR iar4d OR iard OR icm4ard OR ict4d OR ict4p OR ict4rd OR ict4d OR it4d OR m4d OR apps OR broadband OR "cellular phon\*" OR digital OR e\*mail OR e\*service OR "global positioning system\*" OR gps OR gsm OR "handheld device\*" OR handset\* OR ict OR "instant messag\*" OR internet OR "land lin\*" OR laptop OR microcomp\* OR pda OR \*phone OR phone\* OR radio OR satellit\* OR sms OR tablet\* OR tele\* OR "text messag\*" OR web\*based OR web\*delivered OR wireless) AND PUBYEAR > 1999 AND NOT SUBJAREA(bioc OR ceng OR CHEM OR dent OR eart OR ener OR heal OR immu OR mate OR math OR medi OR neur OR nurs OR phar OR phys)) AND (TITLE-ABS-KEY("developing area\*" OR "disadvantaged area\*" OR "emerging area\*" OR "impoverished area\*" OR "lami area\*" OR "less developed area\*" OR "lesser developed

area\*" OR "low developed area\*" OR "lower developed area\*" OR "low income area\*" OR "lower income area\*" OR "middle income area\*" OR "poor area\*" OR "remote area\*" OR "rural area\*" OR "transitional area\*" OR "under-developed area\*" OR "under-served area\*" OR "developing countr\*" OR "disadvantaged countr\*" OR "emerging countr\*" OR "impoverished countr\*" OR "lami countr\*" OR "less developed countr\*" OR "lesser developed countr\*" OR "low developed countr\*" OR "lower developed countr\*" OR "low income countr\*" OR "lower income countr\*" OR "middle income countr\*" OR "poor countr\*" OR "remote countr\*" OR "rural countr\*" OR "transitional countr\*" OR "under-developed countr\*" OR "under-served countr\*" OR "developing econom\*" OR "disadvantaged econom\*" OR "emerging econom\*" OR "impoverished econom\*" OR "lami econom\*" OR "less developed econom\*" OR "lesser developed econom\*" OR "low developed econom\*" OR "lower developed econom\*" OR "low income econom\*" OR "lower income econom\*" OR "middle income econom\*" OR "poor econom\*" OR "remote econom\*" OR "rural econom\*" OR "transitional econom\*" OR "under-developed econom\*" OR "under-served econom\*" OR "developing nation\*" OR "disadvantaged nation\*" OR "emerging nation\*" OR "impoverished nation\*" OR "lami nation\*" OR "less developed nation\*" OR "lesser developed nation\*" OR "low developed nation\*" OR "lower developed nation\*" OR "low income nation\*" OR "lower income nation\*" OR "middle income nation\*" OR "poor nation\*" OR "remote nation\*" OR "rural nation\*" OR "transitional nation\*" OR "under-developed nation\*" OR "under-served nation\*" OR "developing people" OR "disadvantaged people" OR "emerging people" OR "impoverished people" OR "lami people" OR "less\* developed people" OR "low\* developed people" OR "low\* income people" OR "middle income people" OR "poor\* people" OR "remote people" OR "rural people" OR "transitional people" OR "under\*developed people" OR "under\*served people" OR "developing place\*" OR "disadvantaged place\*" OR "emerging place\*" OR "impoverished place\*" OR "lami place\*" OR "less developed place\*" OR "lesser developed place\*" OR "low developed place\*" OR "lower developed place\*" OR "low income place\*" OR "lower income place\*" OR "middle income place\*" OR "poor place\*" OR "remote place\*" OR "rural place\*" OR "transitional place\*" OR "under-developed place\*" OR "under-served place\*" OR "developing population\*" OR "disadvantaged population\*" OR "emerging population\*" OR "impoverished population\*" OR "lami population\*" OR "less developed population\*" OR "lesser developed population\*" OR "low developed population\*" OR "lower developed population\*" OR "low income population\*" OR "lower income population\*" OR "middle income population\*" OR "poor population\*" OR "remote population\*" OR "rural population\*" OR "transitional population\*" OR "under-developed population\*" OR "under-served population\*" OR "developing region\*" OR "disadvantaged region\*" OR "emerging region\*" OR "impoverished region\*" OR "lami region\*" OR "less developed region\*" OR "lesser developed region\*" OR "low developed region\*" OR "lower developed region\*" OR "low income region\*" OR "lower income region\*" OR "middle income region\*" OR "poor region\*" OR "remote region\*" OR "rural region\*" OR "transitional region\*" OR "under-developed region\*" OR "under-served region\*" OR "developing world" OR "disadvantaged world" OR "emerging world" OR "impoverished world" OR "lami world" OR "less\* developed world" OR "low\* developed world" OR "low\* income world" OR "middle income world" OR "poor\* world" OR "remote world" OR "rural world" OR "transitional world" OR "under\*developed world" OR "under\*served world" OR destitute OR "develop\* aid" OR "development goal\*" OR "economic development" OR famin\* OR "human development" OR "international development" OR "low gross national" OR lmic\* OR "low\* GDP" OR "low\* income" OR minorit\* OR penurious OR poverty\* OR "third world" OR afric\* OR asi\* OR caribb\* OR "Central Americ\*" OR "Latin Americ\*" OR sahara\* OR "South Americ\*" OR "south\*country" OR "West Indi\*"

OR "third world" OR afric\* OR asi\* OR caribb\* OR "Central Americ\*" OR "Latin Americ\*" OR sahara\* OR "South Americ\*" OR "south\*country" OR "West Indi\*" OR afghanistan OR bangladesh OR benin OR "Burkina Faso" OR burundi OR cambodia OR "Central African Republic" OR chad OR comoros OR congo OR eritrea OR ethiopia OR gambia OR guinea OR haiti OR kenya OR korea OR "Kyrgyz Republic" OR liberia OR madagascar OR malawi OR mali OR mauritania OR mozambique OR myanmar OR nepal OR niger OR rwanada OR "Sierra Leone" OR somalia OR tajikistan OR tanzania OR togo OR uganda OR zimbabwe OR albania OR armenia OR belize OR bhutan OR bolivia OR cameroon OR "Cape Verde" OR congo OR "Côte d'Ivoire" OR djibouti OR egypt OR salvador OR fiji OR georgia OR ghana OR guatemala OR guyana OR honduras OR indonesia OR india OR iraq OR kiribati OR kosovo OR lao OR lesotho OR marshall OR islands OR micronesia OR moldova OR mongolia OR morocco OR nicaragua OR nigeria OR pakistan OR "Papua New Guinea" OR paraguay OR philippines OR samoa OR "São Tomé and Príncipe" OR senegal OR "Solomon Islands" OR "Sri Lanka" OR sudan OR swaziland OR syria OR "Timor-Leste" OR tonga OR ukraine OR uzbekistan OR vanuatu OR vietnam OR "West Bank" OR gaza OR yemen OR zambia OR angola OR algeria OR samoa OR antigua OR barbuda OR argentina OR azerbaijan OR belarus OR bosnia OR herzegovina OR botswana OR brazil OR bulgaria OR chile OR china OR colombia OR "Costa Rica" OR cuba OR dominica OR "Dominican Republic" OR ecuador OR gabon OR grenada OR iran OR jamaica OR jordan OR kazakhstan OR latvia OR lebanon OR libya OR lithuania OR macedonia OR malaysia OR maldives OR mauritius OR mexico OR montenegro OR namibia OR palau OR panama OR peru OR romania OR russia OR serbia OR seychelles OR "South Africa" OR "St. Lucia" OR "St. Vincent" OR suriname OR thailand OR tunisia OR turkey OR turkmenistan OR tuvalu OR uruguay OR venezuela) AND PUBYEAR > 1999 AND NOT SUBJAREA(bioc OR ceng OR CHEM OR dent OR eart OR ener OR heal OR immu OR mate OR math OR medi OR neur OR nurs OR phar OR phys)) AND (TITLE-ABS-KEY(agri\* OR agro\* OR animal\* OR "aqua-culture\*" OR \*bean OR bean\* OR camel\* OR cattle OR chicken\* OR commerc\* OR commodit\* OR corn OR cow\* OR credit OR \*crop OR crop\* OR cultivat\* OR dairy\* OR entrepren\* OR \*farm OR farm\* OR feed\* OR financ\* OR \*fish OR fish\* OR \*food OR food\* OR fruit\* OR goat\* OR grain\* OR horti\* OR livestock\* OR meat OR maize OR mari\*culture OR market\* OR "micro-business" OR "micro-enterpr\*" OR "micro-and-small" OR olive OR organic OR pastoral\* OR \*pond OR potato OR poultr\* OR property\* OR protein OR \*seed OR seed\* OR sheep\* OR sme? OR "small-business" OR "small-enterpr\*" OR smallhold\* OR "small-hold\*" OR soil OR sugar\* OR "supply chain\*" OR trade\* OR \*traders OR \*trading OR transaction OR tomat\* OR "value chain\*" OR vegetab\* OR wheat) AND PUBYEAR > 1999 AND NOT SUBJAREA(bioc OR ceng OR CHEM OR dent OR eart OR ener OR heal OR immu OR mate OR math OR medi OR neur OR nurs OR phar OR phys)) AND (TITLE-ABS-KEY(asset\* OR benefit\* OR capital OR consume\* OR consumption OR earning\* OR employ\* OR empower\* OR effect\* OR efficacy OR expenditure\* OR food\* OR impact OR income\* OR inequal\* OR job\* OR "labour supply" OR livelihood\* OR "living standard\*" OR nutrition\* OR perform\* OR price\* OR productiv\* OR profit\* OR result OR revenue\* OR salar\* OR "transaction costs" OR utility OR wage\* OR wealth OR welfare OR well\*being OR yield\* OR success OR fail\* OR "lesson\* learned") AND PUBYEAR > 1999 AND NOT SUBJAREA(bioc OR ceng OR CHEM OR dent OR eart OR ener OR heal OR immu OR mate OR math OR medi OR neur OR nurs OR phar OR phys)) AND (TITLE-ABS-KEY(apprais\* OR assess\* OR baseline OR "before and after" OR coefficient\* OR "co-efficient\*" OR "cohort analy\*" OR "comparative analys\*" OR "comparative design\*" OR "comparative stud\*" OR comparison OR control\* OR counterfactual\* OR covariate OR demostrat\* OR difference OR econometr\* OR "economic research" OR "equivalent group\*" OR estimat\* OR evaluat\* OR evidence OR experiment\* OR "Heckman model\*" OR "instrumental variable\*" OR intervention\* OR investigat\* OR "kernel matching" OR "least squares"

OR "linear probability" OR "log linear" OR "match\* group" OR "matching on observable\*" OR "matching with replacement\*" OR measur\* OR multivariate OR "multi-variate" OR "nearest neighbo\*" OR "non random\*" OR "non-comparison" OR "observational stud\*" OR panel\* OR placebo OR "post test\*" OR "post-intervention" OR posttest\* OR "pre and post" OR "pre post" OR "pre test\*" OR "pre-intervention" OR pretest\* OR "Probit model\*" OR proof OR "propensity score\*" OR "prospective allocation" OR proven OR proving OR psm OR quantitative OR random\* OR rct\* OR regression\* OR "retrospective allocation" OR review OR statistic\* OR stratification OR "stratified matching" OR survey\* OR "time series" OR "Tobit model\*" OR "treatment group\*" OR trial OR "two group\*") AND PUBYEAR > 1999 AND NOT SUBJAREA(bioc OR ceng OR CHEM OR dent OR eart OR ener OR heal OR immu OR mate OR math OR medi OR neur OR nurs OR phar OR phys))

### III.II.III. Final version Web of Knowledge

#### Final query

The final query used is a combination of all five components below using the 'AND' Boolean operator, yielding the following query.

Results: 2489

#5 AND #4 AND #3 AND #2 AND #1

*Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH Timespan=All Years*

#### Individual queries

#1 (ICT)

Results: 347,458

(TI=("electronic access\*" OR "electronic applica\*" OR "electronic communicat\*" OR "electronic exchang\*" OR "electronic messag\*" OR "electronic mail" OR "electronic service\*" OR "electronic web\*" OR mobile& OR "information access\*" OR "information applica\*" OR "information communicat\*" OR "information device\*" OR "information exchang\*" OR "information messag\*" OR "information mail" OR "information service\*" OR "information techn\*" OR "information web\*" OR c4d OR "development informatics" OR "e-development" OR iar4d OR iard OR icm4ard OR ict4d OR ict4p OR ict4rd OR ict4d OR it4d OR m4d OR apps OR broadband OR "cellular phon\*" OR digital OR e\*mail OR e\*service OR "global positioning system\*" OR gps OR gsm OR "handheld device\*" OR handset\* OR ict OR "instant messag\*" OR internet OR "land lin\*" OR laptop OR microcomp\* OR pda OR \*phone OR phone\* OR radio OR satellit\* OR sms OR tablet\* OR tele\* OR "text messag\*" OR web\*based OR web\*delivered OR wireless) AND PY=(2000-2013)) AND Language=(English)

*Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH Timespan=All Years*

#2 (Development)

Results: 1,404,198

(TS=("developing area\*" OR "disadvantaged area\*" OR "emerging area\*" OR "impoverished area\*" OR "lami area\*" OR "less developed area\*" OR "lesser developed area\*" OR "low developed area\*" OR "lower developed area\*" OR "low income area\*" OR "lower income area\*" OR "middle income area\*" OR "poor area\*" OR "remote area\*" OR "rural area\*" OR "transitional area\*" OR "under-

developed area\*" OR "under-served area\*" OR "developing countr\*" OR "disadvantaged countr\*" OR "emerging countr\*" OR "impoverished countr\*" OR "lami countr\*" OR "less developed countr\*" OR "lesser developed countr\*" OR "low developed countr\*" OR "lower developed countr\*" OR "low income countr\*" OR "lower income countr\*" OR "middle income countr\*" OR "poor countr\*" OR "remote countr\*" OR "rural countr\*" OR "transitional countr\*" OR "under-developed countr\*" OR "under-served countr\*" OR "developing econom\*" OR "disadvantaged econom\*" OR "emerging econom\*" OR "impoverished econom\*" OR "lami econom\*" OR "less developed econom\*" OR "lesser developed econom\*" OR "low developed econom\*" OR "lower developed econom\*" OR "low income econom\*" OR "lower income econom\*" OR "middle income econom\*" OR "poor econom\*" OR "remote econom\*" OR "rural econom\*" OR "transitional econom\*" OR "under-developed econom\*" OR "under-served econom\*" OR "developing nation\*" OR "disadvantaged nation\*" OR "emerging nation\*" OR "impoverished nation\*" OR "lami nation\*" OR "less developed nation\*" OR "lesser developed nation\*" OR "low developed nation\*" OR "lower developed nation\*" OR "low income nation\*" OR "lower income nation\*" OR "middle income nation\*" OR "poor nation\*" OR "remote nation\*" OR "rural nation\*" OR "transitional nation\*" OR "under-developed nation\*" OR "under-served nation\*" OR "developing people" OR "disadvantaged people" OR "emerging people" OR "impoverished people" OR "lami people" OR "less\* developed people" OR "low\* developed people" OR "low\* income people" OR "middle income people" OR "poor\* people" OR "remote people" OR "rural people" OR "transitional people" OR "under\*developed people" OR "under\*served people" OR "developing place\*" OR "disadvantaged place\*" OR "emerging place\*" OR "impoverished place\*" OR "lami place\*" OR "less developed place\*" OR "lesser developed place\*" OR "low developed place\*" OR "lower developed place\*" OR "low income place\*" OR "lower income place\*" OR "middle income place\*" OR "poor place\*" OR "remote place\*" OR "rural place\*" OR "transitional place\*" OR "under-developed place\*" OR "under-served place\*" OR "developing population\*" OR "disadvantaged population\*" OR "emerging population\*" OR "impoverished population\*" OR "lami population\*" OR "less developed population\*" OR "lesser developed population\*" OR "low developed population\*" OR "lower developed population\*" OR "low income population\*" OR "lower income population\*" OR "middle income population\*" OR "poor population\*" OR "remote population\*" OR "rural population\*" OR "transitional population\*" OR "under-developed population\*" OR "under-served population\*" OR "developing region\*" OR "disadvantaged region\*" OR "emerging region\*" OR "impoverished region\*" OR "lami region\*" OR "less developed region\*" OR "lesser developed region\*" OR "low developed region\*" OR "lower developed region\*" OR "low income region\*" OR "lower income region\*" OR "middle income region\*" OR "poor region\*" OR "remote region\*" OR "rural region\*" OR "transitional region\*" OR "under-developed region\*" OR "under-served region\*" OR "developing world" OR "disadvantaged world" OR "emerging world" OR "impoverished world" OR "lami world" OR "less\* developed world" OR "low\* developed world" OR "low\* income world" OR "middle income world" OR "poor\* world" OR "remote world" OR "rural world" OR "transitional world" OR "under\*developed world" OR "under\*served world" OR destitute OR "develop\* aid" OR "development goal\*" OR "economic development" OR famin\* OR "human development" OR "international development" OR "low gross national" OR lmic\* OR "low\* GDP" OR "low\* income" OR minorit\* OR penurious OR poverty\* OR "third world" OR afric\* OR asi\* OR caribb\* OR "Central Americ\*" OR "Latin Americ\*" OR sahara\* OR "South Americ\*" OR "south\*country" OR "West Indi\*" OR "third world" OR afric\* OR asi\* OR caribb\* OR "Central Americ\*" OR "Latin Americ\*" OR sahara\* OR "South Americ\*" OR "south\*country" OR "West Indi\*" OR afghanistan OR bangladesh OR benin OR "Burkina Faso" OR burundi OR cambodia OR "Central African Republic" OR chad OR



comoros OR congo OR eritrea OR ethiopia OR gambia OR guinea OR haiti OR kenya OR korea OR "Kyrgyz Republic" OR liberia OR madagascar OR malawi OR mali OR mauritania OR mozambique OR myanmar OR nepal OR niger OR rwanada OR "Sierra Leone" OR somalia OR tajikistan OR tanzania OR togo OR uganda OR zimbabwe OR albania OR armenia OR belize OR bhutan OR bolivia OR cameroon OR "Cape Verde" OR congo OR "Côte d'Ivoire" OR djibouti OR egypt OR salvador OR fiji OR georgia OR ghana OR guatemala OR guyana OR honduras OR indonesia OR india OR iraq OR kiribati OR kosovo OR lao OR lesotho OR marshall OR islands OR micronesia OR moldova OR mongolia OR morocco OR nicaragua OR nigeria OR pakistan OR "Papua New Guinea" OR paraguay OR philippines OR samoa OR "São Tomé and Príncipe" OR senegal OR "Solomon Islands" OR "Sri Lanka" OR sudan OR swaziland OR syria OR "Timor-Leste" OR tonga OR ukraine OR uzbekistan OR vanuatu OR vietnam OR "West Bank" OR gaza OR yemen OR zambia OR angola OR algeria OR samoa OR antigua OR barbuda OR argentina OR azerbaijan OR belarus OR bosnia OR herzegovina OR botswana OR brazil OR bulgaria OR chile OR china OR colombia OR "Costa Rica" OR cuba OR dominica OR "Dominican Republic" OR ecuador OR gabon OR grenada OR iran OR jamaica OR jordan OR kazakhstan OR latvia OR lebanon OR libya OR lithuania OR macedonia OR malaysia OR maldives OR mauritius OR mexico OR montenegro OR namibia OR palau OR panama OR peru OR romania OR russia OR serbia OR seychelles OR "South Africa" OR "St. Lucia" OR "St. Vincent" OR suriname OR thailand OR tunisia OR turkey OR turkmenistan OR tuvalu OR uruguay OR venezuela) AND PY=(2000-2013)) AND Language=(English)

*Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH Timespan=All Years*

### #3 (Agriculture/rural)

Results: 4,819,634

(TS=(agri\* OR agro\* OR animal\* OR "aqua-culture\*" OR \*bean OR bean\* OR camel\* OR cattle OR chicken\* OR commerc\* OR commodit\* OR corn OR cow\* OR credit OR \*crop OR crop\* OR cultivat\* OR dairy\* OR entrepren\* OR \*farm OR farm\* OR feed\* OR financ\* OR \*fish OR fish\* OR \*food OR food\* OR fruit\* OR goat\* OR grain\* OR horti\* OR livestock\* OR meat OR maize OR mari\*culture OR market\* OR "micro-business" OR "micro-enterpr\*" OR "micro-and-small" OR olive OR organic OR pastoral\* OR \*pond OR potato OR poultr\* OR property\* OR protein OR \*seed OR seed\* OR sheep\* OR sme? OR "small-business" OR "small-enterpr\*" OR smallhold\* OR "small-hold\*" OR soil OR sugar\* OR "supply chain\*" OR trade\* OR \*traders OR \*trading OR transaction OR tomat\* OR "value chain\*" OR vegetab\* OR wheat) AND PY=(2000-2013)) AND Language=(English)

*Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH Timespan=All Years*

### #4 (Effects)

Results: 11,034,680

(TS=(asset\* OR benefit\* OR capital OR consumption OR earning\* OR employ\* OR empower\* OR effect\* OR efficacy OR expenditure\* OR food\* OR impact OR income\* OR inequal\* OR job\* OR livelihood\* OR "living standard\*" OR nutrition\* OR perform\* OR price\* OR productiv\* OR profit\* OR result OR revenue\* OR salar\* OR "transaction costs" OR utility OR wage\* OR wealth OR welfare OR well\*being OR yield\* OR success OR fail\* OR "lesson\* learned") AND PY=(2000-2013)) AND Language=(English)

*Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH Timespan=All Years*

## #5 (Study method)

Results: 11,448,202

(TS=(apprais\* OR assess\* OR baseline OR "before and after" OR coefficient\* OR "co-efficient\*" OR "cohort analy\*" OR "comparative analys\*" OR "comparative design\*" OR "comparative stud\*" OR comparison OR control\* OR counterfactual\* OR covariate OR demonstrat\* OR difference OR econometr\* OR "economic research" OR "equivalent group\*" OR estimat\* OR evaluat\* OR evidence OR experiment\* OR "Heckman model\*" OR "instrumental variable\*" OR intervention\* OR investigat\* OR "kernel matching" OR "least squares" OR "linear probability" OR "log linear" OR "match\* group" OR "matching on observable\*" OR "matching with replacement\*" OR measur\* OR multivariate OR "multi-variate" OR "nearest neighbo\*" OR "non random\*" OR "non-comparison" OR "observational stud\*" OR panel\* OR placebo OR "post test\*" OR "post-intervention" OR posttest\* OR "pre and post" OR "pre post" OR "pre test\*" OR "pre-intervention" OR pretest\* OR "Probit model\*" OR proof OR "propensity score\*" OR "prospective allocation" OR proven OR proving OR psm OR quantitative OR random\* OR rct\* OR regression\* OR "retrospective allocation" OR review OR statistic\* OR stratification OR "stratified matching" OR survey\* OR "time series" OR "Tobit model\*" OR "treatment group\*" OR trial OR "two group\*") AND PY=(2000-2013)) AND Language=(English)

*Databases=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH Timespan=All Years*

## IV. Duplicate removal

Source	Retr.	With.	Net.	Betw.	(New) total
<i>Databases</i>					
Scopus	3094	218	2876	-	2876
Web of Science	2489	8	2481	1091	4266
<i>Publishers</i>					
SAGE	460	0	460	3	4723
TandF	431	47	384	14	5093
Wiley	303	0	303	70	5326
Palgrave	173	0	173	1	5498
Elsevier	51	0	51	7	5542
JSTOR	14	0	14	0	5556
<i>Journals</i>					
EJISDC	80	0	80	0	5636
EJICTHD	24	0	24	0	5660
ITID	50	0	50	2	5708
IJICTDRA	18	0	18	0	5726
AJIC	10	0	10	1	5735
ICTer	6	0	6	0	5741
<i>Totals</i>	7203	273		1189	5741

## V. Summaries of selected studies

### I. National studies

1	Aker, 2010	17	He, Liu, Zheng, & Cui, 2011
2	Alampay, 2006	18	Islam & Grönlund, 2011
3	Aminuzzaman, et al, 2003	19	Jensen, 2007
4	Armstrong, et al, 2012	20	Jiang, Wang, Zhang, & Fu, 2010
5	Beuermann, et al, 2012	21	Katengeza, Kiiza, & Okello, 2011
6	Blumenstock & Eagle, 2010	22	Kiiza & Pederson, 2012
7	Chang & Just, 2009	23	Kuppusamy, Raman, & Lee, 2009
8	Chang & Tuan, 2011	24	Moussa, Otoo, et al, 2011
9	Chong, Galdo, & Torero, 2009	25	M. Muto, 2012
10	Chowdhury, 2006	26	Megumi Muto & Yamano, 2009
11	Fafchamps & Minten, 2012	27	Nazari & Hassan, 2011
12	Futch & McIntosh, 2009	28	Ommani, 2011
13	Gandhi, et al, 2007	29	Svensson & Yanagizawa, 2009
14	Ghosh & Prasad, 2012	30	Zanello, 2012
15	Hashim & Khair Uz, 2010	31	Zhang, Wei, & Feng, 2009
16	Hassan, et al, 2009		

Most of the extracted relationships have been summarized in a figure, except for the mitigating effects of distance to markets in two studies (22 and 25), farm-gate selling (22) and perishability in (25).

1. (Aker, 2010) studied the influence of mobile phones on price dispersion in grain markets in Niger by combining market price information with panel data of traders and transporters (n=415). In a so called difference-in-difference analysis while controlling for possible confounding variables she found that mobile phone introduction led to a reduction in price dispersion across markets of somewhere between 10 and 16 percent.
2. (Alampay, 2006) studied ICT use (various technologies) in the Philippines by comparing a rural and an urban community (n≈250 for each community). He found that some less densely populated areas with geophysical barriers tended to have less access to ICTs due to infrastructural problems. Overall significant factors for ICT use were the level of education, age, and income of the respondents. Regarding gender, he found difference only on one location, where women were more capable than men in the use of cell phone and computers, although he noted that this might be related to higher education levels of the women. Concerning the nature of ICT use, it was found that personal use prevailed over business use, although a clear definition of both was not provided.
3. (Aminuzzaman, Baldersheim, & Jamil, 2003) studied the 'Village Phone scheme', an intervention introduced by the Grameen Bank, a micro-lending institution in Bangladesh. The Village Phone scheme provides mobile phone access by leasing out mobile pay phone sets that the lessee than can exploit. Data was obtained through a survey conducted among operators and users in various locations (n=350). The study found that users of the Village Phone were generally from the younger generation, mostly male (while lessees were generally female) and had an above average education. Impacts were relatively qualitative and self-assessed, and are not taken into

account for further analysis. Advantages mentioned a lot were for example the provision of choices for decision making, strengthening relations with business partners, faster access to information and the creation of new opportunities.

4. (Armstrong, Gandhi, & Lanjekar, 2012) studied the influence of ICT for access to information for farmers in India (n=100). They found no clear relationship between age and ICT use. For education also no significant correlation was found, while income and ICT did significantly correlate.
5. (Beuermann, McKelvey, & Vakis, 2012) estimated effects of mobile phone coverage on measures of household wellbeing in Peru (n=45,401). They found that mobile phone coverage increased cell phone ownership and utilisation (measured by expenditures). Wellbeing was measured by household expenditures. It was found that mobile phone coverage (and use) led to significantly increased expenditures on health, transportation and general consumption, while poverty incidence was found to decrease.
6. (Blumenstock & Eagle, 2010) studied mobile use in Rwanda by comparing mobile phone users to the population at large (n=901). They found that phone users tended to be male, better educated, and wealthier than the population at large, and that richer phone owners generally used their phone more.
7. (Chang & Just, 2009) studied internet use and effects for farm households in Taiwan by conducting relatively rigorous econometric analyses on data from a yearly conducted external household survey (n=1131). They found that internet use was higher among households with higher income and educational achievements. It was also found that age was positively correlated with internet use, while the presence of elderly (65+) was related to a decrease. Also internet use was found to be higher in urban locations compared to rural ones. It was also found that internet use was likely to have led to increased income, although the authors issued a (general) warning for model misspecification in such the type of analyses.
8. (Chang & Tuan, 2011) studied green bean producers in the Dakar region in Senegal (n=144). In their sample, various ICTS were used, with respectively mobile phones, telecentre, landline and radio being the most popular technologies. As mobile phones had a near full adoption rate under the green bean producers, the technology found uninfluenced by social-demographic characteristics. Regarding the other technologies, radio was found to be particularly popular by older generations, while TV was used more by younger, female respondents. ICT was also related to perceived marketing risks, concluding that *usage of radio and TV both showed negative relationship with most of marketing risks and information needs*. However, this analysis was not particularly strong as no control was applied for confounding factors such as corporation/association members, hence this analysis was not taken into account.
  - Radio: users: older, lower education, association members, not relevant: gender,
  - TV: female, younger
  - Telephone: younger, education, non-association members, not: gender
  - Telecentre: not: age, gender, education, membership
9. (Chong, Galdo, & Torero, 2009) studied the income effect of pay-phones in rural areas in Peru by making use of a quasi-natural experiment by means of statistical analysis and propensity score matching (n=1000). They found significant positive effects on both farm and non-farm income of over 15 percent.

10. (Chowdhury, 2006) studied the effect of phone access on market participation for farmers in Bangladesh. They used statistical techniques on data from a household survey (n=284). They found a significant effect of 14%, but noted the possibility of omitted variable bias.
11. (Fafchamps & Minten, 2012) studied Reuters Market Light, an sms-based agricultural information service. They noted that initially interest in and subsequently uptake of the service was relatively low. Concerning effects, interestingly no significant effect on prices was found. The service did however seem to have increased access to wholesale markets, while farm-gate selling was reduced. It was concluded that although the service did not translate into higher prices for sellers, it did seem to have increased arbitrage across markets. Apart from that, no effects were found on changes in farming practices, transaction costs and value-added.
12. (Futch & McIntosh, 2009) – similar to (Aminuzzaman et al., 2003) – studied the Grameen Bank's Village Phone project, but focused on Rwanda instead of Bangladesh. They used household surveys (n=382) to measure the effect of the intervention. Although a randomized study design was intended, it turned out that operators with larger businesses in more attractive markets were more likely to receive the intervention than smaller groups with possible repayment problems, and so randomization failed. Study results indicated increased phone access and as result of the intervention, leading to a (self-reported) improvement in the arrangement of transportation to markets and reduction in travel time and distance. For trade volume and price, positive difference-in-difference point estimates were reported, but these did not prove to be statistically significant. It was noted that the lack of effects might be caused interlinkage of credit provision by established buyers which presented sellers from realizing higher prices. Another potentially mitigating factor was found selection bias of the intervention towards more efficient markets with less potential for further improvement. Finally the presence of a similar product (Tuvugane) that potentially had already realised the expected benefits was noted.
13. (Gandhi, Veeraraghavan, Toyama, & Ramprasad, 2007) studied the effect of Digital Green – a video based extension service – on adoption of improved agricultural practices. Digital Green is based on the production and use of locally created content for dissemination and training of agricultural practices. The study reported that although there generally was little variation in the types of practices adopted between the intervention and control groups, adoption levels were significantly higher for participants receiving the intervention (85% versus 11%).
14. (Ghosh & Prasad, 2012) analysed annual data on telephone connections and economic activity from India for cointegration and Granger causality. The study found no long term relationships, but did discover a short-term Granger causality from telephone connections to economic growth.
15. (Hashim & Khair Uz, 2010) studied ICT investment effects in Pakistan using time series data over the period 1950-2007. The study is not the strongest of its kind as telecommunication investment is proxied by investment in the "transport and communication sector" and there is a significant risk of omitted variable bias. The study did however conclude to have found a significant effect of ICT investment on domestic trade and an ever stronger one on foreign trade.
16. (Hassan, Hassan, Shaffril, & d'Silva, 2009) focused on the barriers Malaysian agro-based entrepreneurs experienced in using ICTs (n=450). The problems reported basically related lack of knowledge and experience regarding ICTs and their potential benefits. It was found that older respondents (especially those older than 51) experienced more ICT-related difficulties. Respondent education achievement was also found to be of influence, with better education related to less barriers and higher ICT usage. Similarly, a higher income could be related to higher ICT use.

17. (He, Liu, Zheng, & Cui, 2011) researched the effects of ICT on agricultural growth in China using panel data for 1999-2006 to correlate ICT investment and physical and social capital with the agricultural component of GDP. Despite a relatively high risk of omitted variable bias, the study claimed significant impact of ICT and agricultural growth.
18. (Islam & Grönlund, 2011) studied mobile ownership and use among farmers in rural Bangladesh (n=420). They found no statistically significant relationship between income or land size and mobile phone ownership, noting that even the poorest people had mobile phones. Education was also found an insignificant predictor. Age was however found to be a strong indicator of phone ownerships, with younger people significantly more likely to have one, as were families with more children. One a more qualitative note it was found that SMS use was relatively low as it was found unreliable since messages often failed to reach intended recipients.
19. (Jensen, 2007) concerned himself with the impacts of mobile phone introduction among fishers in India (Kerala). In a rigorous analysis based on microlevel data from a survey, he found that the use of mobile phones led to reduced price dispersion across markets and convergence to the 'law of one price'. Simultaneously, waste was eliminated and welfare of both producers and consumers was found to have increased.
20. (Jiang, Wang, Zhang, & Fu, 2010) studied the willingness to pay for an agricultural information service among 293 farmers in China. They found that farmers with a higher education were more willing to pay for the service. Such positive relationship was also found for farmer income, agricultural production and land holdings. Although not entirely similar, the 'willingness to pay' concept is taken as 'ICT use' for this analysis.
21. (Katengeza, Kiiza, & Okello, 2011) investigated the effect of market information systems (MIS) and market integration in Malawi. It was found that the introduction of the Malawi agricultural commodity exchange in 2004 resulted in better integration of spatially distanced markets when measured by price movements between markets.
22. (Kiiza & Pederson, 2012) focused on the relationships between market information systems (MIS) and adoption of improved seed for farmers in Uganda (n=1206). It was found that adoption of market information systems was higher for farmers that sold their products through markets versus those selling at the farm-gate. Adoption was also found more likely for farmers with access to (micro-) finance, those with higher household wealth, and those participating in farmer groups or cooperatives. Distance to markets was found to be negatively related to adoption of market information systems. Education was not found to be significant for adoption, while higher age was linked to a negative effect. Adoption of the MIS was related to a significantly higher use of improved seeds, and through that on higher farm returns.
23. (Kuppusamy, Raman, & Lee, 2009) looked at effects of ICT investment (as proxy for ICT use) in Malaysia between 1995 and 2006 using an autoregressive distributed lag econometric model on time series data. They found significant private sector effects in the manufacturing and wholesale sector over both long and short run, while for both the agricultural and government sector no significant relationships were found.
24. (Moussa, Otoo, Fulton, & Lowenberg-Deboer, 2011) examined the effects of radio broadcasting on uptake of agricultural extension (an improved storage method for cowpeas) in Niger and Burkina Faso (n=2381). They compared demonstration with and without enforcement by radio broadcasts, and found significant effect, even more so for women and younger people.
25. (M. Muto, 2012) studied the effect of mobile phones on rural-to-urban migration (n=856). He found a significant increase in the chance of job oriented rural-to-urban migration when related

to the possession of a mobile phone. Possession of mobile phones was found to be related to education level and asset value. According to the authors, such increase in non-agricultural employment could be considered beneficial in poverty reduction.

26. (Megumi Muto & Yamano, 2009) used panel data (n=856) to study the effects of mobile access on marketing of agricultural commodities. They found household assets and education levels to be significantly related to mobile phone possession, while age was negatively related. They found positive effects on market participation at the community level for banana producing households in rural areas living at greater distance to markets. For maize – which is less perishable than bananas, no effects were found. The authors concluded that overall effects are more significant for producers of perishable crops in more remote areas.
27. (Nazari & Hassan, 2011) investigated the educational role of television in improving farmers' knowledge in Iran (n=161). They found significant increase in knowledge from agricultural TV broadcasts.
28. (Ommani, 2011) studied ICT use among farmers in Iran (n=181). They found positive correlations between ICT use and respondent income and education level, as well as with self-reported ICT skills and social participation. However, social participation and ICT use might well be indicators of the same underlying factors (e.g. information needs, outgoing character, etc.) and is therefore not used for further analysis.
29. (Svensson & Yanagizawa, 2009) studied the effect of a radio based market information system in Uganda, by exploiting variations between households with and without radio access, based on a household surveys. They found a positive effect of the service (proxied by radio access) of 15% on farm-gate prices, which was ascribed to better bargaining positions for the respective farmers.
30. (Zanello, 2012) focused on the effects of mobile phone and radio use on market participation and transaction costs in northern Ghana by analysing household data (n=393) for farmers on ICT usage and market transactions. A division was made between producers with a deficit and a surplus for food. They found that receiving price information generally increased market participation for buyers and sellers. However, using mobile phones was related to increases in market intensity while quantity traded was reduced. Radio use was related to an increase in quantity traded. According to the authors, [m]obile phones seem to be more effective in encouraging entry to the market, reducing search costs, whereas listening to market information on the radio seems to influence the quantity traded and affect the patterns of purchases and sales. The noted that mobile phones might enable a more pro-active approach, while radio does not always offer exactly the information required.
31. (Zhang, Wei, & Feng, 2009) studied the effects of internet permeability (the ratio of internet users in the total population) in China by means of econometric modelling. By testing data from the China Internet Development Statistical Report 2004 for Granger causality, they found positive effects from internet use (and education) on GDP, and vice versa. Based on that conclusion they advised to minimize regional imbalances in internet availability.



## II. Supranational studies

The included studies analysing at a multi-country level were coded according to the table beneath. A brief summary of the studies is provided below the table:

a	Agüero, Urteaga, & Maria, 2011	o	Gomez, 2013
b	Badran & Badran, 2011	p	Hosman, Fife, & Armeiy, 2008
c	Bagchi, Solis, & Gemoets, 2003	q	Levendis & Lee, 2012
d	Bakay, Okafor, & Ujah, 2011	r	Lio & Liu, 2006
e	Baliamoune-Lutz, 2003	s	May, 2012
f	Bankole, Shirazi, & Brown, 2011	t	Močnik, 2010
g	Bollou, 2006	u	Morawczynski & Ngwenyama, 2007
h	Chabossou, et al., 2009	v	Samoilenko, 2013
i	Chavula, 2012	w	Seo & Lee, 2006
j	Clarke & Wallsten, 2006	x	Shamim, 2007
k	Dimelis & Papaioannou, 2010	y	Silva, Ratnadiwakara, & Zainudeen, 2009
l	Djiofack-Zebaze & Keck, 2009	z	Soper, Demirkan, Goul, & Louis, 2006
m	Dutta, 2001	aa	Zainudeen, 2011
n	Gholami, Guo, Higón, & Lee, 2009		

- A. (Agüero, Urteaga, & Maria, 2011) analysed mobile phone expenditures in six Asian countries (Bangladesh, Pakistan, India, Sri Lanka, the Philippines, and Thailand) using data from a sample of 9,540 poor mobile phone users collected in 2008. They found that the poorest quintile of each country spent over 20% of their income on mobile services. Using Engel curves to estimate income elasticity of mobile services it was concluded that that expenditures these services are highly inelastic to income and therefore constitute a necessity.
- B. (Badran & Badran, 2011) analysed the relation between broadband internet and economic growth in 22 emerging countries (Algeria, Argentina, Bahrain, Brazil, Colombia, Jordan Kuwait, Lebanon, Malaysia, Mexico, Morocco, Oman, Qatar, Russia, Saudi Arabia, Syria, Tunisia, Turkey, Egypt, UAE, Venezuela, and Uruguay) over 1998-2008. Using an augmented Solow model for estimation, they found a positive effect of broadband penetration on economic growth, while telecom investment was not found to be significant (which was explained by a possible lag or lack of critical mass).
- C. (Bagchi, Solis, & Gemoets, 2003) studied cell phone adoption in Latin America and the Caribbean by conducting pooled regressions on data over 1989-1999. The study found significant economic growth effects from the adoption of cell phone and landline phones, which became stronger as diffusion increased (following a so called Gompertz curve). It was also found that cell phones were adopted faster than telephones. It should however be noted that the study hardly controls for additional variables, and hence is at significant risk of suffering from omitted variable bias.
- D. (Bakay, Okafor, & Ujah, 2011) investigated what factors drove ICT diffusion in Latin America between 2004 and 2008. Using the ICT readiness index as a proxy for ICT diffusion (which could be considered a debatable choice), they found significant relations between ICT adoption and the relative amount of youth in the population, per capita income, literacy levels (which were higher in urban areas) and ICT expenditure. No significant relations between ICT readiness and income inequality and annual GDP growth rates (instead of GDP levels) were found.

- E. (Baliamoune-Lutz, 2003) studied ICT diffusion (based on data on the use of cell phones, internet hosts and users, and computers) in 47 developing countries between 1998 and 2000. They found income to be a determinant of ICT uptake, although effects were mild for mobile phones and internet hosts. Government trade policies (openness of trade) were also found to be related to ICT diffusion, as were political rights and civil liberties. Most relationships were found to run the other way as well, with ICT use enhancing economic development, political rights and civil liberties. Education was however not found to be significantly related to or influenced by ICT uptake.
- F. (Bankole, Shirazi, & Brown, 2011) studied the effect of ICT investments on the human development index in 51 low, middle and high income countries. Although suffering from potential omitted variable bias, the authors established significant effects of ICT investment on GDP across all country types, as well as on education.
- G. (Bollou, 2006) researched total factor productivity in the ICT sector in West Africa between 1995 and 2002. They found a connection between ITC investment and total factor productivity, but noted that it was on decline, possibly due to exogenous factors such as education (or variables not included).
- H. (Chabossou, Stork, Stork, & Zahonogo, 2009) used a household survey on 17 African countries to investigate ICT adoption. They found income and education to be of significant influence, while no such relationship was found for gender, age and social network membership. Mobile expenditure was however found to be relatively inelastic to income.
- I. (Chavula, 2012) studied the effects of internet use on per capita income in 49 African countries. They found significant impact on economic growth of fixed telephony and internet usage for upper-middle-income countries, and an even stronger growth effect from mobile telephone use for both upper-middle, upper-low and low-income countries. As hardly any additional factors were taken into account, the findings are however subject to significant risk of omitted variable bias.
- J. (Clarke & Wallsten, 2006) examined the effect of internet penetration on international trade for developing countries. Testing for causality, they found that increased penetration could be related to higher exports to developed countries, but found no such effect on trade with other developing countries.
- K. (Dimelis & Papaioannou, 2010) compared 42 developing and developed countries over the 1993-2001 period. They found a positive effect of ICT on economic growth for all country groups, although the effect was stronger for developing countries.
- L. (Djiofack-Zebaze & Keck, 2009) conducted regressions over a panelled dataset of 177 countries over a 7-year period starting in 1997 to study the effects of mobile phone use. They found that increased access to mobile networks resulted in significant increases in GDP.
- M. (Dutta, 2001) examined the direction of causality between telecommunications infrastructure and GDP growth for thirty developing and developed countries over a 24-year period. Reasonable evidence was found for an influence from telecom infrastructure to economic activity, while for a reversed relationship only limited evidence was identified.
- N. (Gholami, Guo, Higón, & Lee, 2009) uses panel data on 37 countries from 1996 to 2004 to study ICT spillovers by estimating a Cobb-Douglas functional form model. The study found that ICT spillover effects from developed to developing countries are higher for recipient countries with a higher internet penetration rate. This means that developing countries can benefit from ICT capital of developed ones, and more so when internet use in the country is higher.

- O. (Gomez, 2013) studied data on public access computing (e.g. telecenters and cybercafés) in 25 developing countries. The study is one in a broader set using the same, rather extensive set of data. The statistical analyses conducted are however not the most extensive ones possible. Apart from some more qualitative findings on ICT project success factors, the study reports that users generally are relatively young (hardly any elderly were found to use the facilities), medium educated (illiteracy and absence of education hardly occur in the data), and have moderate incomes (higher incomes probably buy their own equipment instead of using public access facilities). Education (30%), personal needs (25%) and entertainment (19%) are the most pressing (self-reported) information needs; information about jobs, health, government services or agriculture scored significantly lower (under 10%).
- P. (Hosman, Fife, & Armev, 2008) used generalized method of moment estimates to investigate the effects of ICT expenditure on GDP growth in 42 developing countries. They found a relatively low but significant exogenous effect of ICT investment on the GDP growth rate, controlling for inflation, education and openness of trade.
- Q. (Levendis & Lee, 2012) studied the impact of mobile and fixed telephones on economic growth in 29 Asian countries for 1981 to 2006 by estimating regression models while paying particular attention to endogeneity of variables. They found significant positive impact from telecom on economic growth, with impact increasing with higher levels of telephone penetration; suggesting that *“more phones, more growth” should actually state “more phones, even higher growth”*. Additionally, returns on ICT were found to be significantly higher for richer countries than for poorer countries.
- R. (Lio & Liu, 2006) used data over the period 1995-2000 for 81 high, higher-middle, lower-middle and low-income countries to examine the relationships between ICT adoption and agricultural productivity. They found that ICT matters in explaining the differences in agricultural productivity across countries. According to them, *the result implies that a smaller amount of labor, livestock, machinery, and fertilizer can produce the same level of agricultural output if these inputs are used within a better information and communication infrastructure*.
- S. (May, 2012) studied ICT access in four East African countries (Kenya, Rwanda, Tanzania and Uganda). According to them, *[w]hen looking at the full sample, households without ICT are poorer in all dimensions than those with ICT, particularly in respect of education, services and economic assets. When only households below an income poverty line are considered, these gaps disappear, leaving only education as the major difference between those with ICT and those without. A multivariate analysis confirms the importance of formal education, but not surprisingly suggests that there is also an interaction between education and income, and that this enhances ICT access. A three-dimensional plot of the data shows that while additional units of education and income increases the probability of ICT access, the slope is far steeper when these are combined*.
- T. (Močnik, 2010) examined socio-economic factors related to internet use in a cross-country analysis by performing factor analysis and multiple regressions on 31 datasets for 182 low, middle and high income group countries. For low income countries, the factors most significant for internet use were found to be literacy rate, age, schooling and the number of telephone lines. For lower middle income countries the same factors were found of significance, supplemented by the number of computers and income. Population density, unemployment and usage costs were found not to be of relevance. As the number of phone lines was already included, it is not

greatly surprising that population density was (no longer) found relevant as this factor likely covariates with the number of phone lines in an area.

- U. (Morawczynski & Ngwenyama, 2007) used multivariate adaptive regression splines to explore relationships between ICT investments, healthcare, education and GDP in Benin, Cameroon, Senegal, Ivory Coast and Niger. They found ICT investment to be a significant predictor of GDP growth, with education and health care investment as a mitigating factor. ICT was found to be related to literacy rates, but so were education and healthcare. The outcomes regarding health care investments are somewhat remarkable introducing suspicion of model misspecification or omitted variable bias.
- V. (Samoilenko, 2013) investigated the micro-economic impact of telecom investments by using structural equation modelling on a data set containing 18 transition economies (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovenia, Slovakia, Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Kazakhstan, Kyrgyz Republic, Moldova, Romania, Ukraine) over the period from 2003 to 2008. The results suggest that regardless of the level of economic development, investments in telecoms tend to decrease prices of telecom products, and that the reduction in purchase prices leads to a reduction in the cost of usage of telecom products. Another important finding is that a lower cost of usage (e.g. subscription fee, contracts, etc.) of telecom products leads to an increase in levels of international trade participation, disposable income, and labor market participation, the factors which serve as microeconomic precursors of macroeconomic outcomes (e.g. GDP).
- W. (Seo & Lee, 2006) studied the relationship between ICT investment and total factor productivity in 38 countries (of which 16 non-OECD members) using pooled time-series data for 1992-1996. For non-OECD countries, no significant relation was found between ICT investment and total factor productivity. This might be related to the relatively early period of analysis, where investment did not reach a threshold level required for effects, or lack of complementary factors such as human capital. Additionally, significant externalities were found from ICT investments in OECD countries increasing total factor productivity in non-OECD countries.
- X. (Shamim, 2007) researched relationships between the ICT and financial sectors and economic growth for the period 1990-2002 in 61 developed, emerging and developing countries. ICT was measured by four variables (mobile subscriptions, computers, internet use and internet hosts per 100 inhabitants). Although additional variable inclusion is limited (increasing risk of omitted variable bias), the study did test for Granger causality. The study found that ICT use – especially internet and mobile phone use – significantly enhance financial depth (the ratio of financial sector liquid liabilities to GDP), and through that channel stimulated economic growth.
- Y. (Silva, Ratnadiwakara, & Zainudeen, 2009) studied mobile phone adoption among bottom of the pyramid (BoP) users in Bangladesh, Pakistan, India, Sri Lanka, the Philippines, and Thailand. The study found that mobile phone adoptors (owners –instead of use or users) at the BoP are more likely to be younger, male, have a higher relative income and usually a secondary education, and with most of their closest contacts already having phones of their own (the latter of which can potentially be related to a network externalities effect). It was also found that living near a town with electricity access was related to higher mobile use.
- Z. (Soper, Demirkan, Goul, & Louis, 2006) studied the effect of ICT expenditures on institutionalized democracy and foreign direct investment over a five year period (1998-2003) by estimating least-squares regression models with time lags. They found significant effects from ICT expenditures

on both dependent variables starting after a 1-year incubation period. The study might however suffer from omitted variable bias.

AA. (Zainudeen, 2011) studied the adoption of 'more-than-voice' services among 'bottom-of-the-pyramid' mobile phone users in six countries in emerging Asia. According to the authors, more-than-voice refers to services and applications accessible through mobile phones beyond voice and peer-to-peer SMS. Examples include mobile money services, government services, agricultural information services, social networking services, and so on. Results indicated that use of the targeted services among the poor population was relatively low, and practically absent in three of the six countries. Therefore use was only studied for Sri Lanka, the Philippines and Thailand, based on 393 users. It was found that those that did use more-than-voice services generally were younger, better educated, had more contacts and had been using mobile phones for a longer period than non-users, while females had a slightly lower chance of using such services than males.

## VI. Data extraction

### III. Local focused studies

Author	Year	Sample	Area	Participants	Technology	Collection	Method	Weakness
Aker, J. C.	2010	415	Niger	Traders	Mobile	1996-2006	DiD	none
Alampay, E. A.	2006	515	Phillipines	Villagers	Various	2004	Statistical	-
Aminuzzaman, S.	2003	350	Bangladesh	Rural pop.	Mobile	1999-2000	Statistical	Self reported
Armstrong, L. J.	2012	100	India	Farmers	Broad	unclear	Statistical	-
Beuermann D.	2012	45,401	Peru	Rural pop.	Mobile	2004-2009	Regression	Omitted var.
Blumenstock, J.	2010	901	Rwanda	Cell users	Mobile	2009	Statistical	-
Chang, H.H.	2009	1,131	Taiwan	Farmers	Internet	2004	Regression	-
Chang, W. I.	2011	144	Senegal	Producers	Market info	2006	Statistical	-
Chong, A.	2009	1,000	Peru	Rural pop.	Phone	unclear	Control	-
Chowdhury, S. K.	2006	284	Bangladesh	Farmers	Phone	2001	Regression	-
Fafchamps, M.	2012	933	India	Farmers	Reuters	2006-2007	RCT	-
Futch, M.	2009	382	Rwanda	Villagers	Mobile	2006-2007	DiD	Non-random
Gandhi, R.	2009	236	India	Farmers	Video	2007-2008	RCT	-
Ghosh, S.	2012	external	India	National	Phone	1980-2007	ARDL	-
Hashim, S.	2010	external	Pakistan	National	Broad	1950-2007	Regression	Proxy for ICT
Hassan, M. A.	2009	450	Malaysia	Agro-sector	Broad	2007-2008	Statistical	-
He, P.	2011	external	China	Agro-sector	Broad	1999-2006	Regression	-
Islam, M. S.	2011	420	Bangladesh	Farmers	Mobile	2007-2008	Regression	-
Jensen, R.	2007	300	India	Fishers	Mobile	1996-2001	Regression	-
Jiang, Y.	2010	293	China	Farmers	Mobile	unclear	Regression	-
Katengeza S.	2011	market	Malawi	Market prices	Market info	1994-2007	statistical	-
Kiiza, B.	2012	1,206	Uganda	Farmers	Various	unclear	Probit	-
Kuppusamy, M.	2009	external	Malaysia	National	Broad	1992-2006	ARDL	Omitted var.
Moussa, B.	2011	2,381	Niger, Burk.F.	Farmers	Radio	unclear	Logistic	-
Muto, M.	2012	856	Uganda	Broad pop.	Mobile	unclear	Regression	-
Muto, M.	2009	856	Uganda	Farmers	Mobile	unclear	Regression	-
Nazari, M. R.	2011	161	Iran	Farmers	Television	unclear	Pre-post	-
Ommani, A. R.	2011	181	Iran	Farmers	Various	unclear	Statistical	-
Svensson, J.	2009	external	Uganda	Traders	Radio	2004-2005	DiD	-
Zanello, G.	2012	393	Ghana	Farmers	mobile pho	2009-2010	Regression	-
Zhang, M. H.	2009	external	China	National	Internet	2004	Granger	-

## IV. Supranational studies

Author	Year	Sample	Area	Participants	Technology	Collection	Method	Weakness
Agüero, A.	2011	9,540	6 countries		Mobile	2008	Regression	Omitted var.
Badran, M. F.	2011	external	22 countries		Internet (br	1998-2008	Regression	Omitted var.
Bagchi, K.	2003	external	Lat-Am		Phone; cell	1989-1999	Regression	Omitted var.
Bakay, A.	2011	external	Lat-Am		Various (IC	2004-2008	Regression	-
Bali moune-Lutz,	2003	external	47 countries		Various (in	1998-2000	Regression	-
Bankole, F. O.	2011	external	51 countries		Various	1994-2003	SEM	-
Bollou, F.	2008	external	6 African		Various	1995-2002	Regression	Omitted var.
Chabossou, A.	2009	external	17 African		Mobile pho	2007-2008	Statistical (-	
Chavula H. K.	2012	external	49 countries		Various	1990-2007	Regression	Omitted var.
Clarke, G. R. G.	2006	external	98 countries		Internet	2001	Regression	-
Dimelis, S. P.	2010	external	42 countries		Various	1993-2001	Regression	-
Djiofack-Zebaze, C	2009	external	177 countries		Mobile pho	1997-2003	Regression	-
Dutta, A.	2001	external	30 countries		Landline ph	1970-1993	Granger	Omitted var.
Gholami, R.	2009	external	37 countries		Various	1996-2004	Regression	Omitted var.
Gomez, R.	2013	25,000	25 countries		Telecentres	2009	Conclusion	-
Hosman, L.	2008	external	42 countries		Broad	2000-2006	Regression	Omitted var.
Levendis, J.	2012	external	29 Asian		Mobile pho	1981-2006	Regression	-
Lio, M.	2006	external	81 countries		Broad	1995-2000	Regression	FGLS
May Julian, D.	2012	8,071	4 African		Various	2007-2010	Statistical (-	
Močnik, D.	2010	external	182 countries		Internet	2004	Regression	-
Morawczynski, O.	2007	external	5 West-Afr.		Telecom	1993-1999	Regression	Omitted var.
Samoilenko S. V.	2013	external	18 transitional		Telecom	2003-2008	SEM	-
Seo, H.-J.	2006	external	38 countries		Broad	1992-1996	Regression	-
Shamim, F.	2007	external	61 countries		Broad	1990-2001	Regression	-
Silva H. D.	2009	9,540	6 Asian		Mobile	2008	Regression	-
Soper, D. S.	2006	319	29 emerging		Broad	1993-2003	Regression	Omitted var.
Zainudeen, A.	2011	2,524	6 Asian		Mobile: mo	2008	Regression	-