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The Internet and Poverty: OPENING THE BLACK BOX

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FOREWORD

There is a large push in Latin America to develop and implement 'national broadband plans' to promote economic growth and development more broadly, for example by connecting broadband to schools and subsidizing connectivity to the poor. However, there is little to no research that addresses the fundamental question of whether or not this is sound policy. Does broadband adoption have positive economic and social impacts? Can it help alleviate poverty?

This book takes advantage of relatively new and highly disaggregated data sets that allow the analysis of the effects of access at the individual, student, business and household levels. This is opposed to the majority of existing studies that use aggregate data with large samples that smooth over the interesting variations at a disaggregated level. This type of study more accurately and robustly addresses the policy question of whether or not (and even for whom) there are development impacts related to broadband access.

In addition, this book applies a theoretical framework connecting broadband adoption to different development outcomes – thus expanding our understanding of the connections between broadband adoption and development goals such as poverty alleviation. This framework was based around three theoretical effects of broadband access: aggregate economic growth, less unequal income distribution and social inclusion. It seeks, as the title of the book suggests, to uncover the mechanisms through which the adoption of broadband affects the livelihoods of the poor. The development and refinement of this theoretical framework is a clear contribution to the field.

What does the book reveal? The findings corroborated the growth effect of broadband, i.e., that an increase in broadband is linked to economic gains. However, the effects found are more modest than previously estimated (as much as five times lower than the more optimistic estimations.) Also, broadband in schools has mixed effects – it is positively associated with student achievement when there are appropriate related changes in classroom activities, but has null or even negative effects when not associated with adequate teacher training. Broadband in schools also has an effect on student motivation (e.g., drop in absenteeism, among other indicators) and can compensate for differences in ICT access outside schools – providing an important inclusion effect.

The research also shows that a focus on capacity building as part of technological roll-outs is critical. Otherwise, more and better connectivity will disproportionately benefit the already better off. In other words, the book confirms that technology can both exacerbate inequality as well as reduce it – depending upon critical elements of the context and related initiatives associated with its deployment. Lastly, the ethnographic study conducted in Mexico shows that the youth are increasingly important mediators for other household members in the process of broadband adoption. This combination of qualitative and quantitative methodologies is another strength of the book.

The findings in this book are crucial to current debates about the best way to catalyze access to broadband infrastructure in Latin America. I recommend every Latin American policy-maker, academic, technologist and civil society actor involved in this field read this book to better understand how to foster economic growth and inclusion in the region.

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EXECUTIVE SUMMARY

This report summarizes the findings of a multi-country research project aimed at estimating the contribution of high-speed Internet access (hereafter broadband) to poverty alleviation in Latin America. The project was funded by IDRC and implemented by DIRSI (Diálogo Regional sobre la Sociedad de la Información), a regional ICT policy research network. The project had three overarching goals: a) to provide rigorous evidence about the contribution of broadband adoption to poverty alleviation and various other development goals, under different settings and for different populations; b) to articulate the empirical evidence with a conceptual framework about the mechanisms through which broadband adoption has a positive development impact; and c) to orient policymakers and the development community in terms of the expected impact of broadband investments for different development goals and under different implementation scenarios.

The methodology favored a quasi-experimental approach, which took advantage of the increased availability of disaggregated data on ICT adoption and use in several countries. This data was combined with multiple other sources such as household surveys, school censuses and standardized test scores for K-12 students. Five case studies were commissioned to local research teams in Brazil, Chile, Colombia, Ecuador and Peru. In addition, in-depth interviews with users and non-users were conducted as part of an exploratory study to understand how the poor obtain, share, and utilize information and communication resources in their everyday lives – what we call the *informational lives of the poor*. This ethnographic component was conducted in three low-income communities in Mexico: a poor semi-urban community, a semi-rural community, and a remote rural community, each with different levels of ICT connectivity.

In general the results corroborate the positive contribution of broadband to overall economic growth (what we call the *growth effect*), but the impact is significantly more modest than previously estimated – as much as five times lower than the more optimistic estimations. The results also corroborate the presence of a positive *income effect* associated with broadband availability at the local level, which raises labor incomes by as much as 7.5% over a two-year period in some estimates. This benefit was found to accrue to all workers regardless of whether they in fact adopted broadband, thus confirming earlier results about the spillover effect of broadband.

The *income effect* of broadband was found to be larger for men than for women. The hypothesis is that this is due to differences in human capital as well as to gender differences in occupations, which in Latin America are still affected by traditional views about the role of men and women in the household. This was confirmed by the in-depth interviews, which revealed that adult women often see the Internet as a foreign technology that only the younger generations are capable of using. However, when the income effect is estimated among those who have used the Internet in the last 12 months, the difference in wage gains between men and women disappears. These findings suggest that while the externality effects of broadband are disproportionately appropriated by men, once women become users they are able to reap similar benefits.

The picture that emerges from the evaluation of broadband-in-schools programs is more mixed. Overall the findings confirm that simply connecting schools to broadband is expected to have a very small effect on student achievement (as measured by standardized language and math tests). The most promising results were found when broadband availability triggered unexpected changes in classroom activities, such as using current news to teach grammar and math. There is also evidence of a statistically significant (although small) negative impact on student achievement for some student cohorts, suggesting that lack of adequate teacher training diverted the use of broadband to non-educational activities (at least from a traditional curriculum perspective). These findings suggest the urgent need to revisit school connectivity programs in order to ensure that classroom use of digital resources is properly articulated with the school curriculum and the overall educational goals of the initiative.

On the other hand there is evidence that connecting schools to broadband motivates students and promotes a better learning environment. The *motivational effect* is reflected in a small but significant reduction in drop-out rates, as well as small but significant increases in pass rates. In connected schools teachers also reported a significant drop in student absenteeism, in disciplinary problems, and in verbal and physical aggression. This suggests that one of the key impacts of broadband-in-schools initiatives is to more positively engage students with school activities. While these short-term gains did not result in higher test scores, there is little doubt that an engaging educational environment is a precondition for better learning outcomes. The fact that broadband connectivity increases student motivation and compensates for differences in access to ICTs outside the school environment provides a strong rationale to attempt to improve, rather than abandon, these types of initiatives. In other words, the *inclusion effect* of broadband-in-schools programs should be considered an important goal on its own.

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01. PRESENTATION: A NEW TECHNOLOGY PARADOX

For many years, the so-called "Solow computer paradox" confounded academics and policymakers alike. Originally identified by Nobel-laureate economist Robert Solow, the paradox referred to the lack of evidence about the impact of investments in IT technology made by U.S. companies in the 1980s on firm productivity, and more generally on aggregate economic growth. As Brynjolfsson (1993) notes, the paradox revealed a large gap between the expectations about the economic gains from computers and related innovations in data processing technologies – hailed by some as the biggest technological revolution in human history – and what the productivity statistics revealed.

Today, a similar paradox has emerged about the contribution of high-speed Internet access (hereafter broadband) to development in general, and more specifically to poverty alleviation. To many, broadband represents a major boost to development. For example, the United Nations Broadband Commission, a high-level group of industry leaders and senior policymakers, has argued that in order to achieve the Millennium Development Goals (MDGs) by the target date of 2015, countries must strongly invest in broadband infrastructure and promote adoption. Otherwise, "they will lose the opportunity to reap the economic and social benefits that broadband brings" (UN Broadband Commission, 2011, p. 1).

On the other hand, many others question this optimism. For example, based on a review of the existing literature, Kenny (2011) argues that there is limited evidence about the positive economic impact of broadband, and concludes that "the impact of broadband rollout on achieving the MDGs would be marginal" (p. 1). Others argue that most of the gains associated with broadband are being appropriated by those already well-off, thus exacerbating inequalities and making broadband a questionable development investment. Forman et al. (2012) summarize their findings as follows: "We find that while the Internet is widespread, the payoffs are not" (p. 1).

Academics are often skeptical about easy answers and high-profile policy initiatives. But even for the well-intentioned policymaker, looking for empirical guidance about the true economic and social returns of public investments in broadband can be utterly frustrating. Surprisingly, this has not discouraged governments around the world from making large commitments to so-called "national broadband plans". Many of these plans were presented as a response to the international economic crisis of 2008-2009, as part of economic stimulus packages to create jobs and reignite economic growth. The implicit assumption was that the link between broadband investments and development was beyond doubt.

In Latin America, many governments were quick to jump on this bandwagon. Brazil alone has committed about USD $3.2 billion through 2014 (0.13% of its GDP) to a plan that combines the development of a national fiber backbone, tax exemptions, and investments in R&D and training in broadband and related technologies. Argentina is committing USD $1.8 billion (0.4% of its GDP) to a similar plan through 2015. Colombia's Vive Digital plan is even more ambitious, encompassing initiatives to migrate government services online, provide broadband subsidies and training to poor households, and build a national fiber backbone in remote areas. The estimated price tag through 2014 is USD $2.25 billion, or 0.62% of its current GDP. For perspective, this represents over a third of the government's yearly expenditures on health services.[1]

National broadband plans are often articulated with ICT investments in education. Over the past few years, high-profile programs to equip schools with computers and Internet connectivity have proliferated in the region (IADB, 2011). Again, despite lacking a clear understanding of the benefits of ICT investments in basic education, governments have committed significant funding to various programs, convinced that providing students with computers and connecting schools to the Internet would improve learning outcomes.

Are national initiatives to connect households and bring broadband into schools a wise development investment? Assuming that broadband adoption does have positive economic and social impacts, are we certain that these benefits are being appropriated by those at the bottom of the socioeconomic pyramid? **Can broadband truly help address fundamental development challenges, and in particular help alleviate long-term poverty?**

This report seeks to contribute to answering these questions in two fundamental ways. First, we present

[1] For further discussion about these plans see Galperin et al. (2013).

the results of five rigorous case studies about the impact of broadband adoption on key development outcomes in Latin America. Unlike most existing studies, our case studies examine the evidence at the most disaggregated level available. In other words, they are based on microevidence about the effect of broadband at the level of the individual or the student who is using (or not using) broadband. This has many advantages over studies based on aggregate data (typically at the provincial or national level), among them the use of large samples and the ability to control for many of the confounding factors in statistical analyses. We believe our case studies are therefore more robust in their conclusions about the true development impact of broadband.

Second, we provide a theoretical framework that lays out the mechanisms through which the adoption of broadband affects (or does not affect) key economic and social outcomes. This is an important step forward in our understanding of broadband's role in development. Most existing studies provide limited theorization about impact mechanisms – resulting in what we term a broadband black box. This conceptual gap makes it difficult to disentangle the multiple possibilities that broadband affords. If broadband adopters are on average better off than the rest, is this because they are able to find more employment, to acquire new skills, to draw on a larger network for social support, or perhaps to demand better social services from the government? Our theoretical framework draws on a large body of existing literature in order to address these fundamental questions. The empirical evidence from the case studies is therefore interpreted against this theoretical backdrop.

> TO SUMMARIZE, THIS REPORT HAS THREE OVERARCHING GOALS:

1. *To provide rigorous evidence about the contribution of broadband adoption to poverty alleviation and various other development goals, under different settings and for different populations.*
2. *To articulate the empirical evidence with a conceptual framework about the mechanisms through which broadband adoption has a positive development impact.*
3. *To orient policymakers and the development community in terms of the expected impact of broadband investments for different development goals and under different implementation scenarios.*

02. HOW TO STUDY THE DEVELOPMENT IMPACT OF BROADBAND?

There is no shortage of reports about how broadband is improving the lives of people in the developing world. These reports, while insightful in several ways, do not provide a solid empirical foundation for policymaking, as they naturally tend to emphasize the success stories and do not provide adequate guidance about the cost-effectiveness of policy initiatives. On the other hand, there are several empirical studies which attempt to measure the development contribution of broadband, yet they tend to say little about the microfoundation of broadband's impact.

Part of the problem in existing studies lies in their level of data aggregation. With a few exceptions, most studies examine whether provinces/states or countries where broadband develops faster (relative to others) also achieve better results in other social or economic variables of interest. Due to this high level of data aggregation these studies offer little insight about the underlying mechanisms at play, no matter how rigorous the methodology used. Does broadband have a positive economic impact because individuals are better informed about job opportunities or because firms adapt processes and become more productive? Do benefits accrue exclusively to broadband adopters or, as suggested by some authors, do non-adopters reap gains as well? These types of questions can only be answered by using more disaggregated data about broadband adoption and use. In other words, they require looking at individuals and organizations which use (or do not use) broadband, rather than examining effects at the level of states or countries.

The problem is aggravated by the characteristics of broadband as a general-purpose technology (hereafter GPT). Understanding the development impact of fixed or mobile telephony was relatively simpler insofar as these communication technologies served a single purpose: they allowed individuals (at home, at work, and later on the move) to make voice calls or send short text messages to each other. Any impact that resulted from their adoption could be tied to this specific use. By contrast, broadband is a classic GPT: it enables multiple uses (known as applications or services), and in fact only becomes useful in the presence of such complementary products. This makes impact attribution even more problematic, since the overall effect of broadband adoption may be averaging the differential impact of various specific uses, some of which may be positive, some neutral and some even negative. Parsing out the effect of the various potential uses of broadband can only be accomplished through studies with lower levels of data aggregation.

An alternative found in a growing number of recent studies about the impact of ICTs is the use of experimental methods such as randomized controlled trials (RCTs). There are many advantages to RCTs including the ability to identify the specific causal mechanism of interest, the ability to manipulate ICT use for a specific purpose (the so-called treatment), and the ability to test for counterfactuals, which allows for strong causal claims in the results obtained. Yet the approach also has many drawbacks. RCTs are difficult to set up and expensive to conduct, and thus tend to be based on small samples of individuals within a very specific experimental context. Whether the results obtained hold under different settings, for different populations or with variations in the treatment (known as the external validity problem) will always remain uncertain.

In this study we favor a quasi-experimental approach to understand the impact of broadband on development. As the name suggests, quasi-experimental studies share many of the desirable characteristics of RCTs, including low levels of data aggregation and the ability to disentangle the causality problems found in earlier studies. Yet they differ from RCTs on an important point: the lack of random assignment of units to treatment or control group. This makes causal attribution more difficult, and thus we apply various statistical techniques to compensate for this problem. On the other hand, quasi-experiments have several advantages over other alternatives:

- *In contrast to RCTs, quasi-experiments can take advantage of large samples, thus mitigating external validity problems. This also allows results to be subject to validity tests under different settings and for different populations. Some of our case studies are based on census data, which by definition eliminates external validity concerns.*

- *Despite non-random assignment to treatment and control groups, there are many techniques which allow researchers using quasi-experiments to build counterfactuals, and thus make credible causal claims about impact (or lack thereof). Our case studies use a variety of techniques to ensure that* *the causal claims made are methodologically robust (or otherwise note when the data available only allows for plausible associations).*

The empirical studies summarized in this report share several common characteristics. First, they focus on adoption and use at the lowest possible level of aggregation – the individual, the household, the student, the business. Second, they take advantage of the increased availability of microdata on broadband adoption and use produced by national statistics offices and other government entities. This enables the use of very large samples (in some case over 100,000 observations) representative at the national level. In our opinion, the ability to draw conclusions from several thousand cases at the national level more than compensates for the loss of precision in relation to RCTs. Table 1 provides a snapshot of the data used in each of the five empirical case studies summarized in this report.

Table 1: The empirical case studies

	COUNTRY	SAMPLE		DATA SOURCES
Connected to Learn? The effect of broadband Internet on school quality in Brazil	Brazil	Panel data of students and teachers 2007-2011 Number of observations: between 83,000 and 124,000		School census and test scores (Prova Brasil) from Ministry of Education and administrative data for PBLE program from ANATEL
Can information and communication technologies (ICTs) have a positive impact on student performance? Evidence from Chile	Chile	Two cohorts of primary-level students in public schools (2005-2011) Number of observations: between 110,000 and 133,000		Test scores (SIMCE) and information about ENLACES program from Ministry of Education
Internet and economic activity in Colombia 2007-2011: An analysis at the level of municipalities and 23 major cities.	Colombia	Panel of municipalities based on household survey data (2005-2011) Number of observations: 5,000		Annual household survey from national statistics office and deployment information from Ministry of ICT
Impact of broadband deployment in Ecuador	Ecuador	Panel of individuals in urban areas 2009-2011 Number of observations: 24,000 individuals		National household survey conducted by Ecuador's National Institute of Statistics and Census
Internet access, type of access and educational outcomes: Evidence for the Peruvian case	Peru	Panel data of students at school level (2007-2011) Number of observations: 10,000	School census and test scores data from Ministry of Education	Difference-in-difference with matching: students from connected schools are compared to those from unconnected schools on key educational outcomes

> What is broadband? One problem encountered throughout this study is that broadband is defined differently across countries (typically in terms of download speeds) and in some cases by different government agencies within countries. Rather than establishing a single definition applicable to all countries, we opted for letting local research teams work with different definitions better suited to the data available in each country. While this poses some challenges in terms of cross-country comparison of results, we believe it allowed local researchers the flexibility to work with large amounts of data without unnecessarily restricting

In addition, we complement the results from the five quasi-experimental studies with personal interviews conducted as part of an exploratory study to understand how the poor obtain, share and utilize information and communication resources in their everyday lives – what we call the *informational lives of the poor*. This study builds on previous work carried out by DIRSI (Galperin and Mariscal, 2007; Barrantes and Galperin, 2008; Agüero, 2008) and several others (Donner, 2009; Zainudeen and Ratnadiwakara, 2011) which has examined patterns of expenditure, modes of access and uses of new ICTs by the poor. However, it takes a step further by shifting the center of attention from the modes of access and use of particular technologies to the modes of information seeking and use of communication resources in local settings.

This exploratory ethnographic study was conducted in three low-income communities in Mexico with different socioeconomic characteristics: a poor semi-urban community, a semi-rural community, and a remote rural community, each with different levels of connectivity. In the outskirts of San Miguel de Allende, broadband connectivity is available from different operators serving the richer city center. In Santiago Nuyoo, a semi-rural community in Oaxaca, shared Internet access is available from public telecenters and private cybercafés, while a recent mobile banking initiative has brought local voice and text-messaging services. Finally, the remote rural community of Las Margaritas still lacks any kind of ICT service, and thus served as an ethnographic control group. With the help of local partner organizations with experience in these communities, 31 in-depth interviews were conducted with local residents. The interviews focused on how the adoption of broadband and other ICTs (or lack thereof) was changing the patterns of information seeking and the structure of information networks (e.g., who talks to whom about what), and whether such changes could be tied to relevant development outcomes. Table 2 summarizes the key facts of the ethnographic study.

Table 2: Ethnographic study: Key facts

	LAS MARGARITAS	SANTIAGO NUYOO	SAN MIGUEL DE ALLENDE
Location	Municipio de Catorce, San Luis de Potosí	Tlaxiaco, Oaxaca	Guanajuato
Type of community	Rural	Semi-rural	Urban outskirts
ICT connectivity	None	Public Internet access and mobile telephony (local service only)	All services available
Local partner	Taller de Operaciones (NGO)	Telecomm Telegráfos (public entity)	Sociedad Civil Jóvenes Adelante (NGO)
Fieldwork dates	November 2012	November 2012	March/April 2013
Number of interviews	10	11	10

This report's key findings are presented in four separate sections. The first (section 3) summarizes the theoretical framework that guides the interpretation of results, which is based upon a wide review of the existing literature about the development impact of broadband. The second (section 4) summarizes the results of the two empirical case studies that examined the link between broadband and economic development (in Ecuador and Colombia). The third (section 5) summarizes the findings from the three case studies that examined the relation between broadband and educational achievement (in Brazil, Chile and Peru). The fourth (section 6) summarizes the findings from the ethnographic case study in Mexico. They are followed by a conclusion (section 7) which discusses the policy implications and suggests new research directions.

03. LINKING BROADBAND WITH POVERTY ALLEVIATION: THEORY AND EVIDENCE

From the vast number of studies that examine the development impact of the Internet (broadband studies being a subset of this literature), we now have a fairly good understanding about the patterns of Internet adoption by different populations, in different countries and under different social and economic circumstances. What is generally lacking is a conceptual framework linking Internet adoption to positive development outcomes. In our view, part of the problem is that most studies start from the wrong end of the link. In other words, they start from the technology adoption end rather than from the development challenge that needs to be addressed. Several critics have noted the technological centrism in much of the existing literature (see Heeks, 2009; Warschauer, 2003), yet only recently has progress been made on conceptualizing Internet adoption not as a goal in itself but rather as a potential mechanism, among others, to address specific development challenges.

In this report we flip the conventional analysis on its head and start from the perspective of the development challenges at hand. We focus on the most fundamental of all: poverty alleviation. Conceptually, we must therefore be able to establish the transmission channels that link broadband adoption with sustained poverty alleviation. Empirically, we must be able to observe such effects and estimate the size of this contribution under different circumstances and for different populations.

3.1 > DEFINING POVERTY: A MULTIDIMENSIONAL APPROACH

Does broadband contribute to poverty alleviation? The answer to this question depends in part on how poverty is defined. In this study we take a multidimensional definition of poverty rooted in Sen's well-known capabilities approach (Sen, 1999). Under this approach, being poor is defined not only as having an income below a certain monetary threshold, but also as lacking other non-monetary endowments (such as good health, education and rich social ties) which are strongly correlated with well-being, and which are good predictors of the ability to generate income (and thus to escape poverty in the traditional sense) in the future.

What are the necessary conditions to make significant progress in alleviating poverty? The vast literature on poverty is in agreement that, without sustained economic growth, it is unlikely that countries will be able to make significant progress in poverty alleviation (see Lopez, 2004). However, it is also agreed that growth is not enough, particularly in regions with high levels of inequality as is the case of Latin America. Growth dynamics must therefore be complemented with redistribution policies that reduce income inequality and break poverty cycles (Ravallion, 2004).

Recent studies for Latin America and the Caribbean confirm the strength of the impact of economic growth on poverty reduction. According to estimates by Cruces and Gasparini (2013) poverty in the region dropped by 12.9 percentage points between 1990 and 2010. Almost three quarters of this drop can be attributed to the effect of economic growth, while reductions in income inequality account for the rest.

While the growth effect is stronger, changes in income distribution also have an important impact on poverty. What explains the decrease in income inequality in the region, which has been particularly visible in the last decade? While this is a much-debated question, the available evidence points to two key factors (López-Calva and Lustig, 2010). First, changes in the composition of labor demand. While a definitive understanding of these changes is still lacking, there is agreement that stronger labor markets have helped reduce poverty, raising incomes and providing some of the basic benefits associated with formal employment. Second, the sharp increase in social protection programs, and in particular of conditional cash-transfer programs such as Bolsa Familia in Brazil and Oportunidades in Mexico. The key factor is that these programs are unrelated to formal employment status, and thus targeted at the poorest and most vulnerable. By 2010 it was estimated that almost 20% of the population in the region was covered by various social protection programs. In this context, we can distinguish three interrelated effects which are strongly associated with poverty reduction:

1. *A growth effect, which recent data confirms to be the strongest contributor to poverty reduction.*
2. *An employment effect, which is associated with economic growth, and affects poverty either through wage increases (the return on labor), through reduced unemployment (the strength of labor demand), or both.*
3. *An inclusion effect, which relates to increases in non-monetary poverty endowments such as access to information and social capital, which in turn improve the quality of public goods (both provided by the state and self-provisioned).*

The identification of these three interrelated effects is the first step in establishing a theoretical link between broadband adoption and poverty alleviation. If broadband is causally linked to poverty reduction, its effect will work through one or more of the impact channels identified above. A brief review of evidence for each of these effects is discussed below.

3.2 > THE GROWTH EFFECT OF BROADBAND

As noted, economic growth is the strongest driver of long-term poverty reduction. It is therefore not surprising that the debate about the contribution of broadband to development centers on whether broadband adoption can boost growth rates in the developing world. There are many empirical studies that provide estimates of the positive impact of broadband on aggregate economic growth (Koutrompis, 2009; Qiang and Rosotto, 2009; Czernich et al., 2011). Yet as critics such as Kenny (2011) and Mayo and Wallsten (2011) note, these studies are beset by methodological difficulties, among them potential biases in the estimations due to endogeneity problems. At its most basic, this means that it is not possible, given the models used, to determine whether increases in broadband penetration are in fact promoting economic growth, or whether it is economic growth that promotes broadband adoption (a problem known in econometrics as reverse causality).

Another problem identified is the lack of controls for a third variable (such as better governance) which could simultaneously be causing both increased broadband penetration and economic growth (a problem known in econometrics as omitted-variable bias).

In a sense these difficulties are part of life in the social sciences. Yet when the links between cause and effects are not sufficiently theorized, they become even more problematic. We believe part of the problem lies in the high level of data aggregation used in these studies, typically covering entire provinces or nations. Following the microdata approach favored in this study, we conducted a thorough review of the microeconomic literature linking broadband adoption with known drivers of economic growth. The review suggests three mechanisms through which broadband may accelerate the pace of economic growth:

a. *By raising firm productivity*
b. *By improving market performance through reduced transaction costs*
c. *By promoting a better match between labor supply and demand.*

Starting with firm productivity, it is a widely accepted premise that productivity increases are the main determinant of long-run economic growth. At its most basic, broadband is a general-purpose technology (GPT) which allows individuals and firms to share information in a vastly more efficient manner. Following standard models of economic growth, more efficient sharing of information and ideas will allow businesses 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).

There is a small but growing body of evidence that supports this argument (e.g., Bertschek et al., 2011; Colombo et al., 2012). However, the existing evidence is much more limited than the theoretical potential. This misalignment between theoretical potential and evidence is not surprising given the short lifespan of broadband and its characteristics as a GPT. In fact, historical studies about the productivity impact of other GPTs such as the steam engine, electric power and computers themselves have found results consistent with what is being observed for broadband. Among these key results are:

- *That the short-run impact of the adoption of a GPT on firm productivity may be negligible or even negative because of adjustment costs related to learning and the relocation of labor and other activities (Helpman and Trajtenberg, 1996; Aghion and Howitt, 1998).*

- *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).*

- *That the full potential of GPTs is realized only when complementary innovations become available (Rosenberg, 1982).*

These earlier findings suggest that the productivity impact of broadband (and therefore its impact on economic growth) may be limited in the short term, as the existing evidence suggests, but grow rapidly as firms and other organizations adapt processes and make complementary investments in human capital and new products that take advantage of the inherent properties of broadband technology.

A second mechanism through which broadband adoption can positively affect long-term growth is by enhancing the performance of markets for goods and services across the economy. A basic economic principle states that, under perfectly competitive markets, production factors such as labor and capital will be optimally allocated to the most productive firms, rewarding them and thus stimulating growth. However, it is also well established that there are many reasons that prevent markets from being perfectly competitive as often assumed. A well-known example is when market participants have incomplete or asymmetric information (Stigler, 1961; Salop and Stiglitz, 1977). The more information about the quality or quantity of goods in a market is incomplete or unevenly distributed, the more opportunities for rent-seeking behavior, which results in deviations from optimal allocation of production resources.

It follows that any mechanism that improves access to information by people and businesses will contribute to accelerate long-term growth by making markets more competitive and improving the allocation of resources across the economy. As noted, broadband is a generic technology which greatly reduces the costs associated with information acquisition and dissemination. Hence, by lowering search costs and increasing market transparency, the adoption of broadband can be expected to reduce frictions and lower opportunities for rent-seeking, ultimately improving economic performance as a whole.

So far, most studies have focused on the impact of the rollout of basic communications infrastructure on supply chains in agricultural markets, given the role these markets play in the welfare of the poorest. In a path-breaking study, Jensen (2007) showed how the availability of mobile phone services in South India resulted in a reduction in price dispersion across fish markets, and to an increase in both consumer and producer welfare. Similar findings are reported by Aker (2010), who estimates that the introduction of mobile phones is associated with a 20% reduction in grain price differences across markets in Niger (although no increases were found in prices paid to producers). Similarly, Camacho and Conover (2011) found that when farmers in Colombia received regular price and weather information through text messages they had a significant reduction in crop loss relative to those not receiving this information. Beuermann (2011) also found that the availability of payphones in rural villages in Peru helped raise agricultural income by about 16%, which the authors attribute to reductions in information asymmetries between farmers and traders.

While these studies focus on the impact of mobile and public telephony, there is growing evidence that broadband also reduces information asymmetries and enhances market performance. 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. In summary, the evidence confirms that the widespread adoption of new ICTs by firms and households is linked to better market performance in a variety of contexts, thus improving resource allocation across the economy and ultimately spurring growth.

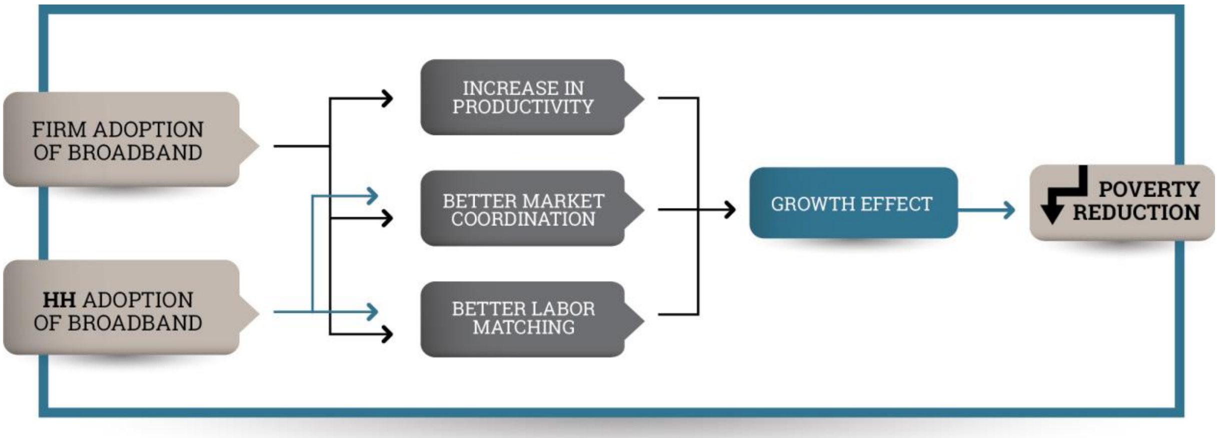
The third and final mechanism, the positive impact of broadband on labor markets, is a special case of the discussion above. Labor markets are particularly relevant to the welfare of the poor, given their lower skills and higher vulnerability to unemployment or income losses. Given the centrality of poverty reduction in our research analysis, we will further examine whether broadband is found to improve coordination in labor markets, reducing friction (for example, the time it takes to find a new job) and improving matching between labor supply and demand, in the following section.

Several studies have found a positive effect of ICT adoption on labor markets. For example, Aker, Clemens and Ksoll (2011) show how mobile telephony is helping to match urban jobs with individuals in rural Niger. Kuhn and Mansour (2011) also provide strong evidence that broadband adoption reduces labor market frictions. They found that, among young jobseekers in the U.S., those using the Internet for job searches were able to find employment 25% faster than those not using the Internet for this purpose. A different study by Mang (2012) finds that job changers who found their new job online are better matched than their counterparts 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 broadening the spatial scope of labor markets.

Figure 1 summarizes the three key linkages between broadband and economic growth: increases in productivity, better market coordination and better labor matching. Two issues are worth noting.

First, the solid lines indicate effects that are predominantly linked directly to broadband adoption, whereas dotted lines indicate effects that have strong externalities, thus benefiting also non-adopters. Second, it is worth noting that simultaneous increases in residential and business broadband access are often necessary for effects to materialize. The most obvious example is better labor matching, which requires that both firms seeking labor and workers seeking jobs have broadband access.

Figure 1: How broadband affects economic growth (stylized facts)



3.3 > THE EMPLOYMENT EFFECT OF BROADBAND

Beyond economic growth, long-term poverty reduction is also associated with improvements in employment opportunities for the poor. Several studies show that, while employment and economic growth are strongly related, different growth trajectories have different labor market implications, and thus affect poverty differently (see Loayza and Raddatz, 2006). In this section we examine the evidence about the impact of broadband development on employment and wages, with particular attention to the balance between high and low skills in the composition of labor demand. We also examine the role of schools in the development of ICT skills. If in fact, as some argue, broadband development disproportionately favors skilled workers, schools have an important leveling role to play. For example, by closing income-driven access gaps in technology adoption, schools can help students from less privileged households to acquire skills with higher labor payoffs.

The impact of new technologies, from the steam engine to microchips, on labor markets has been long debated. A review of the existing literature suggests that the relation is complex and context-dependent. On the one hand, some technologies might help standardize production processes and replace skilled labor, as weaving and spinning machines did in the early days of the industrial revolution (Goldin and Katz, 1998). On the other hand, other technologies increase demand for educated workers, thus placing a premium on skilled labor. In an influential paper, Autor et al. (1998) argue that much of the rise in wage inequality in the U.S. since the 1970s can be explained by the adoption of computers and related technologies. As a generic information technology that requires various skills for effective use, broadband Internet access may aggravate such inequalities. However, it is also possible that, by raising productivity and reducing transaction costs, broadband may boost employment and raise overall wages, even among the less skilled. Further, broadband may compensate for geographical isolation, thus enhancing employment opportunities for the rural poor.

The empirical evidence suggests that Internet diffusion positively affects labor markets regardless of effective adoption – in other words, that Internet technologies have positive labor externalities. 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 many studies. This is also consistent with recent findings by Autor and Dorn (2013), who suggest that the impact of generic information technology investments on wages and employment in advanced economies is U-shaped, with growth at the top and bottom but losses in the middle of the skill distribution.

Several recent studies confirm the skill-bias hypothesis in the case of broadband. For example, Atasoy (2013) finds that broadband availability is associated with a 1.8 percentage point increase in the employment rate in U.S. counties, and the effects are found to be particularly large in counties with a larger fraction of college-educated workers. Yet the study also confirms that broadband availability may be compensating for geographical isolation, as the positive impact on employment is found to be significantly larger in rural counties.[2] The findings reported by Forman et al. (2012) also suggest a strong complementarity between information technologies and skilled labor. Based on these results the authors conclude that Internet investments will tend to exacerbate existing income inequality between regions. In contrast to Atasoy (2013), the authors question the ability of broadband to compensate for geographical isolation in rural areas.
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

[2] Similar findings are reported by Kolko (2012).

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. 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 for 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. Interestingly, the magnitude of the effect increases when the sample is restricted to the poorest households, thus confirming the U-shaped distributional pattern identified by Autor and Dorn (2013).

> To sum up, the available evidence suggests that broadband:

- *Is associated with increases in wages and employment, but those gains are disproportionately appropriated by the more educated workers (thus confirming the skill-bias hypothesis).*
- *May potentially compensate for geographical isolation, allowing businesses and workers to expand beyond local markets. Given that the poor disproportionately live in isolated communities, this may partly compensate the skill-bias identified above.*

> Based on a review of the literature we hypothesize that the widespread adoption of broadband can positively affect employment through three different channels:

1. *By improving labor market coordination.*
2. *By strengthening social capital, which is closely associated with employment (particularly for the poor).*
3. *By promoting the acquisition of ICT skills by current and future workers.*

The first mechanism, improved coordination in labor markets, is an example of the general argument already discussed in the previous section. In the second mechanism, broadband adoption is hypothesized to affect labor market outcomes by changing the structure of social networks in which we interact with one another. The role of social networks in labor markets has been extensively corroborated (Lin, 2001). Social interactions are primarily maintained for reasons other than monetary gains, yet they constitute key channels for the dissemination of information about jobs and wages across members of a social group (Granovetter, 1995). Estimates of the share of successful employment attributable to personal networks vary considerably, and depend on demographic and cultural factors as well as on the industry and job characteristics. For developed countries estimates are in the 30 to 60% range, and comparative studies suggest that the role of social ties in job searching is even greater in developing countries (Ioannides and Datcher Loury, 2004).

It follows from this evidence that any technology that affects the size, the structure, the intensity and the type of interactions that take place in social networks will necessarily affect how employers and workers find each other, and possibly the resulting wage distribution. It is well documented that Internet adoption affects key variables in an individual's social network such as size, intensity, and heterogeneity of ties (Di Maggio et al., 2001). While rigorous studies are still scarce and rapid changes in social network applications present serious research challenges, the available evidence suggests that Internet adoption favors what are commonly referred as "weak ties", as in ties with acquaintances and distant relatives. For example, Boase et al. (2006) find that, after controlling for demographic characteristics, Internet users have a larger network of weak ties, and that those ties are often activated at crucial personal times such as when looking for a job or changing occupations.

In a classic study about social ties, Granovetter (1973) argued that, because our close (or strong) ties are likely to have much of the same information we already have, they are less likely to be helpful in critical tasks such as finding a new job. By contrast, weak ties connect us to a wider and more heterogeneous set of people, and thus are more likely to be valuable sources of non-redundant information. There is also evidence that mobile telephony promotes employment by facilitating contacts between migrant workers and close friends and relatives at home (Aker et al., 2011). As the use of social network applications becomes widespread, as recent data suggests, similar effects could be expected from broadband adoption.

In sum, there is evidence to suggest that broadband adoption by individuals or households has a positive impact on employment by reconfiguring social interactions in ways that favor increased numbers of weak ties as well as the intensification of interactions with strong ties. This is particularly relevant for the poor, who tend to work and live among high levels of labor informality in which the line between personal and productive activities is often blurry (Overa, 2006; Donner, 2009).

The third mechanism that links broadband adoption and employment is the acquisition of ICT skills. Generally speaking, the available evidence confirms that having basic ICT skills is increasingly important for employability. For example, 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 Lopez Boo (2010) found that having basic ICT skills significantly increased the likelihood of being called for a job interview. Further, empirical studies confirm the link between ICT skills and earnings (Di Maggio and Bonikowski, 2008; Mossberger et al., 2007).

From a poverty-reduction perspective, the question then becomes how ICT skills can be acquired. As with any other skill, there are two primary mechanisms: formal training and experience. The first refers to skills acquired in the context of worker training programs, ICT curricula at schools, ICT literacy courses for adults, or any other form of structured ICT training. Alternatively, the second mechanism relates to the acquisition of ICT skills through use for specific purposes in a variety of settings, such as at work, at home or in school. This is also referred to as "learning by using" (Rosenberg, 1982).

The relevance of these two mechanisms for the acquisition of ICT skills has generated much controversy. Yet there is little question that schools have a major role to play in the acquisition of basic ICT skills. Looking for innovative solutions to the larger problem of education quality, many governments in Latin America are implementing ambitious initiatives to introduce computers and the Internet in schools, premised on two key assumptions:

1. *That schools have an important role to play in promoting the acquisition of ICT skills, which are a critical component of human capital in the 21st century (Warschauer and Matuchniak, 2010).*
2. *That the introduction of computers and the Internet in schools can positively affect school performance, promoting learning as well as other desirable outcomes such as motivation and retention (Claro, 2010).*

In general terms the empirical evidence supports the first assumption but provides mixed results about the second. The use of computers and the Internet by students has been found to significantly increase ICT skills. For example, Fairlie (2012) reports that low-income college students randomly selected to participate in a program that provided free computers for home use 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 (2010) report strong results on ICT skills for a voucher program in Rumania designed to promote computer ownership among low-income households, whereas Cristia el al. (2012) report significant computer skill gains among beneficiaries of Peru's One Laptop per Child (OLPC) program. By contrast, the impact of computers and the Internet on learning and other educational outcomes is much less clear. With respect to the use of computers in classrooms, while some studies report positive effects on math and other subjects (Machin et al., 2006; Banerjee et al., 2007; Carrillo et al., 2010), most studies find no significant effects of computer use on student achievement (Angrist and Lavy, 2002; Osorio and Linden, 2009). Interestingly, some even report that the introduction of computers in classrooms negatively affects student achievement, which is attributed to lack of teacher training and displacement of time from other educational activities (e.g., Sprietsma, 2012).

The literature on the impact of broadband programs for schools is less extensive, but the results are equally mixed. Goolsbee and Guryan (2006) analyze the impact of the e-Rate program, a large initiative started in 1998 to promote Internet connectivity in public 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 has negatively affected student learning, which the authors attribute to ineffective use (their findings show that schools which block access to non-educational websites perform relatively better).

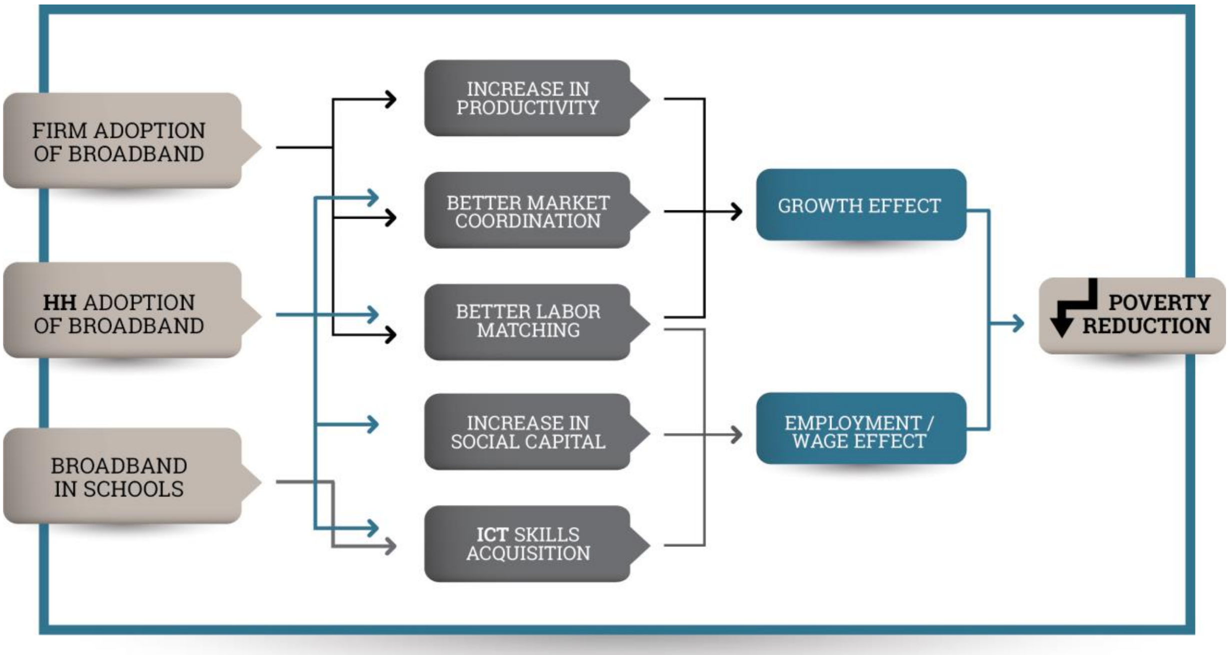
There is also a growing body of literature on the acquisition of ICT skills in public access venues such as cybercafés and telecenters. This is particularly relevant to developing countries, where shared Internet access is still the main connectivity alternative for the majority due to the high cost of individual broadband subscriptions (Galperin and Ruzzier, 2012). For example, in a large survey of Internet users in five developing countries (including Brazil and Chile), researchers found that over half of low-income respondents reported acquiring ICT skills primarily through use at such venues (Sey et al., 2013).

> In sum, previous studies suggest that:

- *ICT skills have become a critical dimension of human capital, positively affecting employment not only in specialized IT fields but also for lower-skill occupations.*
- *Internet use at home or in shared access centers (independent of use at work) by adults promotes skills which translate into income gains, thus suggesting a spillover effect from non-instrumental uses.*
- *Internet use in schools positively affects students' ICT skills, despite mixed evidence about its ultimate effect on other educational outcomes.*

Figure 2 summarizes the potential linkages between broadband adoption and employment, as suggested by the evidence reviewed above. It builds on Figure 1 in order to emphasize the interrelatedness of the growth and employment effects.

Figure 2: How broadband affects economic growth and employment (stylized facts)



3.4 > THE INCLUSION EFFECT OF BROADBAND

Poverty and social exclusion are mutually reinforcing problems. On the one hand, poverty prevents the accumulation of human capital and increases political instability, both of which obstruct the consolidation of more inclusive economic and political institutions (Easterly et al., 2006). On the other, inclusive political and economic institutions are strongly

associated with economic growth (Acemoglu and Robinson, 2012), which as noted before is the key driver of poverty reduction. Can widespread broadband adoption help break this vicious circle and promote social inclusion? **What are the potential channels through which broadband adoption may lead to more inclusive economic and political institutions?**
There are many studies suggesting that ICTs in general, and broadband in particular, promote democratization, social engagement, and other positive outcomes associated with better institutions (e.g., Castells, 2009). Digital activism, a term used to refer to the use of ICTs to effect political change, has been the topic of much controversy in recent years. While some praise the potential of mobile phones and broadband to contest authoritarian regimes and promote more democratic institutions (Hussain and Howard, 2013), others question whether ICTs are in fact a key driver of such changes, and point to the many instances in which digital activism failed to succeed (Shirky, 2011).

Part of the problem is that much of the debate is based on studies presenting anecdotal evidence or case studies of large-scale political changes (such as in the so-called Arab Spring) in which the potential contribution of ICTs is difficult to disentangle from multiple other factors. Further, much of this literature is of limited relevance to the case of Latin America, where the widespread adoption of mobile telephony and the Internet came after democracy and the rule of law had been consolidated in most of the region, at least in broad terms.

Our focus is therefore on the microfoundations of inclusive institutional change. In other words, our focus is not on the relation between ICTs and large-scale social or political changes, but rather on how the widespread adoption of broadband and other communication technologies can make existing institutions more inclusive, and in particular more responsive to the needs of the poor. Our working hypothesis is that broadband adoption results in more inclusive institutions through two key mechanisms: first, by increasing government transparency, thus limiting opportunities for corruption and improving the allocation of public resources; and second, by promoting political engagement and mobilization, which threatens political elites and leads to more responsive government.

As for the first mechanism, several studies show that a more informed population results in more government accountability, increasing the incentives of policymakers to respond to voters' needs (Besley and Burgess, 2002; Stromberg, 2004). For example, Ferraz and Finan (2008) show how the disclosure of information about government corruption in Brazilian municipalities led voters to punish corrupt incumbents. Interestingly, the authors found that the availability of local media outlets enhanced the effects of information disclosure.

Similarly, Gonçalves (2009) examined the impact of posting online the criminal records of incumbent candidates to Brazil's congress and found that voters punished candidates with criminal charges. Chong et al. (2013) report similar results for Mexico, although in this case the effect was to disengage voters from the political process as a way of punishing corrupt incumbents.

Having better tools to access government information is not enough if governments are reluctant to disclose information about their own performance. Fortunately, access to information is increasingly recognized as a basic right by legislators in the region, making it easier for citizens to scrutinize governments (Bertoni, 2011). The combination of better tools for information access and dissemination with legislation that compels governments to disclose data is hypothesized to reduce opportunities for corruption and enhance responsiveness to the needs of the majority, ultimately creating more inclusive economic and political institutions.

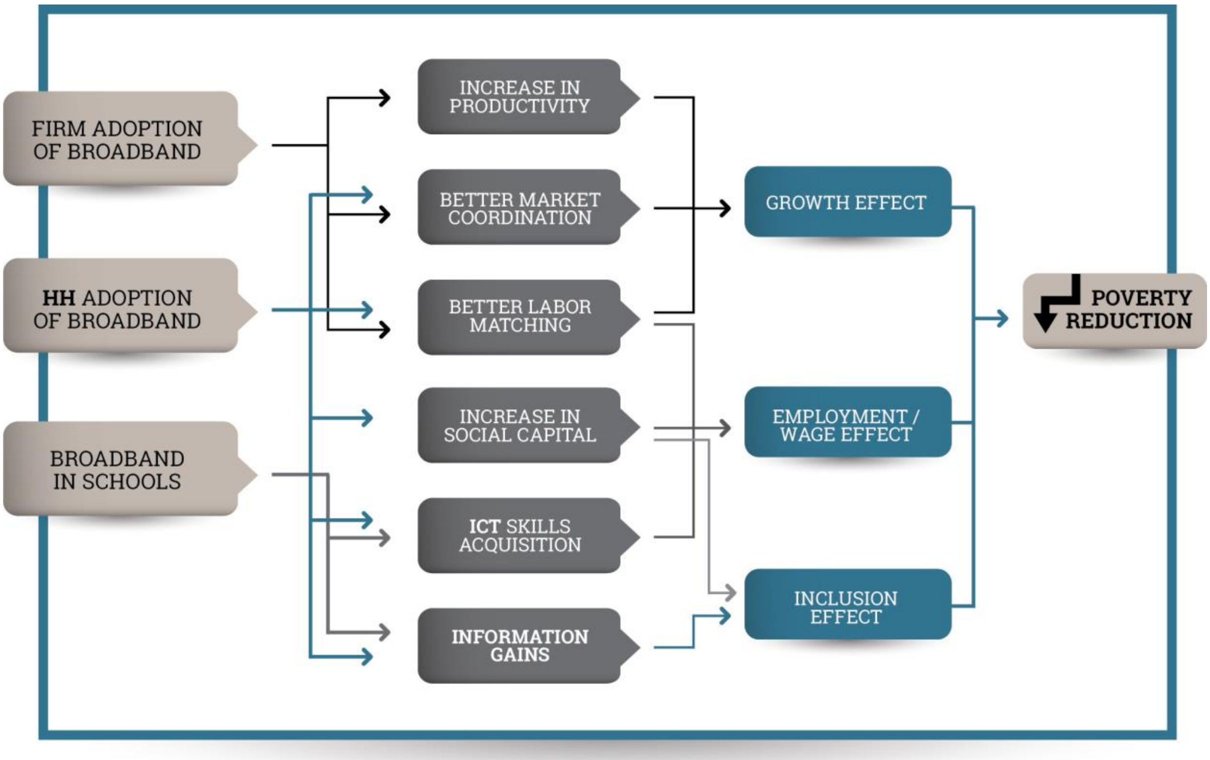
There is also evidence that information disclosure about public service delivery can effect positive changes in the quality of such services. For example, Reinikka and Svensson (2005) report that the disclosure of information about the allocation of school funds in local media reduced corruption and increased the availability of funds for schools in Uganda. In a similar study, Bjorkman and Svensson (2007) 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) led to increases in both the quality and quantity of health services provided. While most of these interventions were based on dissemination through physical means (face-to-face meetings, leaflets, etc.) or traditional media such as local radio and newspapers, it is easy to see how widespread broadband availability could make it easier for beneficiaries to monitor the delivery of public services.

As discussed, citizen oversight of government actions can lead to significant improvements in the quality of public goods. Yet government oversight is itself a public good, and therefore subject to well-known collective action and free-riding problems. For example, learning about corruption and inefficiencies in the delivery of public services is of little use unless individuals are willing to organize and engage in political action to produce changes. 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 broadband development can foster civic engagement and help individuals overcome collective action challenges to political mobilization. In general, the empirical evidence (mostly from developed countries) suggests that Internet adoption can promote civic engagement, with positive effects on voter turnout, campaign contributions, and the intensity of contact with elected officials (Mossberger et al., 2007). For example, Stern et al. (2011) report that broadband use has a positive effect on community participation in the U.S. Interestingly, the authors identify two separate channels for this effect: first, increased social capital (measured by network size), and second, facilitating information access and sharing about community news and events. In turn, increased civic engagement has been linked to positive development outcomes. For example, Gonçalves (2009) documents how Brazilian municipalities which established procedures for citizen engagement in the budgeting process allocated more funds to sanitation and health services, with an observable impact on improved health outcomes.

Figure 3 summarizes the hypothesized linkages between broadband development and social inclusion. It builds on Figures 1 and 2 above to add the third and last mechanism through which increased broadband adoption is expected to affect poverty.

Figure 3: How broadband affects economic growth, employment and inclusion (stylized facts)



04.

THE IMPACT OF BROADBAND ON ECONOMIC GROWTH AND EMPLOYMENT

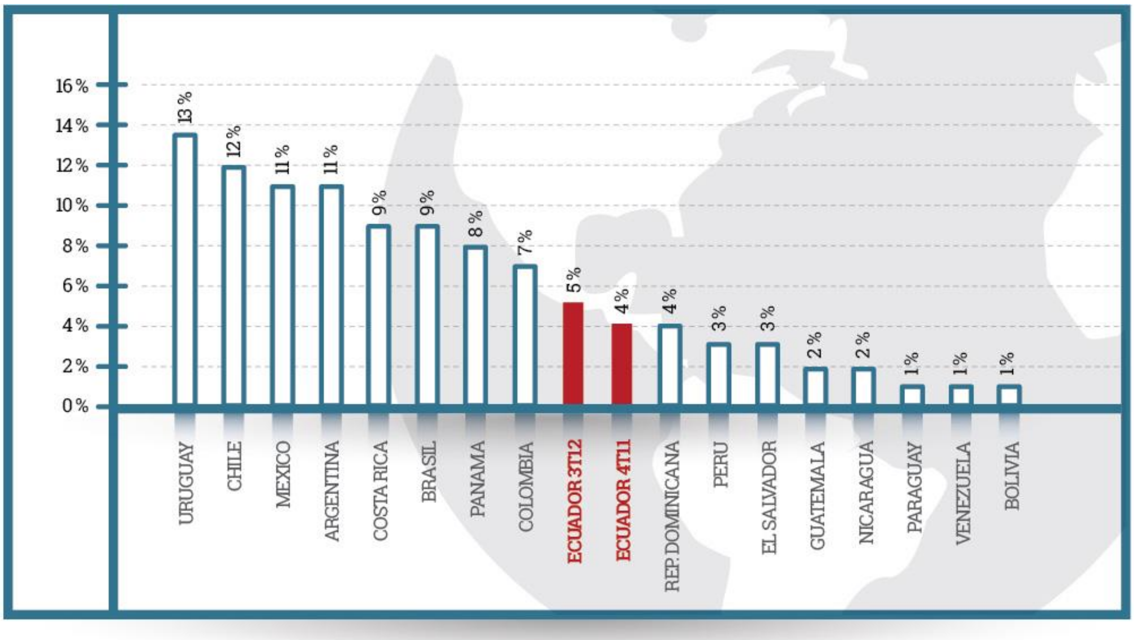
4.1 > ECUADOR CASE STUDY: KEY FINDINGS.

The case of Ecuador illustrates the challenges and opportunities afforded by broadband in Latin America. Until recently, under-provisioning of international capacity severely restricted the development of Internet services in Ecuador. As the country was bypassed by the main undersea cable on the western coast of Latin America, international traffic was routed through Colombia, adding significant transport costs. Not surprisingly, retail Internet services in Ecuador were among the most expensive in the region (Galperin and Ruzzier, 2010). High prices negatively affected Internet adoption, which was significantly below expectations even after controlling for income, education and demographic factors.

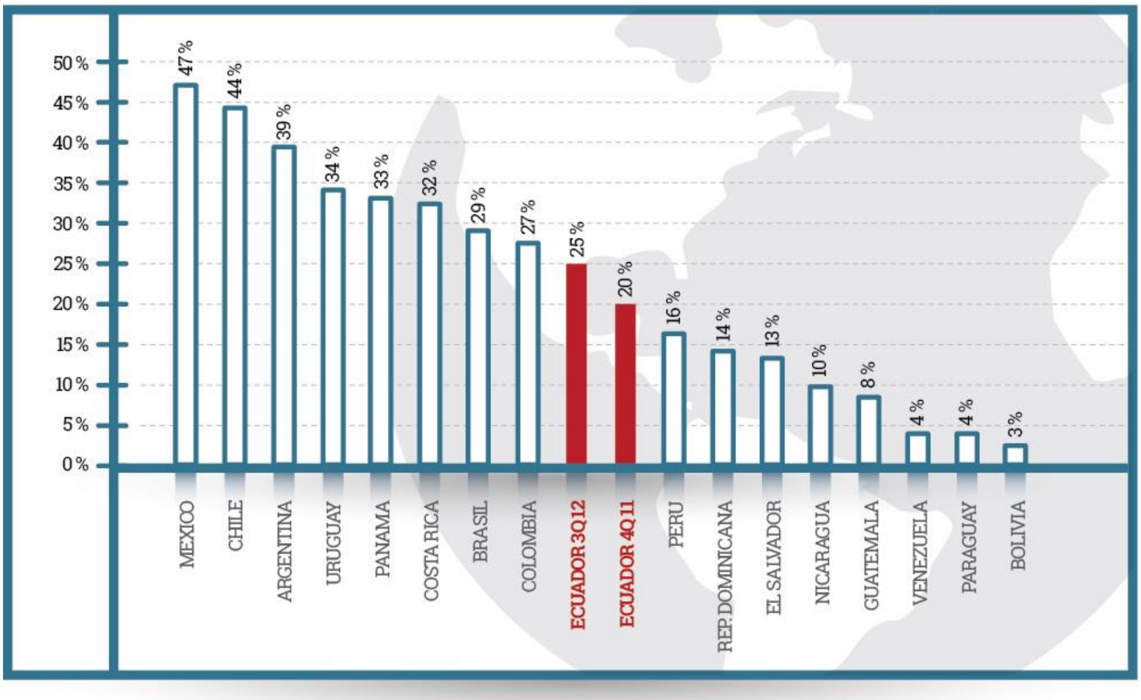
The situation began to change in 2007, when the main undersea cable was finally extended to Ecuador. Further, in 2009, the state telecommunications operator CNT started an aggressive program to extend broadband services across the country. By 2012 Ecuador ranked close to the regional average in broadband adoption (see Figure 4). Despite the recent progress made, the country is still far behind regional leaders such as Uruguay and Chile.

Figure 4: Latin America: Fixed broadband penetration (2011)

a. Penetration (% population)



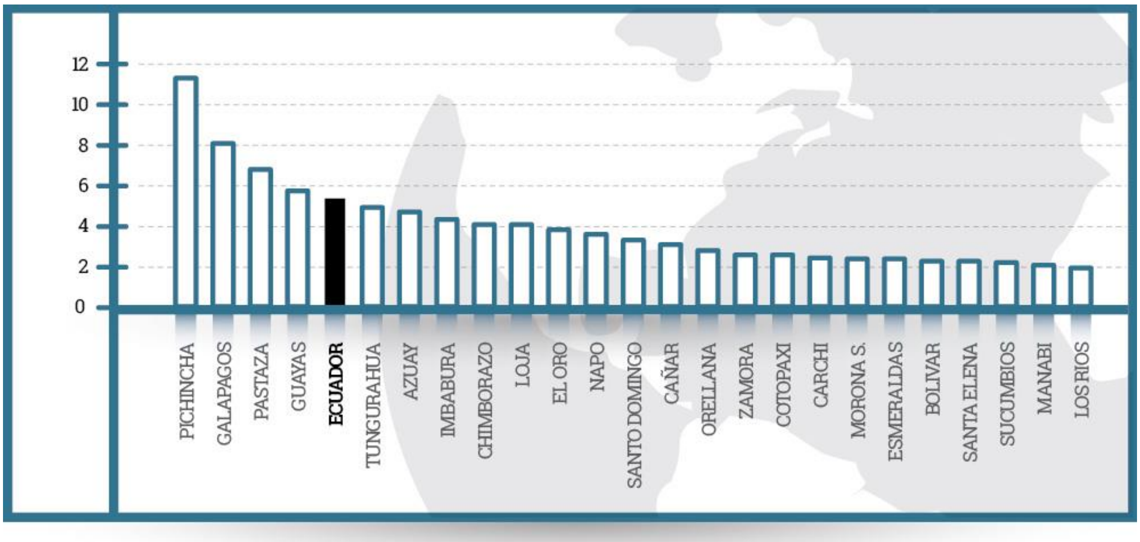
b. Household penetration



> *Source: UIT and SENATEL*

Further, the situation within Ecuador is typical of Latin America: while a few areas are relatively well connected, penetration levels remain very low in the more isolated and poorer regions. As Figure 5 shows, only four provinces (Pichincha, Galapagos, Pastaza and Guayas) have adoption levels that exceed the national average.

Figure 5: Ecuador: Fixed broadband adoption at the provincial level as of 4Q 2012 (%)



> Source: SENATEL

A closer look reveals that part of the problem is continued lack of coverage. Despite the CNT's efforts, about 20% of the Ecuadorian population still lives in municipalities where fixed broadband service is not available. Most of these municipalities are located in the poorer rural areas (see Table 3).[3]

[3] Ecuador is divided in three administrative levels: provinces (first level), districts (second level), and municipalities (third level).

Table 3: Ecuador: Broadband coverage at the municipal level (December 2011)

INDICATOR	URBAN	RURAL	TOTAL
Municipalities with penetration levels > 1 %	144	2	146
Municipalities with penetration levels < 1 %	68	63	131
Municipalities with no connections	9	735	744
TOTAL	**221**	**800**	**1.021**
Municipalities with penetration levels > 1 % (% population)	64.88 %	0.03 %	64.91 %
Municipalities with penetration levels < 1 % (% population)	9.17 %	5.86 %	15.03 %
Municipalities with no connections (% population)	0.24 %	19.82 %	20.06 %
TOTAL (% population)	**74.29 %**	**25.71 %**	**100 %**

> Source: SENATEL

The situation in Ecuador provides an opportunity to determine whether recent increases in broadband penetration have helped create employment, raise incomes and reduce poverty. The key fact is that, as noted, until 2009 the coverage of fixed broadband services was very limited. Between 2010 and 2011, CNT greatly expanded coverage, leading to a significant increase in broadband penetration at the municipal level. This allowed researchers to construct a quasi-experimental design, with 2009 as the starting point (the "before" situation) and 2011 as the ending point (the "after" situation).

In the design of quasi-experiments, a "treatment" (a specific event) is applied to experimental units in what is called the treatment group of individuals. In addition, members of a similar group, the control group, receive no treatment. For the conclusions to have validity, it is essential that the individuals assigned to treatment and control groups be representative of the same population. Based on disaggregated data, the researchers were able to identify the socioeconomic characteristics of individuals living in districts which had no access to broadband in 2009 (due to lack of coverage) and were later connected thanks to the CNT initiative. This treatment group is compared to individuals in the control group, which is composed of individuals living in districts which already had broadband access by the end of 2009.

Ecuador's National Institute of Statistics and Census (INEC) conducts a national household survey on a quarterly basis to collect information on the employment status and income levels of Ecuadorian households. The survey corresponding to the fourth quarter also includes an ICT module, which was added in 2008, in which participants report information about their computer and Internet usage. In order to determine the impact of broadband gains in the 2009-2011 period, the researchers compared the results of the surveys corresponding to the fourth quarter of 2009 and 2011, which included the ICT module. However, because, as noted, rural areas remained poorly covered in 2011, the analysis was limited to urban areas.

By December 2009 only ten districts in Ecuador had a broadband penetration greater than 0.25 connections per 100 individuals (Table 4). This penetration level was considered by the researchers as the minimum threshold to identify districts where residential broadband services were available to the general population. Residents of these ten districts are thus the control group, against which the treatment group is compared.

Table 4: Broadband penetration at district level before and after - control group

DISTRICT	PROVINCE	PENETRATION AT BASELINE (2009)	PENETRATION AT TARGET (2011)	POPULATION
Tena	Napo	0.27 %	3.31 %	60,880
Riobamba	Chimborazo	0.28 %	5.29 %	225,741
Portoviejo	Manabí	0.29 %	3.14 %	280,029
Pastaza	Pastaza	0.30 %	5.64 %	62,016
Tulcán	Carchi	0.51 %	3.14 %	86,498
Manta	Manabí	0.54 %	3.04 %	226,477
Rumiñahui	Pichincha	0.99 %	5.60 %	85,852
Cuenca	Azuay	1.50 %	2.78 %	505,585
Guayaquil	Guayas	2.83 %	6.77 %	2,350,915
Quito	Pichincha	3.06 %	10.22 %	2,239,191

> Source: SENATEL

The treatment group is made up of residents in districts where broadband penetration at the baseline (2009) was below 0.25 connections per 100 inhabitants, and at the target line (2011) had risen above 2.5 connections per 100 inhabitants. Table 5 presents the districts in this group and their evolution in terms of broadband subscribers.

Table 5: Broadband penetration at district level before and after - treatment group

DISTRICT	PROVINCE	PENETRATION AT BASELINE (2009)	PENETRATION AT TARGET (2011)	POPULATION
Chunchi	Chimborazo	0.00 %	3.06 %	12,686
Portovelo	El Oro	0.00 %	2.55 %	12,200
Pimampiro	Imbabura	0.00 %	2.62 %	12,970
Catamayo	Loja	0.00 %	3.48 %	30,638
Macará	Loja	0.00 %	3.59 %	19,018
Gualaquiza	Morona S.	0.00 %	3.46 %	17,162
Sucua	Morona S.	0.00 %	2.95 %	18,318
Mera	Pastaza	0.00 %	5.67 %	11,861
La Troncal	Cañar	0.02 %	2.18 %	54,389
Pasaje	El Oro	0.03 %	2.98 %	72,806
San Miguel	Bolívar	0.05 %	2.35 %	27,244
Zamora	Zamora	0.05 %	5.56 %	25,510
Loja	Loja	0.06 %	4.82 %	214,855
Morona	Morona S.	0.06 %	3.77 %	41,155
Azogues	Cañar	0.07 %	5.06 %	70,064
Atacames	Esmeraldas	0.07 %	2.15 %	41,526
Quevedo	Los Ríos	0.07 %	2.46 %	173,575
Guaranda	Bolívar	0.10 %	2.04 %	91,877
Caluma	Bolívar	0.10 %	2.35 %	13,129
Playas	Guayas	0.10 %	4.73 %	41,935
Ambato	Tungurahua	0.11 %	5.37 %	329,856
Antonio Ante	Imbabura	0.12 %	2.53 %	43,518
Machala	El Oro	0.16 %	4.29 %	245,972
Duran	Guayas	0.16 %	2.66 %	235,769
Esmeraldas	Esmeraldas	0.18 %	2.54 %	189,504
Ibarra	Imbabura	0.20 %	4.33 %	181,175
Lago Agrio	Sucumbíos	0.22 %	2.70 %	91,744

> Source: SENATEL

The analysis includes only those individuals living in urban households belonging to the control or treatment group, based on the definitions above. Also, only respondents who reported labor income, age, health coverage and level of education and who completed the ICT module of the household survey are included. These parameters restricted the sample to 7,664 individuals in the control group and 8,785 in the treatment group. Both groups were found to be statistically similar at the baseline (2009) in basic socioeconomic attributes (age, employment, education, income and so on). This is true of the full sample as well as of a more restricted sample of PC and Internet users in the last 12 months. This enabled researchers to attribute observed differences in the variables of interest in 2011 (such as employment and income) to changes in the availability of broadband in the district, controlling for individual characteristics and their changes throughout the observation period.

A regression model was constructed to estimate the impact of treatment (broadband deployment) on the level of individual income. The model included controls for variables such as age, gender, employment status, health coverage, level of formal education and role within the family group. The findings indicate that broadband availability in the district led to an increase in individual labor income of US$ 25.76 on average, which represents a 7.48% increase in relation to the initial average income of the entire sample. Given that the introduction of broadband occurred between December 2009 and December 2011 (over a two-year period), the annual increase in the income level was 3.67%.

While these overall findings suggest that broadband availability raises income to the entire working population regardless of adoption, researchers wanted to establish whether those who in fact used broadband benefited more than the rest. The sample was thus restricted to those individuals reporting PC and Internet use in the last 12 months. The findings reveal that this group reported even larger income gains. Individuals who reported having used a PC in the last 12 months had an increase in average income level of US$ 38.36, which implies an increase in relation to their initial income level of 8.00% over the two-year period (3.92% per annum). Finally, Internet users reported an increase of US$ 51.86 in labor income, a 10.27% increase over their initial labor income (5.01% per year). These findings are summarized in Table 6.

Table 6: Estimate of the impact of broadband on individual labor income in Ecuador 2009-2011

	TOTAL POPULATION	PC USERS (LAST 12 MONTHS)	INTERNET USERS (LAST 12 MONTHS)
Treatment	*25.76*	*38.36*	*51.86*
	*(12.59) *****	*(22.40) **	*(23.71) *****
Age	*14.73*	*11.31*	*12.84*
	*(0.79) ******	*(1.67) ******	*(1.87) ******
Age^2	*-0.13*	*-0.03*	*-0.04*
	*(0.01) ******	*(0.02)*	*(0.02) **
Men	*72.71*	*82.43*	*85.58*
	*(4.43) ******	*(7.23) ******	*(7.87) ******
Formal employment	*83.27*	*105.38*	*111.95*
	*(5.81) ******	*(10.76) ******	*(12.21) ******
Private health	*145.43*	*134.64*	*134.54*
	*(19.16) ******	*(27.41) ******	*(29.37) ******
Primary education	*-289.98*	*-203.21*	*-150.21*
	*(5.65) ******	*(16.92) ******	*(22.34) ******
Secondary education	*-207.33*	*-156.08*	*-139.82*
	*(4.66) ******	*(7.28) ******	*(8.22) ******
Underemployed	*-270.08*	*-288.14*	*-288.47*
	*(4.40) ******	*(7.42) ******	*(8.16) ******
Head of household	*71.87*	*108.19*	*117.80*
	*(4.86) ******	*(8.14) ******	*(8.92) ******
Observations	*24.028*	*12.062*	*10.497*
Fixed effect per year	*YES*	*YES*	*YES*
Fixed effect by province	*YES*	*YES*	*YES*
Mean income of the group	*344.18*	*479.44*	*504.85*
Impact 2009-2011(%)	*7.48%*	*8.00%*	*10.27%*
Annual impact (%)	*3.67%*	*3.92%*	*5.01%*
R^2	*40.89%*	*36.41%*	*36.36%*

> ***Note: Standard errors in brackets. * Significant at 10%; ** Significant at 5%; *** Significant at 1%.***

These results proved robust to various changes in the threshold levels of penetration used to define the control and treatment groups. Interestingly, when the treatment group threshold is raised to 0.4 connections per 100 inhabitants in 2011 (as opposed to 0.25) the observed impact on labor income for individuals adopting the Internet is significantly larger (9.78% versus 5.01%). This result is important because it suggests the existence of positive externalities of scale as a result of Internet use. In other words, the higher the level of broadband adoption, the greater the impact on income.

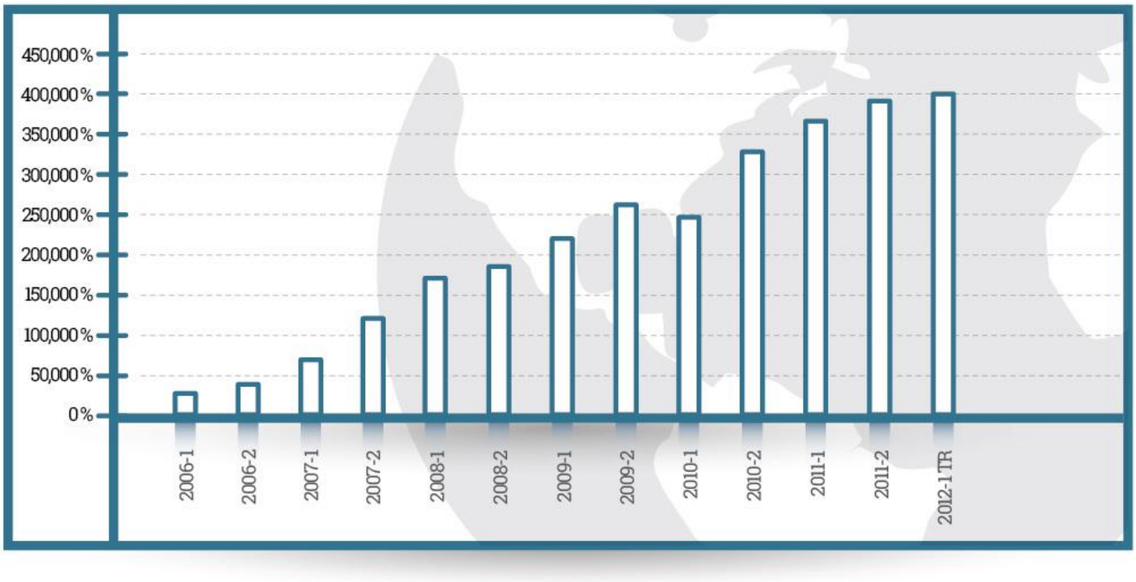
The researchers also investigated whether the observed impact varied by gender. **They found that, on average, the income effect of broadband availability was larger for men than for women. However, when the sample was restricted to those actually using PCs and the Internet, these gender differences vanished.** In other words, while the externality effects of broadband are disproportionately appropriated by men, once women adopt these technologies these differences disappear. The researchers hypothesize that this is due to the different occupations and industries in which men and women are employed. Yet more studies are needed to better understand the gender implications of broadband's impact in Ecuador.

To summarize, the Ecuador case study confirms that broadband availability has a positive effect on income, raising incomes by 7.5% (over a two-year period) in those areas that benefited from the CNT initiative to provide service in districts not previously connected (compared to districts where broadband was already available). This benefit accrued to all workers regardless of whether they in fact adopted broadband services, which suggests that productivity gains by firms and better market performance explain much of these income gains. This is also suggested by null effects on overall employment. Yet these gains were even higher for workers who reported having used the Internet in the last 12 months, which suggests that income and inclusion effects at the individual level also explain part of the reported gains.

4.2 > COLOMBIA CASE STUDY: KEY FINDINGS

In 2011 the Colombian government launched Vive Digital, a large-scale program to promote the development of broadband across the country. The plan was targeted particularly at speeding up broadband investments and adoption in underserved regions. As is the case in most Latin America countries, broadband adoption varies widely within Colombia. For example, Figure 6 shows that business adoption has been growing steadily since 2006, yet a closer look reveals that, by 2011, about half of the connections corresponded to only two provinces (where the cities of Bogotá and Medellín are located), while in the other 29 provinces connectivity levels remained dismally low.

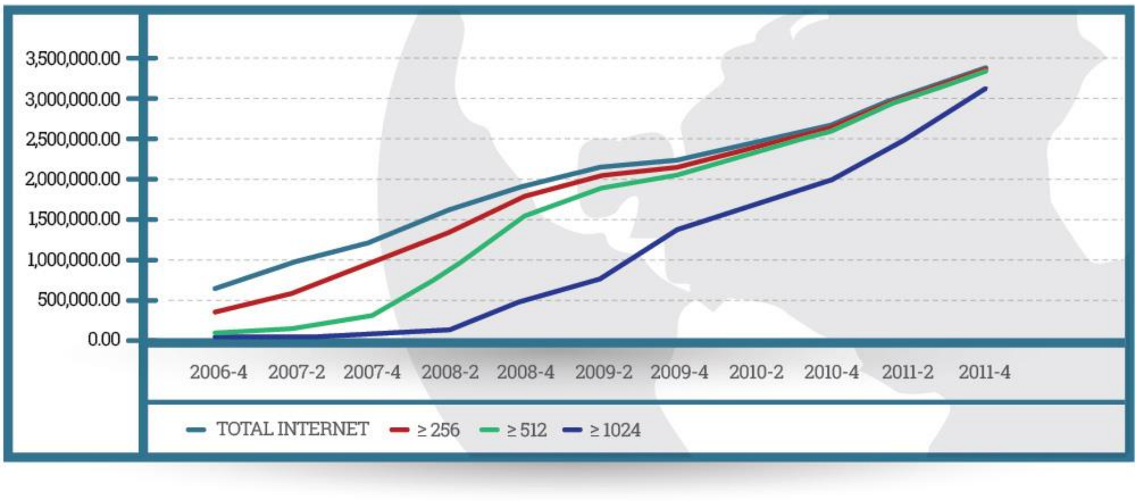
Figure 6: Corporate broadband subscribers (256 Kbps or higher), 2006-2012.



> Source: SIUST, MinTIC

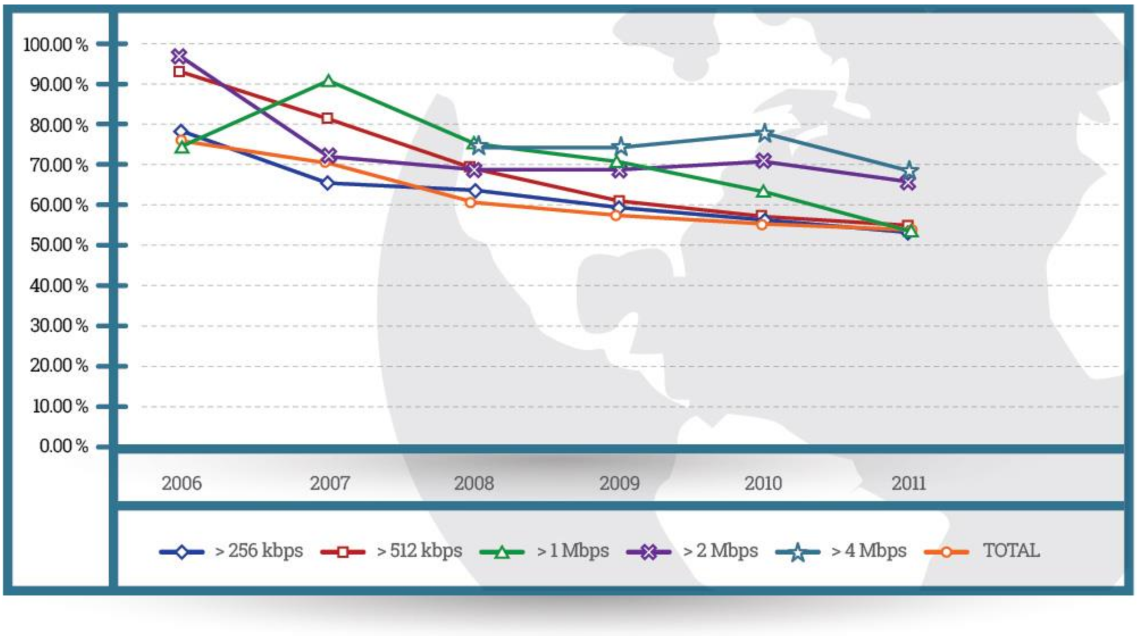
The pattern is similar in the residential segment. Figure 7 presents information for the total number of Internet connections and the total number of connections of at least 256 Kbps or faster, while Figure 8 shows the percentage of those connections concentrated in the cities of Barranquilla, Bogotá, Cali and Medellín, the four most important cities in terms of population and economic activity. These figures reveal several patterns of broadband development in Colombia. The first is that there has been steady growth in the number of households with Internet since the first half of 2007; from the first half of 2008 onwards, this growth is mostly explained by increases in the number of subscribers with connections of at least 512 Kbps. On the other hand, Figure 8 shows a high but slightly decreasing concentration of broadband in the four largest cities.

Figure 7: Total number of Internet and broadband subscribers by speed of connection



> Source: SIUST, MinTIC

Figure 8: Percentage of residential subscribers in four largest cities, 2006-2011



> Source: SIUST, MinTIC

Similar disparities are observed with respect to broadband access by socioeconomic status. Colombia has a long-established household classification system that uses the characteristics of the dwelling and its surrounding environment as indirect indicators of socioeconomic status. Households are classified in six strata, from 1 (low socioeconomic status) to 6 (high). Table 7 presents Internet penetration by socioeconomic level in Colombia between 2007 and 2011. The first result that stands out is the difference in the percentage of connected households in the different strata. At the national level, the average Internet penetration for the wealthiest households (stratum 6) was about 70 times higher in 2007/2008 than for the poorest households (stratum 1). This difference later shrank to about 20 times higher in the period 2009-2011, a significant gain although absolute penetration for the poorest households remained at a paltry 4.2%. Regional disparities are also evident, as connectivity levels outside the main urban centers are significantly lower, even for the wealthiest households. Closing these regional disparities is a key goal of the Vive Digital initiative

Table 7: Households with Internet service by socioeconomic level, 2007-2011 (%)

City	2007-2008						2009-2011					
	Level						Level					
	1	2	3	4	5	6	1	2	3	4	5	6
Country	1.1	4.9	18.0	48.3	62.7	76.1	4.2	15.1	36.4	65.6	74.1	83.6
Main urban centers	1.6	6.0	18.4	49.2	63.7	76.8	6.0	17.9	37.2	66.7	74.9	85.4
Other cities	0.4	0.7	3.6	10.0			1.0	2.7	7.1	19.2	34.4	27.0

> Source: DANE, GEIH

The main question the researchers set out to answer is whether by reducing disparities in broadband access, the Vive Digital program could contribute to mitigating larger socioeconomic disparities in Colombia. With this goal in mind they attempted to estimate how faster broadband adoption at the municipal level was associated with increased economic activity. In order to carry out this empirical exercise, multiple databases were used, including the Integrated Household Survey (GEIH) and industry data from the ICT Ministry (MinTIC). In addition, supplementary information was obtained from the national statistics office (DANE) and the National Planning Department (DNP) for information related to the municipalities' fiscal performance.

A novelty of this case study is that while most existing studies attempt to estimate the welfare impact of broadband based on penetration data for households or individual subscribers, this study differentiates the effect of household adoption from the effect of business adoption. This represents an important contribution to our understanding of the actual mechanisms through which broadband affects economic activity and poverty levels. Another novelty is that the researchers provide estimations for various broadband speed levels, which results in different impact estimates according to broadband quality. The researchers use an instrumental variable approach to mitigate well-known problems of reverse causality between broadband adoption and economic activity.

The following tables present the results of the analysis that links the change in corporate and residential broadband adoption (lagged 1 period) with two proxies of economic activity: tax revenues and the number of firms. It is important to note that for the 1,119 municipalities in the country, the researchers were able to collect information for between 759 and 1,027 municipalities (depending on the variables included in the different regression models), which undoubtedly is a representative sample of Colombian municipalities.

Estimates for the effect of changes in residential and corporate broadband on municipal tax revenues (a first proxy for economic activity) for different broadband speed levels are shown in Tables 8 and 9 respectively. In the tables, column (1) presents the results using average slope of the terrain as an instrument, and column (2) shows the results without the instrumental variable correction.

Overall the results suggest that there is a statistically significant positive relationship between broadband adoption and economic activity at the municipal level. The size of the effect is nonetheless small for both residential and corporate adoption: a 1% increase in residential broadband penetration is associated with an increase of about 0.03% in tax revenues, while a 1% increase in corporate penetration yields an increase of about 0.04% (IV models). Interestingly, there are only slight variations depending on broadband speed levels, which suggests that what really matters is whether households and businesses are connected rather than the quality of connections.

Table 8: The impact of residential broadband on tax revenue

	(1)	(2)	(1)	(2)	(1)	(2)
Ln Broadband >256Kbps	0.0322**	0.0135***				
	(0.0128)	(0.0019)				
Ln Broadband >512Kbps			0.0272***	0.0122***		
			(0.0101)	(0.0017)		
Ln Broadband >1024Kbps					0.0248**	0.0111***
					(0.0101)	(0.0016)
Ln Total income 2005	1.215***	1.215***	1.222***	1.219***	1.227***	1.221***
	(0.0364)	(0.0308)	(0.0374)	(0.0308)	(0.0361)	(0.0308)
Ln School attendance 2005	0.103	0.217	0.107	0.222	0.125	0.223
	(0.28)	(0.20)	(0.28)	(0.20)	(0.27)	(0.20)
Ln Urban pop.	0.483***	0.486***	0.493***	0.486***	0.492***	0.490***
	(0.063)	(0.042)	(0.061)	(0.042)	(0.058)	(0.042)
Ln High-school students pop.	0.0474***	0.0661***	0.0481***	0.0661***	0.0541***	0.0678***
	(0.014)	(0.011)	(0.014)	(0.011)	(0.013)	(0.011)
Ln Residential						
Ln Telephony						
Ln Terrain						
Constant	-3.407***	-4.276***	-3.530***	-4.336***	-3.719***	-4.383***
	(1.275)	(0.947)	(1.299)	(0.947)	(1.231)	(0.946)
Fixed effects by department	yes	yes	yes	yes	yes	yes
Instruments	yes	no	yes	no	yes	no
Observations	5,069	5,463	5,069	5,463	5,069	5,463
R-squared						
Number of municipalities	1,000	1,027	1,000	1,027	1,000	1,027

*> Note: Standard errors in brackets. * Significant at 10%; ** Significant at 5%; *** Significant at 1%.*
(1): Random effects with instruments.
(2): Random effects without instruments.
(3): First-stage results.

Table 9: The impact of corporate broadband on tax revenue

	(1)	(2)	(1)	(2)	(1)	(2)
Ln Broadband >256Kbps	0.0441***	0.0188***				
	(0.015)	(0.003)				
Ln Broadband >512Kbps			0.0369***	0.0200***		
			(0.013)	(0.002)		
Ln Broadband >1024Kbps					0.0294**	0.0177***
					(0.013)	(0.002)
Ln Total income 2005	1.218***	1.219***	1.222***	1.222***	1.230***	1.226***
	(0.052)	(0.031)	(0.047)	(0.031)	(0.038)	(0.031)
Ln School attendance 2005	0.035	0.226	0.047	0.229	0.112	0.230
	(0.406)	(0.202)	(0.358)	(0.202)	(0.275)	(0.202)
Ln Urban pop.	0.529***	0.481***	0.530***	0.478***	0.501***	0.483***
	(0.089)	(0.042)	(0.075)	(0.042)	(0.060)	(0.042)
Ln High-school students pop.	0.0402***	0.0669***	0.0430***	0.0653***	0.0526***	0.0656***
	(0.013)	(0.011)	(0.013)	(0.011)	(0.014)	(0.011)
Ln Residential						
Ln Telephony						
Ln Terrain						
Constant	-3.303*	-4.462***	-3.413**	-4.483***	-3.870***	-4.516***
	(1.870)	(0.944)	(1.652)	(0.943)	(1.273)	(0.944)
Fixed effects by department	yes	yes	yes	yes	yes	yes
Instruments	yes	no	yes	no	yes	no
Observations	5,069	5,463	5,069	5,463	5,069	5,463
R-squared						
Number of municipalities	1,000	1,027	1,000	1,027	1,000	1,027

> Note: Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.
(1): Random effects with instruments.
(2): Random effects without instruments.
(3): First-stage results.

Similarly, Tables 10 and 11 show estimates for the effect of broadband adoption (residential and corporate) on business creation. The presentation of results is similar to that used in Tables 8 and 9 above. Considering the number of firms as a proxy for economic activity, the results reveal that broadband adoption has a positive impact at the municipal level. The estimated impact is still small but significantly higher than in the case of tax revenues: a 1% increase in residential or corporate broadband penetration is estimated to result in an increase of about 0.4% in the number of firms (depending on the model). Again, the impact is roughly similar for different speed levels, confirming earlier findings about the relevance of connectivity rather than quality of service. Another interesting result is that residential adoption has an equally significant effect on the creation of firms as corporate adoption. This suggests that residential broadband can also yield a growth effect through several of the mechanisms discussed in the previous section.

Table 10: The impact of residential broadband penetration on the number of firms

	(1)	(2)	(1)	(2)	(1)	(2)
Ln Broadband >256Kbps	0.468***	0.0267***				
	(0.0433)	(0.0027)				
Ln Broadband >512Kbps			0.378***	0.0255***		
			(0.0312)	(0.0024)		
Ln Broadband >1024Kbps					0.360***	0.0209***
					(0.0353)	(0.0023)
Ln Total income 2005	0.906***	0.898***	1.028***	0.905***	0.886***	0.909***
	(0.0937)	(0.0321)	(0.0921)	(0.0321)	(0.0603)	(0.0321)
Ln School assistance 2005	0.482	0.410*	0.699	0.419*	0.357	0.426*
	(0.68)	(0.22)	(0.67)	(0.22)	(0.38)	(0.22)
Ln Urban pop.	0	0.759***	0	0.760***	0.331***	0.768***
	(0.153)	(0.044)	(0.145)	(0.044)	(0.083)	(0.044)
Ln High-school students pop.	(0)	0.213***	(0)	0.212***	0.160***	0.217***
	(0.050)	(0.016)	(0.044)	(0.016)	(0.041)	(0.016)
Ln Residential						
Ln Telephony						
Ln Terrain						
Constant	2	-4.402***	(1)	-4.496***	0	-4.645***
	(3.204)	(1.040)	(3.121)	(1.039)	(1.853)	(1.040)
Fixed effects by department	yes	yes	yes	yes	yes	yes
Instruments	yes	no	yes	no	yes	no
Observations	5,108	5,120	5,108	5,120	5,108	5,120
R-squared						
Number of municipalities	1,006	1,008	1,006	1,008	1,006	1,008

*> Note: Standard errors in brackets. * Significant at 10%; ** Significant at 5%; *** Significant at 1%.*
(1): Random effects with instruments.
(2): Random effects without instruments.
(3): First-stage results.

Table 11: Impact of corporate broadband penetration on the number of firms

	(1)	(2)	(1)	(2)	(1)	(2)
Ln Broadband >256Kbps	0.484***	0.0399***				
	(0.057)	(0.004)				
Ln Broadband >512Kbps			0.426***	0.0406***		
			(0.047)	(0.003)		
Ln Broadband >1024Kbps					0.204***	0.0332***
					(0.042)	(0.003)
Ln Total income 2005	0.560***	0.904***	0.583***	0.909***	0.514***	0.916***
	(0.044)	(0.032)	(0.040)	(0.032)	(0.027)	(0.032)
Ln School attendance 2005	0.062	0.422*	0.066	0.422*	0.173	0.426*
	(0.239)	(0.223)	(0.219)	(0.223)	(0.145)	(0.223)
Ln Urban pop.	0.253***	0.751***	0.299***	0.752***	0.429***	0.761***
	(0.060)	(0.044)	(0.052)	(0.044)	(0.034)	(0.044)
Ln High-school students pop.	0.395***	0.214***	0.422***	0.210***	0.619***	0.213***
	(0.033)	(0.016)	(0.031)	(0.016)	(0.022)	(0.016)
Ln Residential						
Ln Telephony						
Ln Terrain						
Constant	(0.777)	-4.720***	(1.158)	-4.730***	-2.863***	-4.821***
	(1.216)	(1.038)	(1.100)	(1.038)	(0.759)	(1.039)
Fixed effects by department	yes	yes	yes	yes	yes	yes
Instruments	yes	no	yes	no	yes	no
Observations	5,108	5,120	5,108	5,120	5,108	5,120
R-squared						
Number of municipalities	1,006	1,008	1,006	1,008	1,006	1,008

*> Note: Standard errors in brackets. * Significant at 10%; ** Significant at 5%; *** Significant at 1%.*
(1): Random effects with instruments.
(2): Random effects without instruments.
(3): First-stage results.

In sum, the results for Colombia are relatively robust when considering the relationship between broadband adoption and economic activity. **Further, while much of the literature points to the need to stimulate adoption by businesses, the findings suggest that the effect of household adoption on economic activity is equally important.** Interestingly, no significant differences are found in terms of broadband quality as measured by download speed. Given the low levels of penetration of higher-quality services across municipalities, and the fact that these services have been introduced only recently, the conclusions from this exercise have to be taken as preliminary. However, they corroborate findings from other studies (e.g., Greenstein and McDevitt, 2011) suggesting that the real impact of broadband access takes place when households or businesses are connected, rather than when they upgrade to higher tiers of service.

05. THE IMPACT OF SCHOOL CONNECTIVITY PROGRAMS

5.1 > CHILE CASE STUDY: KEY FINDINGS.

For over 20 years Chile has been actively promoting the introduction of ICTs in schools. ENLACES is probably the best known program. Started in 1992 by the Ministry of Education as a pilot project to introduce PCs in schools and create networks of students and teachers, the program was eventually expanded nationally and branched into several different projects. Among these were the Funds for Broadband and ICT in the Classroom programs.

The Funds for Broadband program, implemented between 2006 and 2010, was designed to subsidize school connectivity in public schools as well as in private schools that receive public subsidies (known together as EES for the Spanish acronym). As of 2007 it was estimated that around 67% of the student population in Chile was enrolled in schools with access to broadband. The program aimed at gradually connecting the remaining students. The initial goal was to connect 3,500 EES schools by 2010, with a start-up cost of US$ 220,000 and an estimated annual cost of US$ 1.7 million. In practice, by 2010 the plan generated subsidies to 4,309 EES schools (out of a total of 9,181) at an annual cost of around US$ 3.5 million. The amount of the subsidy was calculated based on the estimated socioeconomic level of the EES population: it was set at 90% for A (low) and B (medium-low) schools, and at 70% for C (medium-high) or D (high) schools.

The second program, ICT in the Classroom, was a more focused initiative that combined hardware, educational software and teacher training in key ICT domains. Implemented between 2007 and 2011, the program had a goal of reaching 16,000 classrooms. The initiative provided a classroom "kit" consisting of a notebook computer, a multimedia projector, audio equipment and a retractable screen. In addition, the kit included CDs preloaded with educational material in three areas (math, language and natural sciences). Initially targeted at the first to fourth grades, the program was later extended to all primary school grades (first through eighth).

The research team took advantage of the availability of standardized test results for all Chilean schools to evaluate whether these programs had a measurable impact on student performance. Since 1998 the Ministry of Education in Chile has been implementing the Education Quality Measurement System (SIMCE), which measures student performance in three areas: Language and Communication (hereinafter "language"); Mathematics Education (hereinafter "mathematics"), and Understanding of Natural, Social and Cultural Environment (hereinafter "sciences"). Tests are administered in grades four and eight, which allowed researchers to follow the same group of students (a cohort) over time and in relation to whether they attended schools that benefitted from any of the programs described above.

Since only a limited number of schools benefited from the programs, researchers were able to identify a treatment and a control group, and compare results for the same cohort of students over time in each group. This resulted in a dataset with panel data at the school level with two measurement points, namely before and after program implementation. Table 12 presents the information about the student cohorts and test results used for each of the programs under evaluation. SIMCE also provided valuable information about teachers and parents at the school level, thus allowing researchers to examine how socioeconomic variables interacted with the programs under study.

Table 12: Baseline and follow-up information for evaluated cohorts

PROGRAM	EVALUATION COHORT	BASELINE SCORES DATA	FOLLOW-UP SCORES DATA
Funds for Broadband (2006-2008)	2005-2009	SIMCE 4th grade 2005	SIMCE 8th grade 2009
ICT in the Classroom (2007-2011)	2007-2011	SIMCE 4th grade 2007	SIMCE 8th grade 2011

Overall, the findings suggest that both programs have had a very small impact on student learning in math and language. Starting with the Funds for Broadband program, Table 13 shows test results (standardized scores) in language for student cohorts in the control and treatment groups in 2005 (the "before" measurement point) and 2009 (the "after" measurement point).

As shown, students in the treatment group performed better than those in the control group in both years, and in both cases students performed slightly worse in 2009 with respect to 2005. Yet the key observation is that the difference between both groups over time remained essentially the same, which suggests that the program had no effect on the performance of students in the treated group.

Table 13: Cross table of standardized averages: Language

FUNDS FOR BROADBAND PROGRAM	2005	2009	DIFFERENCE
Control group	0.025	-0.089	-0.114***
	(0.005)	(0.006)	(0.008)
Treated group	0.067	-0.032	-0.099***
	(0.005)	(0.005)	(0.007)
Difference	0.042***	0.057***	0.015
	(0.007)	(0.008)	(0.010)

*> Note: Standard errors between parentheses (*** p<0.01; ** p<0.05; * p<0.1).*

Similar results were found for math. As Table 14 shows, students in the treatment group performed better than those in the control group in both measurements, and in this case, both groups improved their performance in 2009 relative to 2005. Yet the key result is that, once again, the difference between groups over time remained the same, suggesting that the program did not alter the advantage that already existed for students in the treatment group.

Table 14: Cross table of standardized averages: Mathematics

FUNDS FOR BROADBAND PROGRAM	2005	2009	DIFFERENCE
Control group	-0.115	0.077	0.192***
	(0.005)	(0.006)	(0.008)
Treated group	-0.068	0.118	0.186***
	(0.005)	(0.005)	(0.007)
Difference	0.046***	0.042***	-0.005
	(0.007)	(0.008)	(0.010)

*> Note: Standard errors between parentheses (*** p<0.01; ** p<0.05; * p<0.1).*

As expected, socioeconomic variables such as household income and parents' education level were found to be strong predictors of test scores, favoring students from more privileged backgrounds. Interestingly, after controlling for these variables, the researchers found that the presence of a computer at home positively affects scores, while in contrast, the availability of Internet at home has a small but statistically significant negative impact on test scores in language and math. This corroborates similar findings obtained in other studies (e.g., Fuchs and Woessmann, 2004; Belo et al., 2010), although the question deserves further studies.

Results for the ICT in the Classroom program are essentially similar. Tables 15 and 16 present a direct comparison of the standardized scores between groups (treated and control) and between periods (2007 and 2011). The data suggests a general improvement in the performance in math over the study period and a small decrease in language scores for both groups. It is also observed that there is a significant difference in the performance of groups, with higher scores for students in the treated group. Again, the key finding is that the difference between groups remains essentially unchanged over time, which suggests that the program did not affect student learning in math or language.

Table 15: Cross table of standardized averages: Language

ICT IN THE CLASSROOM PROGRAM	2007	2011	DIFFERENCE
Control group	-0.020	-0.044	-0.024***
	(0.004)	(0.004)	(0.006)
Treated group	0.063	0.035	-0.028***
	(0.005)	(0.005)	(0.007)
Difference	0.083***	0.079***	-0.004
	(0.007)	(0.007)	(0.010)

*> Note: Standard errors between parentheses (*** p<0.01; ** p<0.05; * p<0.1).*

Table 16: Cross table of standardized averages: Mathematics

ICT IN THE CLASSROOM PROGRAM	2007	2011	DIFFERENCE
Control group	-0.135	0.092	0.227***
	(0.004)	(0.004)	(0.006)
Treated group	-0.054	0.164	0.218***
	(0.005)	(0.005)	(0.007)
Difference	0.081***	0.072***	-0.009
	(0.006)	(0.007)	(0.009)

*> Note: Standard errors between parentheses (*** p<0.01; ** p<0.05; * p<0.1).*

The direct results observed in the previous cross tables were confirmed in the econometric models of difference in differences with and without matching, after controlling for other explanatory variables.

As noted above, many scholars suggest that investments in connectivity have to be complemented with investments in new educational materials and teacher training in order to positively affect learning outcomes. The researchers therefore examined whether students in schools which benefited from both the Funds for Broadband program as well as the ICT in the Classroom program performed better than those in schools which did not participate in either of them. The results were again disappointing, revealing that a combination of both programs did not affect learning outcomes.

Lastly, the researchers looked for different effects within different student populations. Interestingly, they found that the Funds for Broadband program actually had a negative impact on language and math scores for students in schools located in rural areas, suggesting that lack of training diverted the use of broadband to non-educational activities. This is consistent with findings from other studies (e.g., Malamud and Pop Eleches, 2011), and deserves further examination into the reasons why Internet connectivity might negatively affect learning under specific circumstances. By contrast, the ICT in the Classroom program was found to have a positive effect on language test scores (though not on math scores) for students in rural schools, for those from low-income households, and for those who do not have an Internet connection at home. **These findings suggest that, under the right circumstances, programs that integrate hardware and software with teacher training and support can be effective in improving the quality of education for students from less privileged backgrounds.** In sum, government initiatives to mobilize IT in basic education can have a leveling effect for students from poor households, yet the null effects on the larger population suggest that these initiatives have to be carefully targeted, and that investments in content and training are as important as IT investments for such initiatives to succeed.

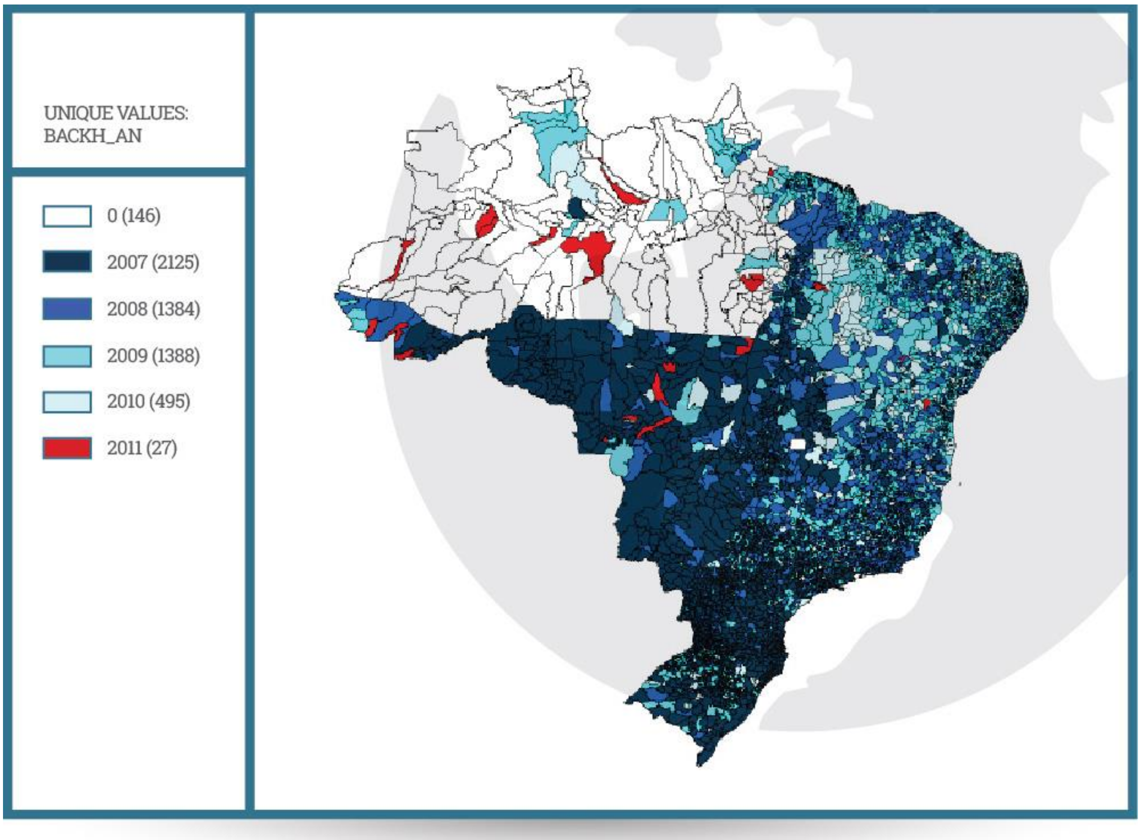
5.2 > BRAZIL CASE STUDY: KEY FINDINGS.

While Brazil is among the better connected countries in the region, connectivity levels vary widely across regions and socioeconomic groups. With the aim of closing these gaps, the government has launched two major broadband initiatives. The first, called the National Broadband Plan, is an ambitious initiative to create a state-owned operator that will operate a national fiber backbone. The second, called the Broadband in Schools Program (PBLE), aimed at providing broadband Internet access to all urban public schools by 2011.

Before the adoption of these initiatives in 2008, it was estimated that about a third of urban schools in Brazil were located in municipalities where broadband services were unavailable. While the rest of the schools were located in municipalities covered by broadband, only 3% of urban public schools in Brazil were in fact connected. Initially, the PBLE targeted 56,685 eligible schools, and determined that 40% of them should be connected by the end of 2008, another 40% by the end of 2009, and the remaining 20% in 2010.

The PBLE target was mostly accomplished by 2011 when approximately 84% of eligible schools were connected, benefiting nearly 24 million students. The schedule of connections between 2008 and 2011 depended heavily on the availability of infrastructure for ADSL-based Internet services in the area, which in turn was related to the distance to the nearest fiber backbone and the presence of a backhaul network. The map in Figure 11 illustrates the phase-in of the program. As observed, the program initially favored schools in the more developed southeast region of the country, and was later extended to the less developed areas in the northeast and Amazon regions.

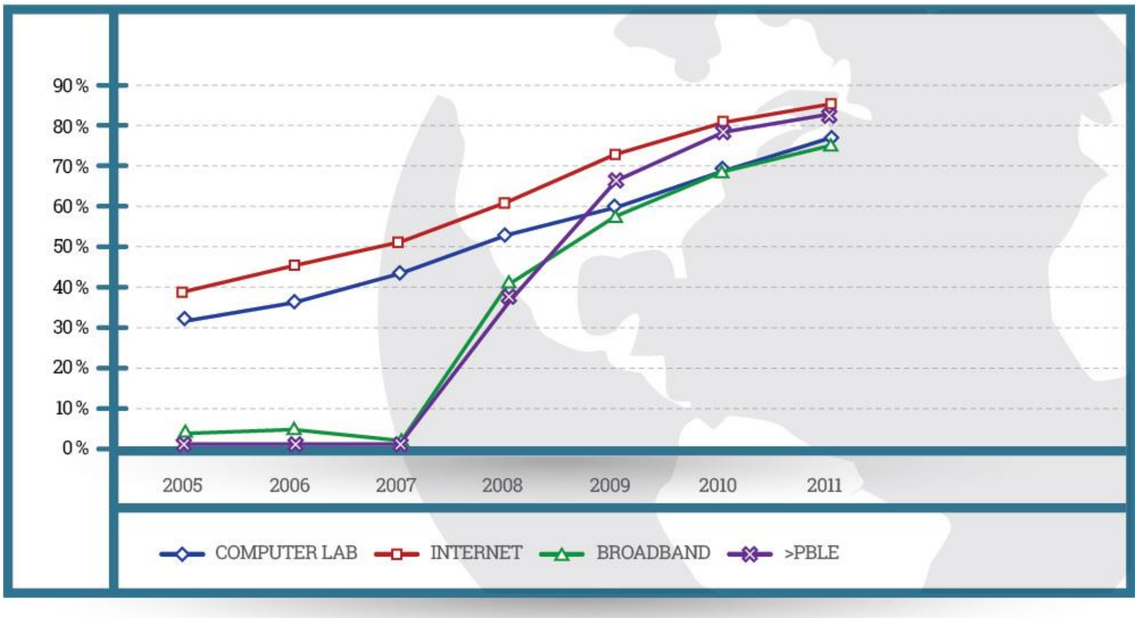
Figure 11: The PBLE implementation map



> Source: Ministry of Education/ANATEL.

The program had a rapid impact on the availability of broadband in Brazilian schools. Figure 12 shows the evolution in the percentage of schools with a computer lab and with Internet or broadband connections over time. It can be observed that most of the gains in broadband connectivity at schools over the past years have been a result of the PBLE initiative.

Figure 12: Urban schools with computer labs, Internet and broadband connections, 2005-2011



> Source: Ministry of Education.

In order to estimate the impact of the program, the researchers took advantage of the availability of detailed data about the implementation of the PBLE provided by the Brazilian telecommunications regulator (ANATEL). Based on this information it was possible to identify for each school the trimester/year in which the school was connected to the Internet, the connection speed, the technology used, and which operator provided the service. This information was merged with educational data from the school census conducted by the Ministry of Education, which includes information about the number of computers at schools, class sizes, and basic information on teachers. In addition, the researchers used information from the bi-annual Prova Brasil, a national standardized tested administered to students in fifth and ninth grade.

All students in these grades from urban public schools with more than 20 students in 2007, 2009 and 2011 were expected to take this test. The test is composed of two sections which measure math and language achievement. The main outcome variables for student achievement are the test scores standardized by grade and year and averaged at the school level. In addition to collecting student information, Prova Brasil also collects information about teachers and principals through a survey that inquires into school activities and perceptions about a variety of school issues, such as the quality of school resources, student behavior, and teaching practices.

The empirical research strategy was based on comparing student achievement and other educational outcomes in schools that benefitted from the PBLE (the treatment group) with schools that did not benefit from the program (the control group). The researchers built a panel of schools and followed the same schools over time to control for other infrastructure changes that might have occurred during the study period. They also took into account the rules of the program and the introduction of physical broadband infrastructure over time, to present instrumental variable estimates that compensate for the fact that schools were not randomly assigned to receive the PBLE program.

The researchers examined the impact of the introduction of broadband in schools for both students and teachers. The first finding confirms that the PBLE program significantly increased the availability of computers connected to the Internet in urban schools as well as the availability of Internet to both students and teachers (see Table 17). The quality of the Internet service available for both teachers and students, as measured by the school principal's perception, also increased significantly. Finally, data from the school census corroborates that the number of computers with Internet for teachers and students increased significantly between 2007 and 2011.

Table 17: Effects of the PBLE on Internet availability at schools

	Internet for students (Yes=1)	Good quality Internet for students (Yes=1)	Internet for teachers (Yes=1)	Good quality Internet for teachers (Yes=1)	# of PCs+Internet for students	# of PCs+Internet for teachers
	(1)	(2)	(3)	(4)	(5)	(7)
Panel A: OLS estimates						
Broadband	0.144	0.124	0.13	0.124	1.55	0.395
	[0.005]***	[0.005]***	[0.005]***	[0.005]***	[0.065]***	[0.064]***
R^2	0.24	0.13	0.23	0.13	0.19	0.07
Observations	111,404	111,404	110,426	110,426	78,714	70,748
Mean dep. var.	0.39	0.24	0.48	0.29	2.89	2.11
Panel B: Instrumental variable estimates						
Broadband	2.262	1.321	0.595	0.33	23.12	3.873
	[0.128]***	[0.095]***	[0.070]***	[0.075]***	[2.143]***	[0.756]***
Observations	111,404	111,404	110,426	110,426	78,714	70,748
Mean dep. var.	0.39	0.24	0.48	0.29	2.89	2.11
School characteristics	Y	Y	Y	Y	Y	Y
School fixed effects	Y	Y	Y	Y	Y	Y
Year effects	Y	Y	Y	Y	Y	Y
State × year effects	Y	Y	Y	Y	Y	Y

> Notes: This table reports the effects of the PBLE on various measures of Internet access at schools. Observations are measured at the school level. Each column presents the results of an OLS regression in Panel A and IV regressions in panel B with school and year fixed effects, and state by year effects. The instrument used in the IV regressions is an interaction between an indicator for whether the municipality was connected to the broadband network in year t-1 and whether the school had a computer lab in year t-1. The dependent variable is listed at the top of each column, and "Broadband" is a dummy that equals 1 if the school reports being connected to a broadband network. The sample consists of urban schools that appear in all three rounds of the Prova Brasil in 2007, 2009, and 2011. The results reported in columns (1) to (4) come from the school principal questionnaire and include data for 2007, 2009 and 2011. The results reported in columns (5) to (8) come from the school questionnaire and it are only available for 2007 and 2009. School characteristics include log of number of students in primary school, students per class, percent female, percent non-white, and a dummy for municipal school. Robust standard errors are displayed in brackets, significantly different from zero at 99 (***), 95 (**), 90 (*) percent confidence.

Having established that the PBLE program improved the availability of ICT infrastructure for urban schools, the researchers examined whether teachers increased their use of ICT in the classroom. The findings show that teachers in schools connected to broadband increased their use of computers and the Internet. When teachers are split between fifth grade and ninth grade, the results show a larger effect for fifth-grade teachers. Moreover, fifth-grade teachers also seem to have changed their classroom activities: as shown in Table 18, the introduction of broadband increases the chances that fifth grade teachers talk about news in the classroom, and use news to teach grammar and math. These positive effects on teaching practices were found to be much weaker for ninth-grade teachers.

Table 18: The effects of broadband on teaching practices

	Use PC (YES=1)	Use Internet (YES=1)	Use DVD (YES=1)	Use books (YES=1)	Use newspaper s (YES=1)	Talk about news (YES=1)	Use news to teach grammar (YES=1)	Use news to teach math (YES=1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: 5th grade OLS estimates								
Broadband	0.05	0.11	0.009	0.001	0.008	0.004	0.012	0.014
	[0.005]***	[0.005]***	[0.003]***	[0.003]	[0.003]***	[0.005]	[0.005]**	[0.005]***
Mean dep var	0.59	0.42	0.90	0.96	0.93	0.58	0.49	0.39
R^2	0.05	0.09	0.01	0	0.01	0.01	0.02	0.01
Observations	218,178	216,369	221,053	149,135	220,134	201,985	201,514	200,699
Panel B: 5th grade Instrumental Variable estimates								
Broadband	1.8	1.595	0.122	0.019	0.079	0.257	0.049	0.19
	[0.179]***	[0.166]***	[0.052]**	[0.039]	[0.048]	[0.090]***	[0.090]	[0.091]**
Mean dep var	0.59	0.42	0.9	0.96	0.93	0.58	0.49	0.39
Observations	213,761	208,496	211,221	139,198	208,513	191,196	190,794	190,395
Panel C: 9th grade OLS estimates								
Broadband	0.03	0.062	0.003	0.002	0	-0.003	0	-0.002
	[0.006]***	[0.006]***	[0.005]	[0.004]	[0.004]	[0.006]	[0.006]	[0.006]
Mean dep var	0.59	0.48	0.76	0.93	0.83	0.40	0.35	0.21
R^2	0.04	0.07	0.03	0.01	0.04	0.01	0.03	0.01
Observations	249,154	248,371	250,833	156,822	253,912	159,414	155,347	156,203
Panel D: 9th grade Instrumental Variable estimates								
Broadband	1.477	1.679	0.133	0.012	0.123	-0.079	0.154	-0.091
	[0.197] ***	[0.215]***	[0.093]	[0.061]	[0.082]	[0.120]	[0.120]	[0.117]
Mean dep var	0.59	0.42	0.90	0.93	0.96	0.32	0.58	0.49
Observations	218,178	216,369	221,053	220,134	149,135	221,388	201,985	201,514
School characteristics	Y	Y	Y	Y	Y	Y	Y	Y
Teacher characteristics	Y	Y	Y	Y	Y	Y	Y	Y
School fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Year effects	Y	Y	Y	Y	Y	Y	Y	Y
State × year effects	Y	Y	Y	Y	Y	Y	Y	Y

> Notes: This table reports the effects of the PBLE on various measures of technology use and teaching practices by teachers. Observations are measured at the teacher level. Each column presents the results of an OLS regression in Panels A and C, and IV regressions in panels B and D with school and year fixed effects and state by year effects. The instrument used in the IV regressions is an interaction between an indicator for whether the municipality was connected to the broadband network in year t-1 and whether the school had a computer lab in year t-1. The dependent variable is listed at the top of each column, and "Broadband" is a dummy that equals 1 if the school reports being connected to a broadband network. The sample consists of urban schools that appear in all three rounds of the Prova Brasil in 2007, 2009 and 2011. All results reported come from the Prova Brasil teacher questionnaire for Math and Portuguese teachers in fifth and ninth grade. School characteristics include log of number of students in primary school, students per class, percent female, percent non-white, and a dummy for municipal school. Teacher characteristics include gender, age indicators, an indicator for a university degree, an indicator for a post-graduate degree, a series of indicators for experience, and a series of indicators for experience in the school. Robust standard errors are displayed in brackets, significantly different from zero at 99 (***), 95 (**), 90 (*) percent confidence.

Next the researchers examined whether broadband Internet access affected student achievement as measured by test scores (Table 19). Interestingly, the results differed across grades. Broadband was found to have a positive effect on learning for fifth graders but not for ninth graders. For fifth-grade students, the improvements are estimated to be between 12% to 15% of a standard deviation in test scores in math and language. These are small but very significant gains, particularly given the short time frame in which the program's impact is being evaluated.

Researchers also examined the impact of broadband on non-cognitive outcomes. In this case, effects were found to be larger for ninth graders. Students in connected schools were about six percentage points (or 8%) more likely to satisfactorily complete the year, and about five percentage points less likely to be held back. These are non-negligible short-term effects, particularly considering that ninth grade is the last year of primary school in Brazil, and passing means the opportunity to enter high school.

Table 19: The effects of broadband on student achievement and attainment

	Test score Portuguese	Test score Math	Pass rate	Repetition rate	Drop-out rate
	(1)	(2)	(3)	(4)	(5)
Panel A: 5th grade OLS estimates					
Broadband	0.008	0.012	-0.214	0.188	0.026
	[0.003]***	[0.003]***	[0.067]***	[0.058]***	[0.033]
R^2	0.09	0.09	0.2	0.14	0.11
Observations	104,068	104,068	107,259	107,259	107,259
Panel B: 5th grade IV estimates					
Broadband	0.119	0.153	2.896	-1.43	-1.461
	[0.046]***	[0.051]***	[1.023]***	[0.891]	[0.478]***
Mean dep var	-0.11	-0.12	86.11	10.81	3.08
Observations	104,068	104,068	107,259	107,259	107,259
Panel C: 9th grade OLS estimates					
Broadband	0	0.003	0.223	-0.109	-0.114
	[0.003]	[0.003]	[0.101]**	[0.089]	[0.060]*
R^2	0.03	0.05	0.1	0.06	0.12
Observations	76,577	76,578	87,197	87,197	87,197
Panel D: 9th grade IV estimates					
Broadband	-0.002	0.073	5.961	-5.204	-0.757
	[0.058]	[0.058]	[1.649]***	[1.456]***	[0.927]
Mean dep var	-0.07	-0.08	78.42	14.92	6.67
Observations	76,577	76,578	87,197	87,197	87,197
Students characteristics	Y	Y	Y	Y	Y
Teacher characteristics	Y	Y	Y	Y	Y
School characteristics	Y	Y	Y	Y	Y
School fixed effects	Y	Y	Y	Y	Y
Year effects	Y	Y	Y	Y	Y
State × year effects	Y	Y	Y	Y	Y

> Notes: This table reports the effects of broadband Internet on test scores, pass rates, repetition rates and drop-out. Observations are measured at the grade/school level. Each column presents the results of an OLS regression in Panels A and C, and IV regressions in panels B and D with school and year fixed effects and state by year effects where the dependent variable is listed at the top of each column. Test scores are standardized by subject, year and grade. "Broadband" is a dummy that equals 1 if the school reports being connected to a broadband network. The sample for test scores consists of schools that appear in all three rounds of the Prova Brasil national standardized test in 2007, 2009 and 2011. The sample for pass and drop-out rates consists of a balanced panel of schools between 2007 and 2011. School characteristics include log of number of students in primary school, students per class, percent female, percent non-white, and a dummy for municipal school. Teacher characteristics include gender, age indicators, an indicator for a university degree, an indicator for a post-graduate degree, a series of indicators for experience, and a series of indicators for experience in the school. Student characteristics include age, gender and race. Robust standard errors are displayed in brackets, significantly different from zero at 99 (***), 95 (**), 90 (*) percent confidence.

Finally, the researches also looked measures of student behavior using data from surveys administered to teachers and school principals. The intuition was that the availability of broadband within schools could also engage students more positively and thus reduce disciplinary problems. These results also proved very significant (Table 20). Fifth-grade teachers reported a significant reduction in student absenteeism, in disciplinary problems, and in verbal and physical aggression. These effects are very significant and large (a 40% to 50% reduction in some specifications). However, these effects did not hold for ninth graders.

Table 20: The effects of broadband on absenteeism and student discipline

	Student absenteeism (Y=1)	Disciplinary problems (Y=1)	Verbal and physical aggression (Y=1)	Teacher victim of theft (Y=1)	Student drugs and alcohol (Y=1)	Student guns (Y=1)
Panel A: 5th grade OLS						
Broadband	-0.001	-0.008	-0.007	-0.005	-0.001	-0.003
	[0.005]	[0.005]*	[0.005]	[0.003]	[0.003]	[0.003]
R^2	0.01	0.01	0.02	0.07	0.1	0.09
Observations	216,465	218,461	230,473	230,473	230473	230473
Mean dep var	0.38	0.7	0.29	0.08	0.04	0.06
Panel B: 5th grade IV						
Broadband	-0.191	-0.273	-0.185	0.006	-0.007	0.034
	[0.099]*	[0.097]***	[0.091]**	[0.054]	[0.042]	[0.046]
Observations	202,500	203,476	208,454	208,454	208454	208454
Mean dep var	0.38	0.7	0.29	0.08	0.04	0.06
Panel C: 9th grade OLS						
Broadband	0.004	0.005	-0.005	-0.004	0	0
	[0.006]	[0.005]	[0.005]	[0.003]	[0.004]	[0.003]
R^2	0.01	0.01	0.01	0.07	0.03	0.06
Observations	251,143	252,921	264,654	264,654	264,654	264,654
Mean dep var	0.51	0.8	0.36	0.06	0.16	0.07
Panel D: 9th grade IV						
Broadband	-0.18	-0.147	0.059	0.11	0.122	0.023
	[0.118]	[0.092]	[0.104]	[0.056]**	[0.083]	[0.057]
Observations	238,602	239,634	244,661	244,661	244,661	244,661
Mean dep var	0.51	0.8	0.36	0.06	0.16	0.07
Students characteristics	Y	Y	Y	Y	Y	Y
School characteristics	Y	Y	Y	Y	Y	Y
School fixed effects	Y	Y	Y	Y	Y	Y
Year effects	Y	Y	Y	Y	Y	Y
State × year effects	Y	Y	Y	Y	Y	Y

> Notes: This table reports the effects of the PBLE on various measures of absenteeism and student discipline from teacher perceptions. Observations are measured at the teacher level. Each column presents the results of an OLS regression in Panels A and C, and IV regressions in panels B and D with school and year fixed effects and state by year effects. The instrument used in the IV regressions is an interaction between an indicator for whether the municipality was connected to the broadband network in year t-1 and whether the school had a computer lab in year t-1. The dependent variable is listed at the top of each column, and "Broadband" is a dummy that equals 1 if the school reports being connected to a broadband network. The sample consists of urban schools that appear in all three rounds of the Prova Brasil in 2007, 2009 and 2011. All results reported come from the Prova Brasil teacher questionnaire for Math and Portuguese teachers in fifth and ninth grade. School characteristics include log of number of students in primary school, students per class, percent female, percent non-white, and a dummy for municipal school. Teacher characteristics include gender, age indicators, an indicator for a university degree, an indicator for a post-graduate degree, a series of indicators for experience, and a series of indicators for experience in the school. Robust standard errors are displayed in brackets, significantly different from zero at 99 (***), 95 (**), 90 (*) percent confidence.

To summarize, the findings reveal that the PBLE, within a few years of its implementation, has had a measurable impact on teaching practices and educational outcomes (both cognitive and behavioral) in Brazilian primary schools. **The researchers established that the program had first-order impacts: it not only increased the availability of broadband Internet in urban public schools (for both teachers and students), but most importantly, it triggered new teaching practices such as talking about current news in the classroom and using news to teach grammar and math to fifth graders.**

In terms of second-order impacts, the PBLE was found to have small but positive effects on student achievement as measured by test scores. Not surprisingly, these effects were found for fifth graders but not ninth graders, since teachers for the first group reported significant changes in teaching practices as a result of the program. In other words, first-order impacts on the availability of Internet connectivity were followed by the adoption of new teaching practices for fifth graders, which resulted in small but measurable learning gains in the short term. Teaching practices for ninth graders seemed to be unaffected by the program, thus yielding null effects on learning.

On the other hand, non-cognitive outcomes were found to be stronger among older students, as ninth graders in connected schools were found less likely to drop out and more likely to pass than those in schools where Internet connectivity remains unavailable. Finally, the researchers found significant reductions in disciplinary problems (particularly for fifth graders) as reported by teachers, suggesting that the PBLE has made a contribution to creating a healthier educational environment for Brazilian students, which may lead to further improvements in learning outcomes for the coming cohorts.

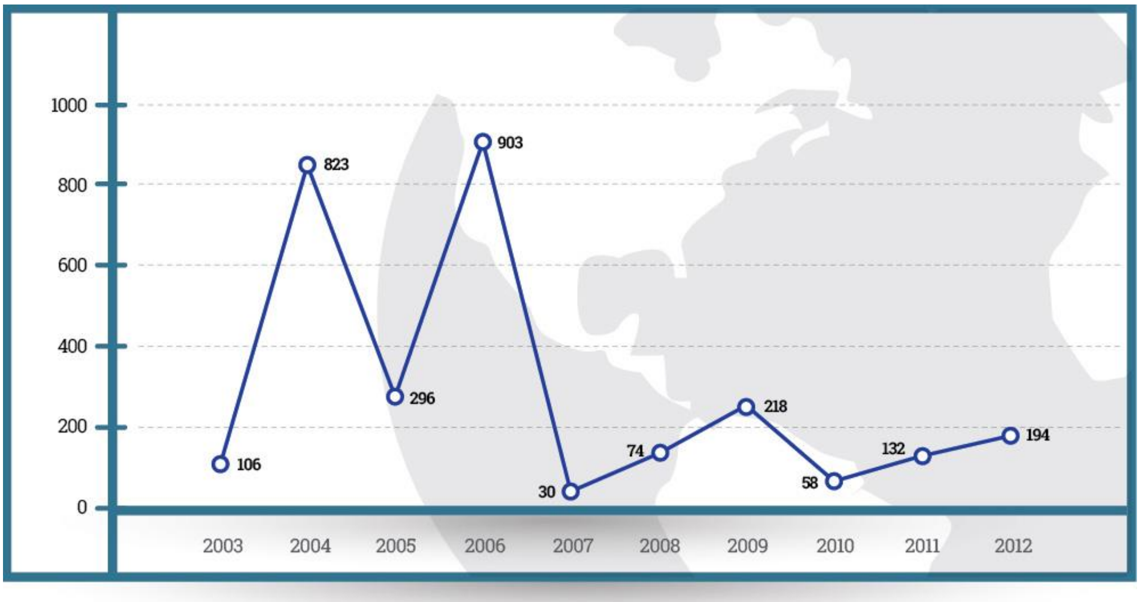
The researchers further examined whether these effects varied by region or level of income. The positive effects described above were found to be larger in wealthier municipalities, suggesting an interaction with socioeconomic variables outside the school environment. They also looked at whether teacher quality and other characteristics affected the results. Not surprisingly, the results revealed that younger teachers tend to make more use of broadband in the classroom. Yet neither teacher training nor age seemed to alter the impact of broadband on learning outcomes. Further studies will be needed to understand how different teachers and different school environments affect the results reported in this case study.

5.3 > PERU CASE STUDY: KEY FINDINGS.

In contrast to Brazil, the development of broadband infrastructure in Peru has been generally slow. This is reflected in the low level of connectivity for Peruvian schools. Only 30% of all Peruvian schools (both public and private) had an Internet connection by 2012. This level is considerably below other countries such as Brazil and Chile, where, as discussed in the previous sections, large-scale government initiatives have significantly increased school connectivity in recent years. Further, only 18% of public schools were connected to the Internet, putting lower-income students at a considerable disadvantage with respect to those from more privileged family backgrounds. Not surprisingly, connectivity levels were even lower in rural schools (only 9%).

To address these disparities, the Peruvian government has launched several initiatives aimed at improving ICT infrastructure in public schools. Among them is the Huascarán Project, an initiative launched in 2001 to subsidize Internet connectivity in public schools across the country. The project was started as a stand-alone program in 2003, and in 2007 it was absorbed by the recently created General Directorate of Educational Technologies (DIGETE). As Figure 13 shows, after 2007 the program was kept alive but the number of new schools connected decreased significantly, as priorities shifted in favor of other programs such as OLPC.

Figure 13: Number of schools connected by DIGETE, 2003-2012



> *Source: DIGETE.*

> The key questions that the researchers set out to answer were:

- *Whether students from schools with Internet connectivity in a given year performed better on a number of educational outcomes compared to those from schools without Internet connectivity.*
-
- *Whether students from schools that received the connectivity subsidy from the Huascarán Project performed better on a number of educational outcomes compared to those from schools that did not receive the subsidy.*

> The methodological strategy was based on available data from three different sources:

- *Information from DIGETE about the schools receiving the connectivity subsidy by year.*
- *The School Census (CE), conducted annually since 1998 by the Ministry of Education (MINEDU).*
- *The School Census Evaluation (ECE), a standardized national test administered since 2007 to second-grade students in two subject areas: reading comprehension and logic-mathematics.*

The researchers built a panel database at the school level based on common observations between ECE and EC for the period 2007-2011. The identification of Internet access and broadband connectivity was made with CE and DIGETE data. The characteristics of each school were obtained from the CE, and the outcome variables from the ECE. The key outcome variable was the percentage of second-grade students who achieved satisfactory performance levels in reading comprehension and logic-mathematics. In order to control for the characteristics of the district where the school is located, the researchers used the National Population Census of 2007 and the Poverty Map database, constructed from the National Census of 2007.

To unambiguously determine whether Internet or broadband availability had any effect on student achievement would require knowing what would have happened to students in connected schools had they not been connected. Clearly, this second scenario is impossible to observe. This is the fundamental problem of any impact assessment: finding the counterfactual. The panel database allowed researchers to apply two econometric techniques to build credible counterfactuals: differences-in-differences (DD) and differences in differences with propensity score matching (DD-PSM). In essence, the DD method consists of comparing the change in the outcome variable of schools with Internet access (the treatment group) to the change in schools that did not receive the service (the control group). The DD-PSM method adds an important element: rather than comparing average scores for all schools in the two groups, comparisons are made between schools with similar characteristics, thus strengthening the results. Schools which received the subsidy in one year but not the following years were dropped from the sample, as were schools which received the subsidy but reported not having PCs.

As schools for which test scores are available were connected progressively over the 2007-2011 period, the researchers were able to construct several comparison groups as shown in Table 21.[4]

[4] Because the ECE was only administered to a small sample of schools in 2008, results for two different panels are reported: first, a smaller panel for the full period 2007-2011, and second, a larger panel which excludes ECE results for 2008.

Table 21: The impact of connectivity: Comparison groups

GROUPS	CONNECTED=1, NOT CONNECTED=0					# OF SCHOOLS (PANEL 2007-11)	# OF SCHOOLS (PANEL 2007, 2009-11)
	2007	2008	2009	2010	2011		
I	0	1	1	1	1	69	157
II	0	0	1	1	1	75	141
III	0	0	0	1	1	157	327
IV	0	0	0	0	1	285	1,032
V	0	0	0	0	0	1,300	8,836
Total						1,886	10,493

> Source: ECE 2007-2011, CE 2007-2011 and DIGETE.

Two general types of comparisons are made: cumulative effects over the entire period (t+k) and effects in the year immediately after schools are connected (t+1). This resulted in the following evaluation scheme (Table 22).

Table 22: Evaluation scheme

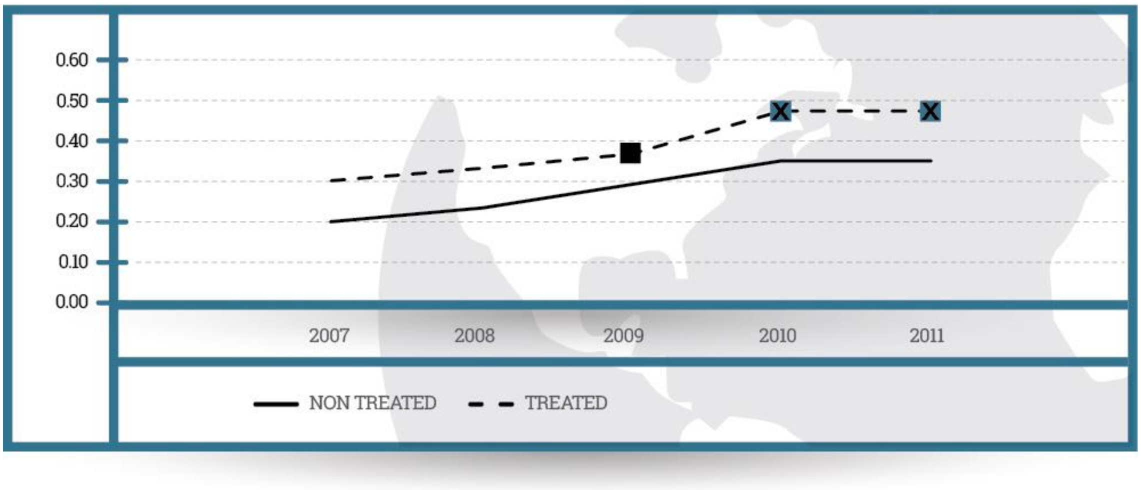
I - Cumulative effects (full period of connectivity)			
Group	**Performance in year t+k with respect to year t-1**		
I vs. IV+V	2009	2010	2011
II vs. IV+V		2010	2011

II - Immediate effects (1 year after connectivity)	
Group	**Performance in year t+1 with respect to year t-1**
I vs. II+III+IV+V	2009
II vs. III+IV+V	2010
III vs. IV+V	2011

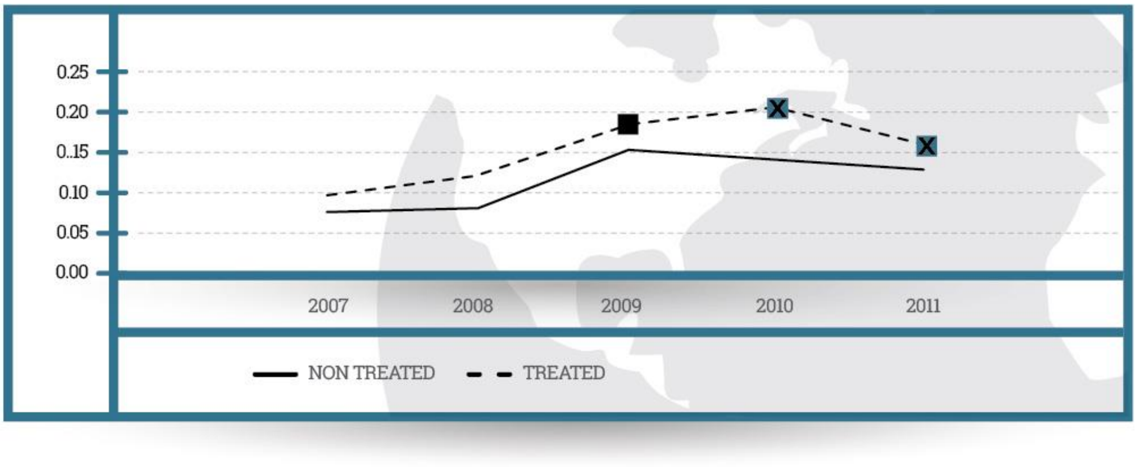
A strong assumption of the DD technique is that the treatment and control groups would have evolved similarly in the absence of the treatment (in this case, in the absence of Internet connectivity) in the outcome variable of interest (in this case, student achievement). Figures 14 a through 14 d graph the evolution of the outcome variable of interest (the percentage of second graders who achieved satisfactory performance on reading comprehension and logic-mathematics) for two evaluation scenarios: group II (schools connected in 2009) and group III (schools connected in 2010). As shown, in the period before the treated schools were connected (2007-2008 in the first case and 2007-2009 in the second), both groups of schools (treated and control) presented similar upward tendencies in test scores. The assumption is therefore that any divergences thereafter could be attributable to the impact of Internet availability within the schools.

Figures 14 a to 14 d: Percentage of students achieving satisfactory performance on test, 2007-2010

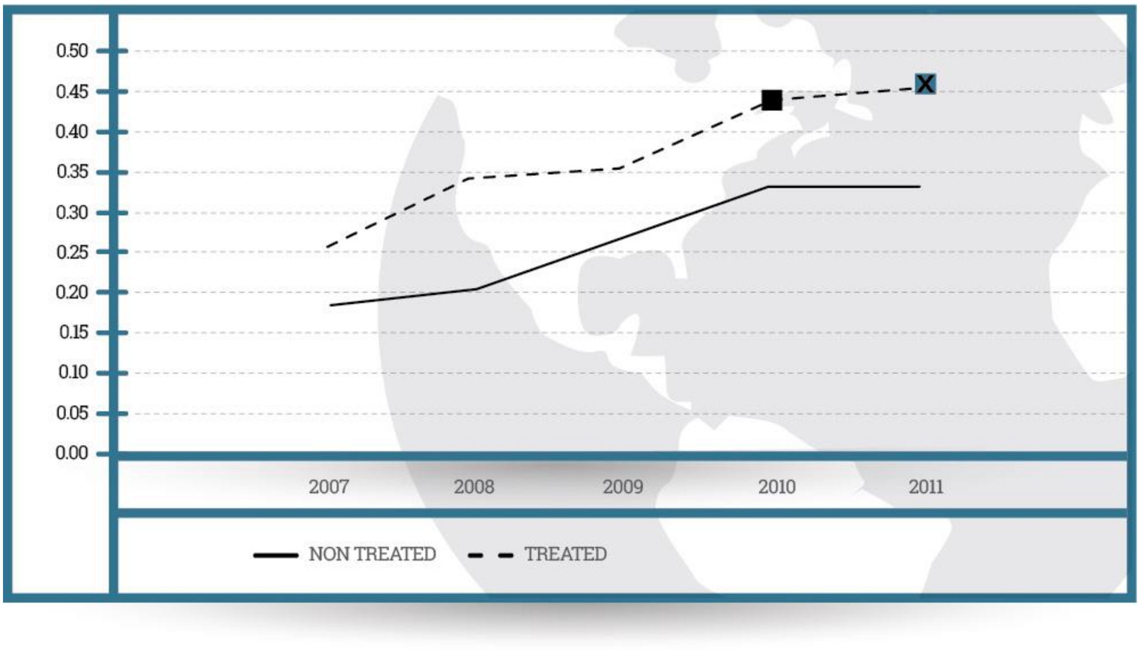
a. Group II (t=2009), reading comprehension



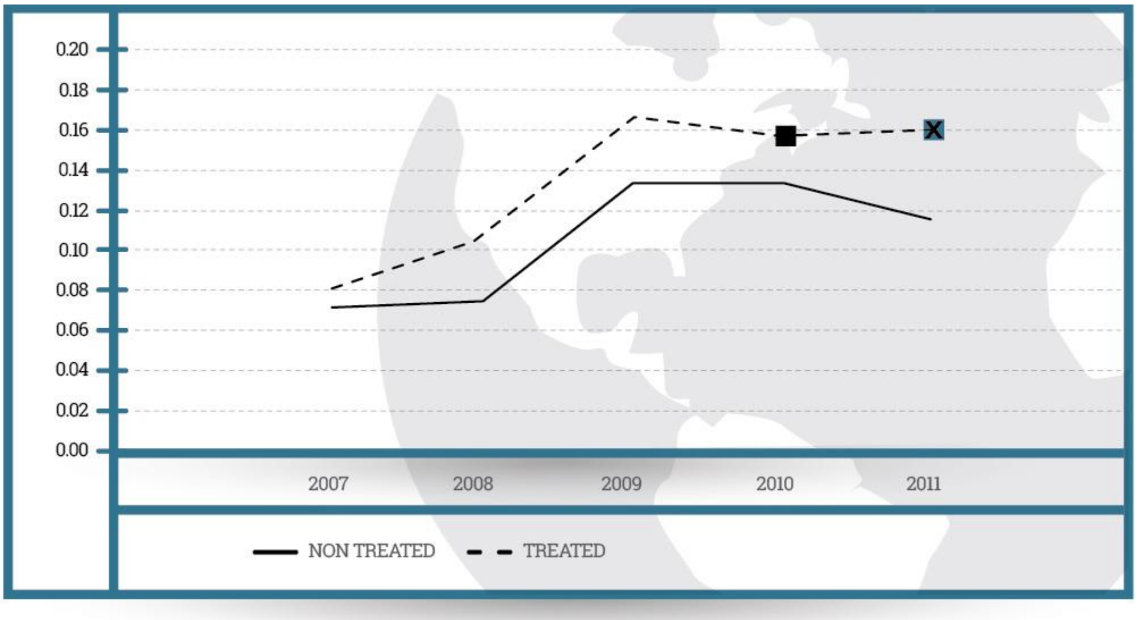
b. Group II (t=2009), logic-mathematics



c. Group III (t=2010), reading comprehension



d. Group III (t=2010), logic-mathematics



> Sources: CE and ECE (2007-2011).

The key results are presented in Tables 23 and 24.[5] Considering the full period of connectivity (Table 23 of cumulative effects), the DD estimator suggests that, without controlling for observable characteristics, Internet access yielded an increase of about 8% in the percentage of students reaching a satisfactory performance in logic-mathematics. Similar effects are observable in reading comprehension when using the larger sample of schools (2007 and 2009-2011). However, when controls are introduced with different PSM techniques (one-to-one, radius and kernel), the strength of the impact is reduced and becomes observable only in the larger panel of schools and at the 90% confidence level.

Considering the more immediate impact (Table 24 of one-year effects), similar positive results are obtained for logic-mathematics scores in both samples, although once again these results are not consistent across PSM specifications. Nonetheless, the impact on reading comprehension scores is found to be essentially null in both samples.

[5] Results are presented for three different PSM techniques: one-to-one, radius and kernel.

Table 23: Cumulative effects of Internet connectivity

Panel 2007-2011										
	Reading comprehension					Logic-mathematics				
	DD without controls	DD w/ linear controls	DD-PSM			DD without controls	DD with linear controls	DD-PSM		
			One to one	Radius	Kernel			One-to-one	Radius	Kernel
Group I vs IV+V: Internet connectivity in t=2008 evaluated in t-1 vs t+1, t+2 y t+3										
$b_{2009-07}$	-0,031	0.025	-0.045	0.042	-0.033	0.084***	0.062	0.048	0.054	0.111
	(0.235)	(0.050)	(0.090)	(0.078)	(0.068)	(0.198)	(0.038)	(0.072)	(0.059)	(0.068)
$b_{2010-07}$	0.006	0.030	-0.018	0.009	0.037	0.079***	0.041	0.022	0.034	0.092
	(0.231)	(0.049)	(0.075)	(0.085)	(0.062)	(0.226)	(0.046)	(0.082)	(0.072)	(0.073)
$b_{2011-07}$	0.044	0.080+	0.047	0.077	0.084	0.066***	0.070+	0.052	0.012	0.066
	(0.236)	(0.048)	(0.078)	(0.075)	(0.057)	(0.206)	(0.040)	(0.072)	(0.061)	(0.058)
N	367	236	236	236	236	367	236	236	236	236
Group II vs IV+V: Internet connectivity in t=2009 evaluated in t-1 vs t+1, t+2										
$b_{2010-08}$	0.028	-0.000	0.009	0.001	0.008	0.030	0.048	0.059	0.060	0.056
	(0.232)	(0.039)	(0.058)	(0.054)	(0.039)	(0.193)	(0.036)	(0.051)	(0.044)	(0.036)
$b_{2011-08}$	0.026	0.001	-0.029	0.015	0.002	-0.007	-0.001	-0.012	0.005	0.005
	(0.217)	(0.039)	(0.054)	(0.051)	(0.042)	(0.175)	(0.031)	(0.038)	(0.033)	(0.025)
N	492	292	292	292	292	492	292	292	292	292

Panel 2007, 2009-2011										
	Reading comprehension					Logic-mathematics				
	DD without controls	DD with linear controls	DD-PSM			DD without controls	DD with linear controls	DD-PSM		
			One to one	Radius	Kernel			One-to-one	Radius	Kernel
Group I vs IV+V: Internet connectivity in t=2008 evaluated in t-1 vs t+1, t+2 y t+3										
$b_{2009-07}$	0.016	0.019	0.045	0.021	0.021	0.090***	0.028	0.026	0.012	0.029
	(0.216)	(0.027)	(0.039)	(0.034)	(0.031)	(0.218)	(0.027)	(0.039)	(0.036)	(0.031)
$b_{2010-07}$	0.048***	0.005	0.051	0.011	0.001	0.081***	0.005	0.009	0.003	0.011
	(0.210)	(0.025)	(0.043)	(0.0389	(0.04)	(0.224)	(0.026)	(0.051)	(0.036)	(0.043)
$b_{2011-07}$	0.087***	0.035	0.075+	0.045	0.044	0.075***	0.017	0.078+	0.038	0.046+
	(0.208)	(0.025)	(0.041)	(0.032)	(0.031)	(0.206)	(0.025)	(0.046)	(0.034)	(0.028)
N	1,558	1,066	1,066	1,066	1,066	1,558	1,066	1,066	1,066	1,066

*> Note: Significance level: *** 0.01%, ** 0.05%, + 0.1%.*

Table 24: One-year effects of Internet connectivity

	Panel 2007-2011									
	Reading comprehension					Logic-mathematics				
	DD without controls	DD with linear controls	DD-PSM			DD without controls	DD with linear controls	DD-PSM		
			One to one	Radius	Kernel			One-to-one	Radius	Kernel
	Group I vs II+III+IV+V: Internet connectivity in t=2008 evaluated in t-1 vs t+1									
$b_{2009-07}$	-0.015	0.024	0.023	0.037	0.062	0.081***	0.073**	0.070	0.070	0.091**
	(0.225)	(0.041)	(0.059)	(0.053)	(0.048)	(0.189)	(0.033)	(0.052)	(0.057)	(0.046)
N	594	373	373	373	373	594	373	373	373	373
	Group II vs III+IV+V: Internet connectivity in t=2009 evaluated in t-1 vs t+1									
$b_{2010-08}$	0.034	0.009	0.022	0.025	0.005	0.031	0.048	0.041	0.055	0.047
	(0.226)	(0.037)	(0.051)	(0.038)	(0.035)	(0.186)	(0.033)	(0.041)	(0.044)	(0.035)
N	640	372	372	372	372	640	372	372	372	372
	Group III vs IV+V: Internet connectivity in t=2010 evaluated in t-1 vs t+1									
$b_{2011-09}$	0.0409**	0.022	-0.015	-0.001	0.018	0.012	0.018	0.025	0.004	0.020
	(0.236)	(0.028)	(0.036)	(0.036)	(0.029)	(0.191)	(0.022)	(0.031)	(0.026)	(0.025)
N	828	381	373	373	373	828	381	373	373	373

Panel 2007, 2009-2011										
	Reading comprehension					Logic-mathematics				
	DD without controls	DD with linear controls	DD-PSM			DD without controls	DD with linear controls	DD-PSM		
			One to one	Radius	Kernel			One-to-one	Radius	Kernel
Group I vs II+III+IV+V: Internet connectivity in t=2008 evaluated in t-1 vs t+1										
$b_{2009-07}$	0.0213	0.016	0.041	0.025	0.024	0.087***	0.037	0.066**	0.049+	0.052**
	(0.218)	(0.025)	(0.04)	(0.024)	(0.023)	(0.214)	(0.024)	(0.032)	(0.026)	(0.025)
N	2,178	1,430	1,430	1,430	1,430	2,178	1,430	1,430	1,430	1,430
Group III vs IV+V: Internet connectivity in t=2010 evaluated in t-1 vs t+1										
$b_{2011-09}$	0.0642***	0.033+	0.040	0.030+	0.035**	0.003	0.015	0.019	0.017	0.016
	(0.232)	(0.018)	(0.024)	(0.016)	(0.016)	(0.201)	(0.015)	(0.023)	(0.015)	(0.014)
N	2,178	2,506	2,454	2,454	2,454	2,178	2,506	2,454	2,454	2,454

> Note: Significance level: *** 0.01%, ** 0.05%, + 0.1%.

Not all schools connected by the Huascarán Project before 2010 had access to broadband services (some received slower connections). Researchers thus examined whether the impact of Internet connectivity on student achievement would be different when considering only schools connected to broadband. For this exercise a different control group was constructed following similar criteria to those used by the Huascarán Project. Given that in this exercise the treatment group is considerably smaller, the researchers proposed two alternative evaluation schemes. In the first one, all schools connected to broadband by 2010 are considered. In the second, schools connected to broadband in 2010 but which already had Internet connectivity previous to broadband are excluded from the treatment group.

As shown in Table 25 the results were in fact much less encouraging. The impact of broadband was found to be positive only in one specification (for reading comprehension in Model 2 for the DD estimator without controls). Controlling for observable characteristics, all estimators are not statistically different from zero. These results suggest that having Internet connectivity in the school is more relevant than the quality of service available. However, these results deserve further studies given the relatively small number of schools in the treated group.

Table 25: One-year effects of broadband connectivity

Model 1: Broadband connectivity in 2010					
	Reading comprehension				
	DD without controls	DD with linear controls	DD-PSM		
			One-to-one	Radius	Kernel
$b_{2011-09}$	0.038	0.005	0.002	-0.007	0.015
	(0.201)	(0.036)	(0.039)	(0.027)	(0.025)
	Logic-mathematics				
	DD without controls	DD with linear controls	DD-PSM		
			One-to-one	Radius	Kernel
$b_{2011-09}$	-0.011	-0.021	-0.001	-0.024	-0.013
	(0.175)	(0.032)	(0.036)	(0.017)	(0.016)
N	1,912	1,383	1,383	1,383	1,383

Model 2: Broadband connectivity in 2010 and no Internet connectivity in 2009					
	Reading comprehension				
	DD without controls	DD with linear controls	DD-PSM		
			One-to-one	Radius	Kernel
$b_{2011-09}$	0.0752**	0.073	0.019	0.053	0.015
	(0.201)	(0.051)	(0.051)	(0.044)	(0.025)
	Logic-mathematics				
	DD without controls	DD with linear controls	DD-PSM		
			One-to-one	Radius	Kernel
$b_{2011-09}$	0.001	-0.028	-0.023	-0.034	-0.022
	(0.176)	(0.044)	(0.035)	(0.022)	(0.017)
N	1,895	1,368	1,368	1,368	1,368

*> Note: Significance level: *** 0.01%, ** 0.05%, + 0.1%.*

Table 26 summarizes the results obtained in this study. Overall, the picture that emerges is of mixed results. The positive impact of Internet connectivity appears to be stronger for logic-mathematics than for reading comprehension, although these results are sensitive to the different specifications. Given the numerous challenges faced by teachers in Peruvian schools, and the lack of investment in teacher training and educational content associated with the Huascarán Project initiative, the lack of strong evidence about a positive impact is hardly surprising.

Table 26: Summary of results

Cumulative effects				
	Full panel (2007-2011)		Reduced panel (2007, 2009-2011)	
	Reading comprehension	Logic-mathematics	Reading comprehension	Logic-mathematics
$b_{2009-07}$	0	0	0	0
$b_{2010-07}$	0	0	0	0
$b_{2011-07}$	0-8%$^{+}$(OLS)	0-7%$^{+}$(OLS)	0-7.5%$^{+}$(OLS)	4.6%$^{+}$(kernel) - 7.8^{+}(one-to-one)
$b_{2010-08}$	0	0		
$b_{2011-08}$	0	0		
One-year effects				
	Full panel (2007-2011)		Reduced panel (2007, 2009-2011)	
	Reading comprehension	Logic-mathematics	Reading comprehension	Logic-mathematics
$b_{2009-07}$	0	7.3**(OLS) - 9.1%**(kernel)	0	4.9%+(radius) - 6.6%**(one-to-one)
$b_{2010-08}$	0	0		
$b_{2011-09}$	0	0	3%$^{+}$(radius) - 3.5%**(kernel)	0

*> Note: Significance level: *** 0.01%, ** 0.05%, + 0.1% (estimation method in parentheses).*

As several authors argue (e.g., Warschauer, 2003), unreasonable expectations about the role of technology often delay necessary investments in content and human capital in school connectivity programs. **However, it may also be that the positive impact of connectivity, at least in the short term, is in creating a more nurturing educational environment for both teachers and students (as the case of Brazil suggested), which over time promotes better learning.** This suggests the need for further evaluation studies that track the performance of Peruvian students in the coming years.

06. THE INFORMATIONAL LIVES OF THE POOR: AN EXPLORATORY STUDY IN MEXICO

In this study the research team sought to generate evidence about the impact of new ICTs (especially broadband) on poverty by looking at the patterns of ICT adoption in three low-income communities in Mexico: Las Margaritas (San Luis Potosí), Santiago Nuyoo (Oaxaca), and Cruz del Palmar, Estancia de Canal and Los Torres on the outskirts of San Miguel de Allende (Guanajuato). The *livelihoods approach* provided the main analytical framework for the study. This approach conceives ICTs as a tool to strengthen a wide range of social and political assets that contribute to the well-being of the poor. **The key question is whether and how ICT access enhances the capabilities of members of low-income communities.**

Using this analytical framework, a qualitative study was designed to explore whether patterns of information seeking and communication networks were affected by the adoption of new ICTs in the communities. The selection of communities was based on geographical variations and different socio-demographic conditions. Las Margaritas is a remote rural community, Santiago Nuyoo is a semi-rural community, and the locations near San Miguel de Allende are semi-urban. Moreover, each of the locations had different levels of access to ICTs: Las Margaritas has no connectivity to ICT services; Santiago Nuyoo has fixed shared access to broadband as well as a mobile banking service that allows for local voice/text messaging; and finally the communities around San Miguel de Allende benefit from all ICT services due to their proximity to higher-income communities.

The researchers planned the fieldwork according to the specific characteristics of the three communities. Las Margaritas represented a control case, revealing the high costs associated with life in a remote community not connected to ICTs. In Santiago Nuyoo, researchers were able to examine changes in information seeking patterns among local residents, comparing shared broadband access with a local-only mobile service and the additional value of mobile payments. In the three small communities around San Miguel de Allende, researchers examined the results of an intervention in which local students were offered a high-quality tablet with mobile broadband service as well as training.6 Figure 15 summarizes the setup of the study:

Figure 15: ICT connectivity in the three communities

Fieldwork was carried out between November 2012 and April 2013, and included 31 in-depth interviews, field observations, diaries and visual registries with key members of the communities. In all three cases, a local non-profit organization with extensive local operations was instrumental in helping the research team identify key community leaders and elicit cooperation from community members.

The results of the study show that one of the key benefits of broadband is the increased access to information not available within the community. However, the results also confirm the finding from numerous other studies that access must be accompanied with capacity-building initiatives. For example, testimonies obtained in Las Margaritas revealed that, even in unconnected communities, local residents have strong beliefs about the Internet and its possible uses. These preconceptions tend to limit the use and adoption of Internet services once they become available: for example, new adopters tend to use the Internet to search for a very limited range of information. Another common belief is that the Internet's main benefit is to support education for the younger generations. However, when access to ICT is complemented with training about information resources such as contact with local governments, social programs or business-related information, searching practices tend to broaden significantly.

Another strong belief among the population at the bottom of the pyramid

[6] Tablets and connectivity were provided by the Nextel Foundation, and the intervention was carried out by the local NGO Jóvenes Adelante.

is that their children are the main beneficiaries of new ICTs. The hopes and expectations of ICT access that are placed upon their children are formed within adverse conditions (poverty, unemployment, informal work and a weak presence of the state), and therefore Internet access becomes very significant in terms of social mobility expectations. Moreover, young people themselves emphasize the capabilities gap in terms of ICT adoption between them and their parents.

However, the results show that this gap may be bridged with appropriate training. The comparison of communities with different modes of access highlights the transformative role of training in changing previous beliefs about ICTs. In the case of San Miguel de Allende, young people were trained in the use of tablets, and they in turn taught their parents. Despite their preconceptions, parents discovered new possibilities and found that access to the Internet could help them in their daily tasks and in obtaining information that could enhance their livelihoods. The following testimony provides a good example:

- *"I thought this was only for the young, we are here in the kitchen and looking for something to eat, but then I was taught and I realized that I can learn, and then I went to tell my neighbor: "Look at me now!" (Homemaker, 43, San Miguel de Allende, April 4, 2013)*

The results of the study also corroborate the importance of information intermediaries, or *infomediaries*, in training potential adopters. However, a finding which is less explored in the literature is the role of family members as infomediaries. The case of San Miguel demonstrated that as the children trained their parents and other family members, positive incentives were reinforced because they shared common assets. Together they searched for information related to payment for services, social programs for which they could apply, and even potential business ventures. In the process of training their parents and siblings, the students gained self-esteem and increased family trust. Overall, the introduction of mobile broadband within the family became a tool that contributed to enhancing human and social capital.

The key role of infomediaries was also evident in the case of Santiago Nuyoo. In this community a training program accompanied the recent deployment of mobile banking or m-banking services. The interviewees considered this training as key to the adoption of m-banking. In turn, these early adopters encouraged others to adopt the service, helping to break common barriers to technological appropriation related to education and age. In this context, "learning by doing" as well as "learning by watching" were found to be especially important for new ICT services to have a broad impact on the community (beyond the younger generation who constitute the majority of users at public community centers and Internet cafes). This is revealed in the following testimony:

- *"So I said, I'll never learn... I could not even imagine having a phone in my hand... and I learned to write and send messages and I thought, it's good. But now I can also send payments, although not many, because we don't spend a lot." (Homemaker, 47, Santiago Nuyoo, October 25, 2012)*

In this regard, while the role of community centers with shared Internet access continues to be important, the findings suggest that individual mobile access is better suited for the inclusion of other family members who, for a number of reasons, are unlikely to patronize public access centers.

As their ICT knowledge and skills increased, community members began to discover innovative uses for broadband. One of the most valued benefits was to establish a more fluid and permanent communication mechanism with family members and friends who had migrated, which provided clear benefits in terms of sociability but also employment, confirming the important role of social capital in this respect. In addition, the case of Santiago Nuyoo showed how broadband adopters often looked for information about how to start a business, how to reduce transportation time and costs, how to streamline government procedures, and other issues with a direct impact on their financial assets.

The research team also found some evidence of an increase in political empowerment through broadband access. In San Miguel de Allende, the acquisition of ICT skills resulted in a change in the trainees' social positioning; these young people began to be recognized and appreciated in the community for their ability to find information and access relevant knowledge online. As a result, the traditional community hierarchies began to change: those who had the knowledge – and, consequently, the power – now depended on the younger members to find certain information and enable more efficient communication with federal government agencies. The following testimony provides an example:

- *"Now, with [the tablet], it will be easier when my delegate calls me to help him write emails or whatever. I'm the only one in town who knows how to use the Internet, so I can help." (Student, 23, San Miguel de Allende, March 24, 2013)*

Finally, the testimony of the members of Las Margaritas, the control case community where no connectivity exists, shows the various costs associated with isolation. For example, while an online site created by tourists promotes the products of Cooperativa Flor del Desierto, where many of the women in the community work, the lack of Internet access prevents the cooperative from reaching this potential demand.

In summary, this pilot study showed that access to broadband accompanied by effective training and learning by doing enabled members of marginalized communities to acquire new skills and new information and communication practices. This, in turn, enabled them to strengthen their human, social and financial assets. Given that the provision of access and training in these communities is still at an early stage, future research will be needed to identify their longer term impact. Table 27 summarizes the results discussed above.

Table 27: Summary of results

COMMUNITY	ICT CONNECTIVITY	KEY PERCEPTIONS	KEY IMPACT	
Las Margaritas	None	Members of the community believe that if connected they could benefit. Most relevant are communication with migrant family members and to sell products from a local cooperative.	-	Local cooperative cannot market products despite online demand.
Santiago Nuyoo	Fixed shared access	Access for educational purposes is most relevant. Also for social ties with migrant family members.	+	Access to educational information Communication with migrant community members
		Internet access at community center is associated with academic activities.	-	Information search limited to educational activities
	Local mobile service (m-banking)	Positive perception of mobile banking services for commercial transactions.	+	Inclusion and financial trainingower transaction costs
		No perceived integration between local mobile services and shared broadband.	-	Local service limits impact of mobile banking initiative
Los Torres, Cruz del Palmar, Estancia de Canal	All services	Tablet with mobile connectivity is integrated into household routine, used by both young and adults.	+	Access to academic information, financial services, social programs and link to authorities Young family members as infomediaries
		Revealed willingness to pay for individual broadband service.	-	Affordability Small sample

07. CONCLUSION: ADJUSTING EXPECTATIONS ABOUT THE DEVELOPMENT POTENTIAL OF BROADBAND

On March 10, 2000 the technology-heavy NASDAQ stock index peaked at 5,048 points, more than doubling its value from just a year before. By April 2001 it had given up all these gains and more, trading at around 1,700 points. Several billions in market capitalization evaporated, and many Internet-related companies folded shortly after, having gone from soaring stock values to oblivion. The burst of the dot-com bubble was a painful reminder that, for all its possibilities to revolutionize the way companies do business and people interact with each other, the Internet was not going to bring about these changes overnight. Unrealistic expectations about the wealth-creation potential of the Internet were drastically adjusted to reflect a more cautious optimism about its long-term economic and social effects.

A similar adjustment of expectations is underway with respect to the role of broadband in development programs. For the past several years a shared euphoria about broadband's potential to transform the lives of the poor inhibited serious debates and rigorous evaluations about the true impact of initiatives to connect public schools or households and businesses in remote regions. Today, after several billions in foreign aid and public investments, the time has come to look back and rigorously examine the cost-effectiveness of such initiatives.

This report seeks to contribute to this adjustment of expectations about the true potential of Internet access to lift people and communities out of poverty. Generally speaking, our results corroborate earlier findings about the positive contribution of broadband to overall economic growth (what we call the *growth effect*), but the impact is significantly more modest than previously estimated – as much as five times lower than the more optimistic estimations. While there is evidence, as many other studies suggest, that the impact of broadband grows with higher levels of penetration, our findings suggest a cautious approach to large public investments in connectivity initiatives, particularly in areas where technology-intensive industries and human capital are underdeveloped. Interpreted differently, our findings corroborate that broadband infrastructure initiatives must go hand-in-hand with investments in human capital in order to raise productivity and affect aggregate output.

Our results also corroborate the presence of a positive *wage effect* associated with broadband deployment at the local level: in Ecuador, the availability of broadband services in previously unserved municipalities helped raise labor incomes by as much as 7.5% over a two-year period. This benefit was found to be appropriated by all workers regardless of whether they in fact used broadband, thus confirming previous results about the spillover effect of broadband throughout the local economy. This result provides strong evidence in favor of national broadband plans that seek to extend broadband infrastructure to municipalities where services are currently unavailable, as is the case of the Argentina Conectada initiative in Argentina, Brazil's National Broadband Plan, and Colombia's Vive Digital program.

By contrast, *employment effects* were found to be small to null, suggesting an interaction between the availability of broadband and human capital. In other words, workers benefited from broadband availability as higher productivity and better labor matching raised incomes for the currently employed. Yet overall employment was unaffected, suggesting that if broadband creates new jobs, it also eliminates others. This is consistent with findings from larger studies about the impact of new ICTs on employment (e.g., Brynjolfsson and McAfee, 2011), as well as with the skill-bias hypothesis discussed earlier. The policy implication that follows from these findings is the need to complement investments in local broadband infrastructure with labor training programs, in order to promote a better match between workers' abilities and the new jobs created by broadband investments.

The *income effect* of broadband was found to be larger for men than for women. Our hypothesis is that this is due to differences in human capital as well as to gender differences in occupations, which in Latin America are still affected by traditional views about the role of men and women in the household. The in-depth interviews conducted in three low-income communities in Mexico largely confirmed this hypothesis, as adult women reported being reluctant to adopt a technology they associate with the more educated or the young. However, these differentiated gender effects disappeared among those who reported Internet use in the last 12 months, thus confirming our hypothesis about the interaction between gender differences in occupations and the appropriation of benefits resulting from broadband availability.

The policy insight that follows is that training programs need to pay particular attention to promoting broadband adoption by adult women in low-income communities in order to ensure a more equal appropriation of benefits between genders. Additionally, the findings from the in-depth interviews suggest that these women are unlikely to become regular Internet users at public access venues, which are patronized almost exclusively by the young. A small-scale intervention in which school-age family members brought the technology into the household proved to be a viable alternative to introduce these women to the Internet.

The picture that emerges from the evaluation of school connectivity programs is decisively more mixed. Overall the findings confirm that simply connecting schools to broadband has a very small effect on student achievement as measured by standardized language and math tests. The most promising results were found when broadband availability triggered changes in classroom practices, such as using current news to teach grammar and math. These students (fifth graders in Brazil) performed better in standardized tests – up to 15% of a standard deviation in some estimates. But in most other cases the results were less encouraging. In fact, in the case of Chile we found evidence of a statistically significant (although small) negative impact on student achievement for some student cohorts, suggesting that lack of adequate teacher training diverted the use of broadband to non-educational activities (at least from a traditional curriculum perspective). These findings suggest the urgent need to revisit school connectivity programs in order to ensure that classroom use of digital resources is properly articulated with the school curriculum and the overall educational goals of the initiative.

When school connectivity initiatives are combined with adequate educational resources and teacher training (as in the case of the Enlaces initiative in Chile) the results were found to be more encouraging, particularly for students in rural schools, for those from low-income households, and for those who do not have an Internet connection at home. The impact was found to be larger in language test scores than in math, confirming findings from other studies which suggest that the availability of online resources motivates students to improve their reading skills (Passey et al., 2004). **These findings suggest that, under the right circumstances, programs that integrate hardware and software with teacher training can be effective in helping students from less privileged backgrounds catch up (at least in terms of language skills) with their peers.**

Additionally, our evidence suggests that connecting schools to broadband motivates students and promotes a better learning environment. The motivational effect is reflected in a small but significant reduction in drop-out rates in Brazil, as well as small but significant increases in pass rates. Yet the most promising results were found in student behavior. In connected schools Brazilian teachers reported a significant drop in student absenteeism, in disciplinary problems, and in verbal and physical aggression. This suggests that one of the key impacts of school connectivity initiatives is to more positively engage students with school activities in general. While these short-term gains did not result in higher test scores, there is little doubt that an engaging educational environment is a precondition for better learning outcomes.

The in-depth interviews confirmed that the Internet plays an increasingly important role in the lives of the young, even in poorly connected communities. This supports the hypothesis that when schools are connected to broadband, students engage more positively with school activities and build ICT skills with social and economic payoffs, even when achievement in standardized tests in unaffected. As Livingstone (2012) notes, even if ICTs are poorly used in the classroom and consequently do not improve test scores, the fact that they increase student motivation and compensate for differences in access to ICTs outside the school environment provides a strong rationale to attempt to improve, rather than abandon, these type of initiatives. In other words, the *inclusion effect* of school connectivity programs should be considered an important goal on its own, particularly if it proves to be a stepping stone for better educational results in the longer term.

Finally, our results suggest that unreasonable expectations about the role of information technologies in development often delay necessary investments in content and human capital as part of broadband connectivity programs. **The Internet, like other ICTs, can be a powerful tool to achieve many development goals, including poverty alleviation. But this potential will not be realized unless human capital investments are properly articulated with connectivity initiatives.**

Another important implication of these findings is that impact evaluation studies should be more broadly designed: if technology alone will not yield meaningful results, more needs to be known about what types of capacity-building programs work and why. Otherwise, policymakers and practitioners will continue to navigate in the dark in the design and implementation of broadband connectivity initiatives.

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