Development Policy Review, 2017, 0 (0): 1–22

Connected for Development? Theory and evidence about the impact of Internet technologies on poverty alleviation

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Based on the assumption that increased access to internet services boosts economic growth and improves the well-being of the poor, governments in both developed and emerging regions are heavily investing in internet connectivity projects. This article reviews the existing evidence as to the impact of internet technologies on various development dimensions, and articulates the empirical evidence into an analytical framework that seeks to identify the micro-linkages between internet adoption and poverty alleviation. The review suggests that the development pay-offs of internet technologies are ambiguous due to two interrelated effects. First, because effective appropriation requires a range of skills as well as complementary investment in human capital and organizational changes. This tends to favour well-educated workers and firms with more innovative capacity and access to finance. Second, because the positive effects of internet dissemination on market co-ordination and political institutions grow exponentially with adoption levels. As a result, while the evidence indicates that advanced economies are reaping significant benefits from internet investments, the returns for less advanced economies, and in particular for the fight against poverty in these regions, remain uncertain.

Key words: internet access, poverty, impact evaluation, literature review

1 Introduction

For many years, the so-called 'productivity paradox' puzzled scholars and policy-makers. Originally stated by economist Robert Solow in the late 1980s, the paradox referred to the lack of empirical evidence about the impact of investments in information technology (IT) on firm productivity, and ultimately on aggregate gross domestic product (GDP) growth (Brynjolfsson, 1993). Today, a similar gap between expectations and evidence has emerged with respect to the contribution of internet technologies to development in general, and more specifically to poverty alleviation.

Over the past decade, governments and donors have invested heavily in internet connectivity projects, based on the assumption that increased access to internet services and applications will boost economic growth and improve the well-being of the poor. A 2011 United Nations report calls on governments to invest in

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broadband infrastructure and promote internet adoption in order to achieve the Millennium Development Goals (MDGs) by the target date of 2015, or else 'lose the opportunity to reap the economic and social benefits that broadband brings' (UN Broadband Commission, 2011:1). Yet the existing studies suggests that the relation between internet adoption and poverty is far more complex.

The question has spawned a large body of academic literature and extensive policy debates. The more sceptical (such as Kenny, 2002) argue that there is limited empirical evidence about the positive development impact of internet technologies, suggesting that 'the impact of broadband roll-out on achieving the MDGs would be marginal' (Kenny, 2011:1). Others such as Auriol and González Fanfalone (2014) suggest that the benefit–cost ratio of broadband investments in developing countries is very high, thus making a compelling case for including specific broadband roll-out targets as part of the new SDGs.

Inconclusive evidence has not deterred governments from committing significant resources to internet connectivity initiatives. According to a report by the International Telecommunications Union (ITU, 2013), 134 countries had a national broadband plan in place by early 2013. While some are little more than broad policy strategy documents, others involve significant public investment in infrastructure, applications and training. A good example is Colombia's Vive Digital, an ambitious initiative encompassing the building of a national fibre backbone, internet service subsidies to low-income households, online government services and various information and communications technology (ICT) training programs. The estimated cost tag is $2.25 billion, about 0.6% of Colombia's current GDP.

This article contributes to the debate about the development impact of internet technologies in two fundamental ways. First, it reviews a broad set of studies of the impact of internet diffusion on a number of social and economic dimensions of poverty. The review favours academic studies in peer-reviewed publications that use rigorous impact evaluation techniques, although in some cases high-visibility reports by multilateral agencies and other development actors are also considered. The goal is to scrutinize the existing literature, summarizing findings (what we know) and identifying key opportunities for future research (what we don't know). While the emphasis is on evidence from developing countries, key studies conducted in advanced economies are also discussed.

Second, the article articulates this body of literature into an analytical framework that seeks to conceptualize the micro-linkages between internet diffusion and poverty alleviation. This is an important step forward in our understanding of the internet's role in development. As discussed below, the existing literature provides limited theorization about impact mechanisms. This conceptual gap makes it difficult to disentangle the multiple possibilities that the technology affords. For example, if we assume that internet adopters are on average better off than the rest, is this because they are able to find better jobs, to acquire new skills, to draw on a larger social network for financial support, or perhaps to demand better services from the government? The analytical framework presented in this article draws on the empirical findings from the literature in order to address these fundamental questions.

The article is organized as follows. The next section presents an overview of the available macro-level literature about the impact of internet technologies on aggregate output and employment, and its distributional effects. Next we lay out a conceptual foundation that seeks to establish the micro-linkages between internet adoption and poverty alleviation, and present evidence for the different impact mechanisms in each of the four subsections. The conclusion resumes the broader discussion about the role of internet technologies in development initiatives, and how the existing evidence can serve to better orient their design and implementation.

2 What we know (and don't) about the economic impact of the internet

There is agreement in the development literature that economic growth is the strongest driver of long-term poverty reduction (Barro, 2000; López, 2004; Kraay, 2006). Investments in telecommunications have long been credited with boosting productivity and economic growth (Madden and Savage, 1998; Roller and Waverman, 2001; Datta and Agarwal, 2004). Building on these findings, several scholars have examined the relationship between internet investments and aggregate economic activity. In other words, these studies attempt to establish whether the internet has a positive *growth effect*.

However a more recent development literature suggests that economic growth is not enough for poverty alleviation, particularly in the presence of high levels of inequality, as is the case in most developing countries (Wade, 2004; Krishna, 2005). While the growth effect is deemed stronger, changes in income distribution also have an important effect on poverty reduction (Ravallion, 2004; Cruces and Gasparini, 2013). Based on these findings, a second body of literature has examined the *distributional effect* of internet technologies.

This section reviews the macro-level evidence about the *growth* and *distributional* effects of internet technologies. The review suggests that internet diffusion does promote aggregate output, although the magnitude of the impact for developing countries is significantly more modest than estimated in earlier studies due to a) threshold effects and b) increasing returns to adoption. In contrast, the evidence about *distributional effects* is mixed. While some studies suggest that internet technologies exacerbate inequality through skill-bias effects in labour markets, others indicate that it favours economic integration of isolated areas. Each of these bodies of literature is discussed in more detail below.

2.1 The growth effect of internet technologies

Early enthusiasm about the positive development impact of internet technologies was largely based on a set of high-profile studies released between 2006 and 2009. In one of these studies, Gillett et al. (2006) examine the impact of broadband availability on economic activity in the US at the zip code level. Based on panel data for 1998–2002 and a standard OLS (ordinary least squares) model with controls by zip code, the study finds that the availability of broadband services (regardless of actual adoption) adds as much as 1.4% to the employment growth rate. In a similar study, Crandall et al. (2007) analyze the economic impact of broadband adoption (rather than just availability) in the US at the state level for the 2003–2005 period. The findings suggest that an increase of 1% in a state's broadband penetration yielded an increase of up to 0.3% in the level of employment per year, although no effects are found on GDP growth. However, Mayo and Wallsten (2011) are unable to replicate these results using data for the 2006–2008 period. In fact, in some of their model specifications broadband adoption seems to negatively affect employment and GDP growth. These authors conclude that previous positive results are not robust and are highly sensible to the period of analysis.

Similar panel studies have been conducted with cross-country data. In a much-publicized World Bank report, Qiang and Rossotto (2009) examine the economic impact of several new ICTs with data from 120 countries for the 1980–2006 period. Two findings stand out from this study. First, the positive impact of internet technologies on GDP growth is found to be significantly larger (as much as three times larger) than the impact of other communication technologies, such as fixed and mobile telephony. Second, the economic impact of the internet is found to be larger for middle- and low-income countries than for high-income countries. Specifically, the authors estimate that a 10-point increase in broadband penetration yields a 1.38-point increase in GDP growth for emerging countries (in comparison to a 1.21-point increase for advanced economies). The report unequivocally concludes that 'broadband's benefits are major and robust for both developed and developing countries' (Qiang and Rossotto, 2009: 45).

This first set of studies has well-known limitations, including difficulties in properly identifying causality and attribution problems due to the level of data aggregation (since, for example, people may work in one zip code and live in another). A key concern is the lack of robust techniques to account for reverse causality in panel data regressions. Simply put, given that the decisions to subscribe to internet services by individuals or firms (or to invest in certain areas by service operators) are not random, it is likely that impact estimators are capturing the effect of internet penetration (or availability) on economic growth as well as the effect of economic growth on internet penetration (or availability). Another problem is the limited set of controls for omitted variables (such as better governance) that could simultaneously be causing both increased internet diffusion and economic growth. As a result, the true effect of internet technologies on economic activity tends to be overestimated in these studies.

A study by Koutrompis (2009) was among the first to address these problems and provide more reliable estimates, although it is limited to a sample of 22 OECD countries for the 2002–2007 period. The author captures the two-way relationship between economic growth and internet investments by modelling the supply, the demand and the output of internet investments in three separate models, which are estimated simultaneously with the main regression that captures the impact of internet on GDP growth. The findings indicate, first, that the impact on economic growth is robust, but more modest than previously suggested; and second, that the impact is not linear but rather grows as penetration increases. The study also identifies a critical mass effect, whereby the positive externalities of internet diffusion kick in only after a certain threshold level of adoption.[1] Similar findings are reported by Katz and Koutroumpis (2012), who suggest that the limited contribution of internet technologies to economic growth in Senegal is due to low adoption levels.[2]

Czernich et al. (2011) utilize a different strategy to control for reverse causality in a cross-country panel regression. Using a panel of OECD countries for the 1996–2007 period, the authors start from the assumption that the provision of broadband depends on previous investment in traditional voice telephony and cable TV networks. Therefore, the authors specify a technology diffusion model in which variations in the ceiling of broadband penetration are determined by the availability of pre-existing telecommunications networks, which is used as instrumental variable. The results suggest a strong contribution of broadband to economic growth, projected to be between 0.9 and 1.5 percentage points in additional per capita GDP growth for every 10-point increase in broadband penetration. Yet their results are only statistically significant above the 10% penetration threshold, thus confirming the critical mass effect identified by Koutroumpis (2009).

The studies reviewed above are summarized in Table 1. In general, the results corroborate the positive contribution of internet technologies to aggregate economic growth (the *growth effect*), although the impact in developing contexts is significantly more modest than previously estimated. Moreover, there is agreement about the nonlinearity of the impacts and the presence of threshold effects. In addition, the strongest evidence is based on studies for advanced economies. Whether increased internet access can significantly boost growth (and therefore promote poverty reduction) in countries with a small share of technology-intensive industries and limited technology-absorption capacity by individuals and firms remains largely uncertain.

2.2 The distributional effect of internet technologies

While the debate about the factors that explain recent changes in income distribution is ongoing, the available evidence points to changes in the composition of labour demand as a key factor (for example López-Calva and Lustig, 2010; Autor and Dorn, 2013). Following this hypothesis, several studies have examined the effect on labour demand in order to examine the distributional effects of internet technologies. These studies build on a long research tradition looking at the impact of new technologies – from the steam engine to microchips – on labour markets. Overall, this literature suggests that the relationship is complex and context dependent. Some technologies might help standardize production processes and replace skilled labour, as weaving and spinning machines did in the early days of the industrial revolution (Goldin and Katz, 1998). However, other technologies increase demand for educated workers, thus placing a premium on skilled labour. This

1. According to Koutrompis (2009), after the critical threshold level of 50% household penetration the positive economic impact of broadband doubles relative to lower penetration levels.
2. The result is consistent with studies for other technologies. For example, Gruber and Koutrompis (2011) show that the impact of mobile telecommunications on economic growth is smaller for countries with low levels of mobile telephony penetration.

skill-bias hypothesis was first presented by Autor et al. (1998) in an influential article which argues that much of the rise in wage inequality in the US since the 1970s can be explained by the adoption of computers and related technologies.

Table 1: The *Growth Effect* of internet technologies

Authors	Data	Methodology	Key findings
Gillett et al. (2006).	Panel of US zip codes and counties for 1998–2002.	Instrumental variable regression and matched sample.	Availability of broadband adds between 1–1.4% to growth rate of employment and 0.5–1.2% to growth rate of business establishments.
Crandall et al. (2007).	Panel of US states for 2003–2005.	OLS regression.	A 1% increase in broadband penetration yields an increase of between 0.2–0.3% in employment rate. No effects on GDP growth.
Qiang and Rossotto (2009)	Panel data of 120 countries for 1980–2006.	OLS regression.	For high-income economies: a 10 percentage point (p.p.) increase in broadband penetration yields a 1.21 p.p. of additional GDP growth. For developing countries: a 10 p.p. increase in broadband penetration yields a 1.38 p.p. of additional GDP growth.
Koutroumpis (2009)	Panel of 22 OECD countries for 2002–2007.	Simultaneous equations model with instrumental variable.	A 10% increase in broadband penetration rate increases economic growth by an average of 0.25%.
Czernich et al. (2011).	Panel of 25 OECD countries for 1996–2007.	Instrumental variable regression.	A 10 p.p. increase in broadband penetration raises annual GDP per capita growth by 0.9-1.5 p.p.
Mayo and Wallsten (2011).	Panel of US states for 2006–2008.	OLS regression.	Small negative effect of broadband penetration on GDP growth and employment.

Source: The authors.

The empirical evidence generally suggests that internet diffusion has a positive impact on labour markets regardless of adoption – in other words, that internet technologies have positive externalities, benefiting both adopters and non-adopters.

Yet the evidence also indicates that benefits tend to be disproportionately appropriated by the most skilled workers, who are also more likely to be already employed, thus explaining the lack of consistent effects on aggregate employment found in earlier studies. This is also consistent with recent findings by Autor and Dorn (2013), who suggest that the impact of generic IT investments on wage and employment in advanced economies is U-shaped, with growth at the top and bottom but losses in the middle of the skill distribution.

For example, Atasoy (2013) analyzes the timing of the changes in broadband diffusion and labour market outcomes in the US between 1999 and 2007 using county-level data. She finds that broadband availability is associated with a 1.8-point increase in the county employment rate, and attributes most of this effect to increases in the scale of existing firms. These effects are found to be larger in counties with a larger fraction of college-educated workers, thus confirming that workers with more abilities benefit more from investments in broadband. Yet the study also suggests that broadband availability may be compensating for geographical isolation, as the positive employment effect is found to be significantly larger in rural counties.[3]

The findings by Forman et al. (2012) also suggest a strong complementarity between internet technologies and skilled labour. The authors study employment and wage growth in U.S. counties between 1995 and 2000, and examine whether the observed differences are associated with the intensity of internet investments by local firms. The results reveal a strong skill bias in the employment effect of internet technologies: whereas the positive effects of internet investment on wage and employment are statistically significant but marginal in magnitude, the effects are found to be very large in a handful (6%) of counties. These locations share several characteristics: large populations, an educated workforce and a large share of IT-intensive industries. Based on these results, the authors conclude that internet investments tend to exacerbate existing wage inequalities between regions. In contrast to Atasoy (2013), the authors question the ability of broadband to compensate for geographical isolation.

Similar findings are reported by Akerman et al. (2013), who exploit random-like variations in broadband availability in Norway to estimate its effect on the productivity of differently-skilled workers. Their results corroborate the skill-bias hypothesis: whereas broadband availability increases the productivity of college graduates, it favours replacement of lower-skill workers, thus lowering their marginal productivity.

Very few rigorous studies have examined the impact of internet technologies on employment and wages in developing countries. One exception is De los Ríos (2010), who examines the impact of internet adoption on household incomes in Peru between 2007 and 2009. The results indicate that individuals who became internet users between 2007 and 2009 experienced faster income growth than those who remained non-users. Further, the reported gains are larger for users in rural areas, confirming the findings by Atasoy (2013). However, the results indicate that internet adoption has no effect on the probability of finding employment. Another exception is Katz and Callorda (2013) who take advantage of a large initiative to expand broadband coverage by the public telecom operator in Ecuador (CNT) to investigate the impact

3. Similar findings are reported by Kolko (2012).

on individual labour incomes. The findings indicate that broadband availability at the county level is associated with an increase of 7.5% in individual labour income over a two-year period, regardless of whether the individual had in fact adopted the service, thus confirming the strong positive externalities of internet investment. However, overall employment effects were again found to be null. Similar findings are reported by May et al. (2011), who use microdata from household surveys in four countries in East Africa (Kenya, Rwanda, Tanzania and Uganda) to examine the impact of increased access to new ICTs on multidimensional poverty over the 2007–2010 period. The findings indicate that gaining access to ICTs is associated with a 2.5% improvement in a household's poverty status.

The studies reviewed above are summarized in Table 2. Overall, the evidence suggests that internet diffusion positively affects wages, though the impacts on aggregate employment are mixed. Further, most studies confirm the skill-bias hypothesis whereby benefits are disproportionately appropriated by the more educated workers. Whether connectivity can compensate for geographical isolation and promote economic diversification in rural areas is uncertain. In particular, answering this question requires a deeper understanding of the channels through which internet technologies affect economic activity and development in general, to which we turn in the next section.

3 Opening the internet black box

The studies reviewed so far generally provide limited theorization about the channels through which internet technologies affect the various social and economic dimensions of poverty. Parsing these micro-linkages is critical for advancing our understanding of the potential contribution of internet investments to poverty alleviation, as well as for evaluating the cost effectiveness of policy initiatives aimed at universalizing access. In this section we organize the existing evidence from various fields into a coherent analytical framework that presents several hypotheses about these impact mechanisms.

From the available evidence we extract four hypothetical mechanisms through which internet technologies may accelerate the pace of economic growth or reduce income disparities (or both), thus contributing to poverty alleviation. They are: a) increases in firm productivity; b) improvements in market co-ordination, particularly labour markets; c) the strengthening of social and human capital; and d) the promotion of inclusive political institutions. Each is discussed in more detail in the following subsections.

3.1 Raising firm productivity

At its most basic, the internet is a general-purpose technology (GPT) that allows individuals and firms to share information in a vastly more efficient manner.[4] Following

4. The term general-purpose technology, or GPT, is used to describe technologies with a wide range of potential applications in households and businesses. For example, the steam engine and electricity are classic examples of GPTs (see Jovanic and Rosseau, 2005).

standard models of economic growth, more efficient sharing of information and ideas will allow firms to find better ways to combine physical and human capital, thus increasing output per worker (Romer, 1990; Aghion and Howitt, 1992). These benefits will accumulate over time due to learning effects, further raising productivity as the new technology progressively disseminates throughout the economy (Howitt, 2004).

Table 2: The *distributional effect* of internet technologies

Authors	Data	Methodology	Key findings
De los Ríos (2010).	Household surveys in Peru 2007–2009.	OLS regression.	Internet adoption is associated with labour income gains of between 13% and 19%.
May et al. (2011).	Household surveys in East Africa 2007–2010.	OLS regression with matched sample.	Access to ICTs is associated with a 2.5% improvement in a household's poverty status. Larger effects for poorer households.
Forman et al. (2012).	Panel of US counties for 1995–2000.	Instrumental variable regression with falsification test.	Internet investments are associated with wage and employment growth only in 6% of counties.
Atasoy (2013).	Panel of US counties for 1999–2007.	County fixed-effects model with falsification test.	Broadband availability is associated with 1.8 p.p. increase in employment rate, with larger effects in rural counties.
Katz and Callorda (2013).	Panel of counties in Ecuador 2009–2011.	Quasi-experiment that exploits progressive roll-out of infrastructure.	Broadband availability yields a 7.5% increase in individual labour income over a two-year period, regardless of adoption.
Akerman et al. (2013)	Panel of firms in Norway 2011–2007	Quasi-experiment that exploits progressive roll-out of infrastructure.	Broadband availability increases marginal productivity of skilled labour by \$0.27 but reduces productivity of unskilled workers by \$0.06

Source: The authors.

Capturing these productivity gains in empirical studies has nonetheless proved elusive, not only because reliable productivity data at the firm level is notoriously demanding to collect, but also because the internet is a relatively recent technology. Despite these challenges, some rigorous evidence has begun to emerge. Colombo et al. (2012) analyze the impact of internet adoption on SME productivity in Italy between 1998 and 2004. The authors differentiate between the adoption of basic applications (such as email and remote banking) and advanced applications (such as VPNs, video conferencing and supply-chain management). The results indicate that whereas the use of basic applications has no productivity impact, the adoption of selected advanced applications results in significant productivity gains, in particular when adoption is combined with organizational changes.

Galiani and Jaitman (2010) report on the impact of an initiative in Argentina to promote the adoption of internet-enabled software that allows small- and medium-scale cattle farmers to track animals throughout the supply chain. The findings indicate that farmers who adopted the system became more efficient and received better prices relative to a control group. Further, Paunov and Rollo (2014) find that internet adoption within a sector has positive impacts on individual firms' labour productivity and innovation capacity, regardless of adoption. Interestingly, these spillover impacts are larger for smaller firms and for firms located in smaller agglomerations, suggesting the presence of catch-up effects related to internet diffusion.

The empirical evidence is, however, significantly more limited than the theoretical potential. This misalignment is in part due to the relatively short existence of the internet and its characteristics as a GPT. In fact, previous research about the productivity impact of other GPTs, such as the steam engine, electric power and computers have found results consistent with what is being observed for internet technologies. Among these key results are: 1) that the short-run impact of the adoption of a GPT on firm productivity may be negligible or even negative because of adjustments costs related to learning and the relocation of labour and other activities (Helpman and Trajtenberg, 1996; Aghion and Howitt, 1998); 2) that the productivity impact of GPTs is strongly dependent on complementary investments in human capital and the reorganization of activities within the firm (Brynjolfsson and Hitt, 2000); and 3) that the full potential of GPTs is realized only when complementary innovations become available (Rosenberg, 1982; Breshnahan and Trajtenberg, 1995). It is therefore likely that the full productivity impact of internet technologies will take several decades to materialize, particularly in developing countries where threshold effects may further delay productivity returns on these technology investments.

3.2 Improving market co-ordination

A basic economic principle states that, under perfectly competitive markets, production factors such as labour and capital will be optimally allocated to the most productive firms, rewarding them and as a result promoting aggregate growth. However, it is also well established that many factors prevent markets from being perfectly competitive. A well-known example is when agents have incomplete or asymmetric information (Stigler, 1961; Salop and Stiglitz, 1977). The more the information about the quality or quantity of goods in a market is incomplete or unevenly distributed, the greater the opportunities for rent-seeking behaviour, which results in deviations from Pareto efficiency (Stahl, 1989). It follows that any mechanism that reduces information-seeking costs and facilitates information dissemination will contribute to the acceleration of long-term growth by improving the allocation of resources across the economy.

There is solid evidence that earlier communication technologies have improved market co-ordination in developing contexts. Most of these studies have focused on the impact of communication infrastructure roll-out on supply chains in agricultural markets. This is highly relevant for development purposes, given that the functioning of agricultural markets plays a central role in determining the incomes of the poorest. For example, Jensen (2007) showed that the availability of mobile phone services in South India resulted in a reduction in price dispersion across fish markets, and in an increase in both consumer and producer welfare. Similar findings are reported by Aker (2010), who estimates that the introduction of mobile phones in Niger is associated with a 20% reduction in grain price differences across markets (although no increases were found in prices paid to producers). Camacho and Conover (2011) similarly found that Colombian farmers who received regular price and weather information through text messages had a significant reduction in crop loss relative to a control group. Muto and Yamano (2009) report that the adoption of mobile telephony by Ugandan farmers improved resource allocation by promoting participation in remote markets.

Building on these studies, there is growing evidence that internet adoption also reduces information asymmetries and enhances market performance in agricultural markets. In a study of soybean farmers in India, Goyal (2010) found evidence that, after a large processor and buyer of soybeans installed internet kiosks in a group of villages, farmers were able to bypass intermediaries and receive better crop prices. The author also found a significant reduction in the dispersion of soybean prices across markets. Similarly, Beuermann (2011) finds that the availability of payphones and telecentres in rural Peru helped raise agricultural income by about 16%, which the author attributes to reductions in information asymmetries between farmers and traders.

The impact of internet technologies on co-ordination in labour markets is a special case of the above discussion, but one particularly relevant to the welfare of the poor. Several studies have examined whether new communication technologies improve the performance of labour markets, reducing friction (such as the time it takes to find a new job) and improving the match between demand and supply. In general, the empirical findings corroborate the theory about positive information effects on labour market co-ordination. For example, Aker et al. (2011) show that an adult education programme in rural Niger, in which students learned how to use mobile phones, increased the likelihood of rural–urban migration. Kuhn and Mansour (2011) find that, among young jobseekers, those using the internet for job searches were able to find employment 25% faster than those not using the internet for this purpose. Mang (2012) finds that job changers who found their new job online are better matched (for example, they report better use of their skills and greater job satisfaction) than those who found their new job through newspapers, friends, job agencies or other channels. The effects are particularly strong for jobseekers in rural areas, suggesting that internet adoption is partly compensating for geographical isolation and is broadening the spatial scope of labour markets.

In summary, the evidence suggests that the diffusion of internet technologies is linked to better market performance in a variety of contexts, thus improving resource allocation across the economy. While most existing studies in developing contexts examine the impact of mobile telephony in agricultural value chains, there is growing evidence that the findings hold true for internet technologies as well as for other markets. The case is particularly strong for labour markets, which in developing countries are characterized by various types of information-related frictions that result in suboptimal employment and poor matching.

3.3 Strengthening social and human capital

Internet diffusion is also hypothesized to contribute to poverty alleviation by promoting the accumulation of two types of intangible asset: social capital and ICT skills. It is well known that the poor often rely on family, friends or neighbours to compensate for limited access to various services, from risk insurance to day care for pre-schoolers (Dercon, 2004). This has spawned an extensive literature on the role of social capital in development. The rapid adoption of new information technologies in emerging regions has renewed this debate, with particular attention to how changes in the structure and dynamics of social networks may in turn affect other social and economic outcomes.

For example, several studies have examined the link between internet use, social capital and employment. The role of personal networks in labour markets has been extensively corroborated: they constitute key channels for information about jobs and wages to disseminate across members of a social group (Lin, 2001; Granovetter, 2005). Given that internet use affects the size, the structure, the intensity and the type of interactions that take place in personal networks, associated changes can be expected in the matching between workers and employers, and possibly in the resulting wage distribution (DiMaggio et al., 2001).

While few rigorous studies have been conducted to test these hypotheses, preliminary findings point in two directions. First, that internet users tend to maintain a larger network of weak ties, and that these ties are often activated at crucial times, such as when looking for a job or changing occupations (Boase et al., 2006). Second, that internet use also intensifies remote ties with close family members and friends, which in turn facilitate labour migration (Aker et al., 2011; Bauernschuster et al., 2011).

Another set of studies suggest that internet adoption increases employability by promoting the acquisition of ICT skills. The assumption is that ICT skills are increasingly becoming a key component of human capital, even in traditional low-skill occupations such as those in the service sector. In a field experiment in which 11,000 fake CVs where submitted to real job openings in sales and administration in two Latin American cities (Buenos Aires and Bogotá), Blanco and López Bóo (2010) found that having basic ICT skills significantly increased the likelihood of being called for a job interview. Several other survey-based studies confirm the association between ICT skills and earnings (DiMaggio and Bonikowski, 2008; Mossberger et al., 2007).

Given the role of schools in human capital formation, many governments and donors have invested heavily in ICT-in-school programs in recent years. These programmes, which combine the provision of equipment, connectivity and teacher training in various ways, are premised on two key assumptions: a) that schools have an important role to play in promoting ICT literacy, and b) that the introduction of computers and the internet in schools can positively affect student performance, promoting learning as alongside other desirable outcomes, such as motivation and retention (Warschauer and Matuchniak, 2010).

In general terms the empirical evidence supports the first assumption, but provides mixed results for the second. The use of computers and the internet in schools has been found to significantly increase students' ICT skills. For example, Fairlie (2012) reports that low-income college students randomly selected to participate in a programme that provided free computers had significantly higher ICT skills than the control group. Interestingly the author reports that effects were stronger for the lowest income students, thus mitigating previous inequalities in exposure to ICTs. Likewise, Malamud and Pop-Eleches (2011) report strong results on ICT skills for a voucher programme in Romania designed to promote computer ownership among low-income households, whereas Cristia el al. (2012) report significant computer skill gains among beneficiaries of Peru's OLPC (One Laptop per Child) programme.

By contrast the impact of computers and the internet on other educational outcomes is much less clear. Most studies find no significant effects of computer use on student achievement in traditional subjects such as language and maths (Angrist and Lavy, 2002; Barrera-Osorio and Linden, 2009; Cristia et al., 2012). Interestingly, some even report negative effects, which are attributed to the lack of teacher training and displacement of time from other educational activities (for example, Sprietsma, 2012). The literature on the impact of internet subsidies for schools is less extensive, but the results are equally mixed. Goolsbee and Guryan (2006) analyze the impact of the e-Rate programme, a large initiative started in 1998 to promote internet connectivity among state-funded schools in California. The authors find that while the initiative successfully reduced connectivity gaps between schools, it had no observable effect on student learning. Further, Belo et al. (2010) find that the introduction of broadband in schools in Portugal negatively affected student learning, which the authors attribute to ineffective use (schools which blocked access to non-educational websites performed better). Finally, recent work on the impact of broadband access at home on educational outcomes suggests that internet use is essentially uncorrelated with school performance (Faber et al., 2015).

In sum, there is evidence to suggest that internet adoption can increase employment opportunities for the poor by promoting the acquisition of basic ICT skills. In addition, internet use has been found to reconfigure social interactions in ways that favour increased numbers of weak ties, which have been shown to be critical in obtaining non-redundant information about jobs and other issues of high relevance to the poor. Finally, internet use is linked to an intensification of ties with close friends and family, thus promoting what Woolcock and Narayan (2000) have termed bonding social capital. This type of capital is associated with increased levels of social trust, which several studies have shown to be particularly important for economic transactions in weak institutional contexts (Fafchamps and Minten, 1999; Overa, 2006). Further, increases in bonding social capital also have important implications for collective action in the political realm, to which we turn in the next section.

3.4 Promoting inclusive institutions

Poverty and political exclusion create a self-reinforcing trap. On the one hand, poverty prevents the accumulation of human capital and increases political instability, both of which negatively affect the quality of institutions that regulate market transactions and organize political life. On the other, inclusive political institutions that promote citizen participation and constrain the actions of political elites are a key determinant of economic well-being.[5] There are many studies suggesting that ICTs in general, and the internet in particular, can promote democratization, social engagement and other positive outcomes associated with better institutions. Yet much of this literature is based on anecdotal evidence or case studies of large-scale political changes (such as the so-called 'Arab Spring'), in which the potential contribution of the internet is difficult to disentangle from multiple other factors.

Despite these challenges, there is a small but growing literature that points to several micro-linkages between internet diffusion and better governance. This literature shows that internet diffusion may result in more inclusive political institutions through two key mechanisms: first, by increasing government transparency and thus limiting opportunities for corruption and improving the allocation of public resources; second, by promoting political engagement and mobilization, which threatens political elites and leads to more responsive government. Each of these mechanisms is further examined below.

3.4.1 Increasing government transparency. Both theoretical and empirical studies indicate that a more informed population promotes better governance (Besley and Burgess, 2002; Strömberg, 2004). It follows that any mechanism that facilitates widespread information access and dissemination is likely to strengthen this effect. For example, Ferraz and Finan (2008) show that the disclosure of information about government corruption in Brazilian municipalities led voters to punish corrupt incumbents. Similarly, Andersen et al. (2011) report that the diffusion of the internet across US states is associated with a significant decrease in corruption incidents in local government. The authors suggest that internet diffusion both increases the risk of detection for corrupt politicians and has a disintermediation effect, enabling citizens to bypass local officials and other information gatekeepers.

5. Acemoglu and Robinson (2012) are a recent example within a substantial literature that dates back, at least, to North and Thomas (1973).

There is also evidence that increased information transparency about the delivery of public services can effect positive changes in the quality of such services. Reinikka and Svensson (2005) report that the disclosure of information about the allocation of school funds in local media reduced corruption and increased the availability of funds for schools in Uganda. In a similar study, Bjorkman and Svensson (2009) document how providing local communities in Uganda with basic information about the quality of health services received (in comparison to other communities and with the standards set by the federal government) reduced capture and led to increases in both the quality and quantity of health services provided. By empowering citizens with information about the performance of politicians and the delivery of public services, internet diffusion is hypothesized to reduce corruption and better align the allocation of public resources with voters' preferences.

3.4.2 Promoting political engagement and mobilization. As discussed, there is evidence that internet diffusion promotes government accountability. Yet government accountability is itself a public good and therefore subject to well-known collective action and free-riding problems. Learning about corruption and inefficiencies in the delivery of public services is both costly and ultimately of little use unless individuals are willing to organize and engage in political action. In a study of corruption in public works in Indonesia, Olken (2005) found that providing information to citizens was much less effective than traditional top-down monitoring of contracts. Not only is collective action difficult to organize, but local elites are often able to trump any proposed changes.

The question then becomes whether internet diffusion can foster civic engagement and help individuals overcome collective action challenges to political mobilization. Theoretically, the reduction in information search and co-ordination costs that improves the performance of markets (discussed above) should also promote political engagement by similarly reducing the cost of acquiring political information and opening new channels for political participation. Yet internet adoption could also reduce civic engagement by displacing time from political activities and favouring entertainment or other non-instrumental uses (see for example, Putnam, 2000).

Despite much theoretical debate, very few rigorous studies have been conducted to test these competing hypotheses. In general, the available evidence suggests that internet adoption has a small, but statistically significant, effect on civic engagement. Longitudinal studies based on large-scale surveys indicate that internet use has positive effects on voter turnout, campaign contributions and the intensity of contact with elected officials (Mossberger et al., 2007; Stern et al., 2011). However, a meta-study by Boulianne (2009) finds that, while most studies suggest an association between internet adoption and civic engagement, the magnitude of the effects is dramatically reduced when controlling for pre-existing political interest.

A study by Campante et al. (2013), which exploits variations in broadband availability across municipalities in Italy, suggests that the relationship between internet adoption and political engagement is multifaceted. On the one hand, the authors find that internet availability is associated with lower voter turnout in parliamentary elections. Yet they find that it is also associated with higher levels of political participation through other means, such as grassroots movements. Overall their findings support the hypothesis (presented by Castells (2009) among others) that internet use does not reduce overall political participation, but rather changes the mechanisms of civic engagement, favouring new forms of collective action.

4 Conclusion

The development community continues to debate the role of internet technologies in addressing the multiple social and economic dimensions of poverty. The enthusiasm with which many governments and development donors have embraced the internet has too often discouraged empirical evaluations about its true contribution for poverty alleviation and the cost effectiveness of the multiple connectivity initiatives under way. In addition, the limitations in existing datasets have presented serious methodological challenges for development scholars. As a result, large public investments in internet infrastructure and training have been guided by reports from industry or advocacy groups, which generally lack the scrutiny that characterizes scholarly work.

The systematic review of the evidence undertaken in this article suggests that the development pay-offs of internet technologies are highly uncertain due to two interrelated effects. First, because effective appropriation requires various skills as well as complementary investments in human capital and organizational changes, which tends to favour well-educated workers and firms with more innovative capacity and access to financing. Second, because the positive effects of internet dissemination on market co-ordination and political institutions grow exponentially with adoption levels. As a result, while the evidence indicates that advanced economies are reaping numerous benefits from internet investments, the returns for less advanced economies, and in particular for the fight against poverty in these regions, remain uncertain.

Conceptually, the article has presented several hypotheses about the impact mechanisms that link internet diffusion and poverty reduction. In some cases (for example, improving market co-ordination, promoting ICT-related human capital), the evidence is unambiguous and supports a moderate optimism about the contribution of internet technologies to development goals. In others (for example, productivity and employment gains), it is more ambiguous and requires careful consideration of its distributional effects. Yet in others (for example, better governance) the available evidence is very limited and leaves key questions unanswered. In this sense, the limited extent and depth of current research is troubling given the importance of the issues at stake and the growth of public investments in internet connectivity initiatives.

This stocktaking exercise is not intended to discourage policy-makers and practitioners from continuing to find ways to leverage new communication technologies for development purposes. Rather, it seeks to better align expectations with empirical results, as well as to encourage further research that more carefully considers heterogeneous effects in the design and implementations of initiatives.[6] Much like investments in transportation and electricity, internet connectivity investments are poised to play a significant role in poverty alleviation initiatives in the future. But still much remains to be understood about their complementarity with other investments (in basic education, in SME productivity, in institutional strengthening) in order to assess their long-term development impact.

first submitted February 2014
final revision accepted February 2016

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