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DATA REQUIREMENTS TO MEASURE THE ECONOMIC IMPACT OF BROADBAND

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1. INTRODUCTION

The explosive diffusion of broadband technology has been inextricably linked to the emergence of the Internet. By 2009, there are 1.8 billion Internet users worldwide and 471 million broadband subscriptions[1]. In most developed countries, Internet penetration has exceeded 60 % of households, and in some, like the Republic of Korea, is about to reach universal adoption (95.9 %)[2]. In addition, in the last five years, the combination of wireless technology and broadband service is taking service adoption from the household to the individual user.

To fuel this diffusion, telecommunications service providers and cable TV operators have been investing considerable amount of capital. Between 2004 and 2010, telecommunications and cable TV companies in the United States invested over US $ 97.7 billion in broadband deployment. Chinese companies have invested US $ 7.44 billion in broadband since 2009[3], while Malaysian operators invested US $ 1.6 billion since 2009[4]. With these amounts of capital being dedicated to the technology, it is natural that policy makers and researchers in the social sciences started looking at the economic and social impact of broadband. In fact, social scientists and policy makers had been researching the economic impact of information and communication technologies (ICTs) for quite a while. The first analyses of the impact of fixed telephone density on economic growth were generated in the mid-1970s by World Bank researchers. Ever since, enhancements both in the quality of data and sophistication of econometric tools have yielded continuous improvement in tackling the question of economic impact of telecommunications. Broadband, however, represents a new challenge for researchers. First, its deployment had been proceeding at an incredibly fast pace. Consequently, the length of time series of broadband adoption was considerably shorter than for voice telecommunications. Second, only the countries that have understood early on its economic potential have proceeded to collect statistics at the beginning of the diffusion process. Third, broadband, as an access technology for data communications, would have an economic impact only in combination with the adoption of information technology. The short time-span of deployment and its characteristic of an enabler of remote information technology access represented a substantial challenge. Third, most importantly, researchers are confronted, particularly in the developing world, with limited data to support efforts to understand the economic impact of broadband.

The purpose of this paper is to provide some guidance to national regulators and policy makers regarding the data requirements in order to conduct rigorous analysis aimed at understanding how broadband contributes to economic growth, and under what conditions this occurs. It begins by briefly introducing the reader to the research that has

[1] Source: Internet World Wide Statistics (September 2009). For June 2010, the number of total Internet users has reached 1.96 billion.

[2] International Telecommunication Union data for December 2009. The OECD reports penetration of 61.7% without Chile and Mexico, and 60% with these two countries.

[3] See Sinopac (2009). Taiwan Research.

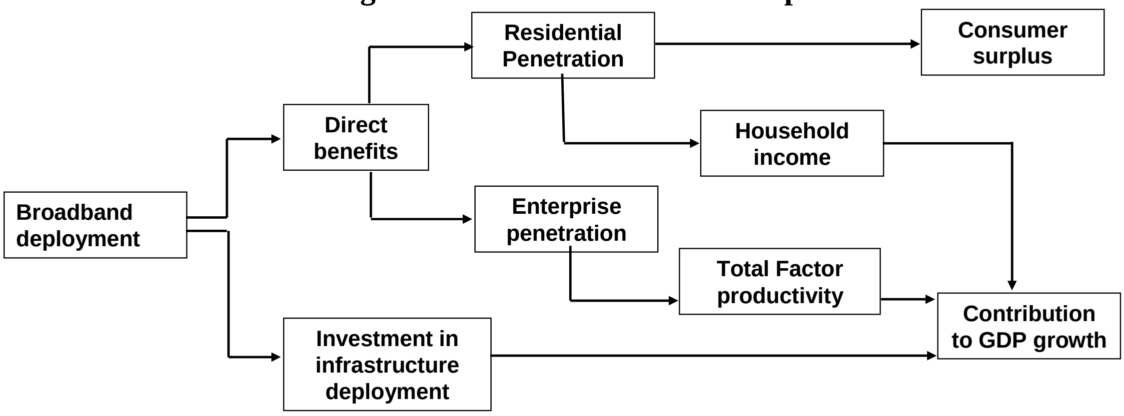
[4] See AM Research (2010). Telecommunications: CAPEX risk from escalating competition in broadband.

been conducted so far in terms of ascertaining the economic impact of broadband. It then presents the underlying analyses and data requirements that have been utilized. On that basis, it defines a set of requirements ("wish list") of data that are required in order to conduct economic analyses.

2. A REVIEW OF THE RESEARCH LITERATURE ON MEASURING THE ECONOMIC IMPACT OF BROADBAND

The economic impact of broadband manifests itself through four types of effects (see figure 1)

Figure 1. Broadband economic impact



The first effect results from the construction of broadband networks. In a way similar to any infrastructure project, the deployment of broadband networks creates jobs and acts over the economy by means of multipliers. The second effect results from the "spill-over" externalities which impact both enterprises and consumers. The adoption of broadband within firms leads to a multifactor productivity gain, which in turn contributes to growth of GDP. On the other hand, residential adoption drives an increase in household real income as a function of a multiplier. Beyond these direct benefits which contribute to GDP growth, residential users receive a benefit in terms of consumer surplus, defined as the difference between what they would be willing to pay for broadband service and its price. This last parameter, while not being captured in the GDP statistics, can be significant, insofar that it represents benefits in terms of enhanced access to information, entertainment and public services.

Research aimed at generating hard evidence regarding the economic impact of broadband is fairly recent. The results of the research and the evidence generated so far fall into three categories:

- Contribution to employment and output of broadband deployment ("countercyclical effect")
- Impact on GDP growth and employment ("externalities")
- Creation of consumer surplus

Each set of studies will be briefly reviewed in turn.

2.1. Contribution to employment and output of broadband deployment

Six national studies have estimated the impact of network construction on job creation: Crandall et al. (2003), Katz et al. (2008), Atkinson et al. (2009), Liebenau et al. (2009) Katz et al. (2009), and Katz et al. (2010). They all relied on input-output matrices and assumed a given amount of capital investment: US $ 63 billion (needed to reach ubiquitous broadband service) for Crandall et al. (2003), CHF 13 billion for Katz et al. (2008) (to build a national multi-fiber network for Switzerland), US $ 10 billion for Atkinson et al. (2009) (as a US broadband stimulus), US$ 6.3 billion to implement the Broadband Technology Opportunity Program (Katz et al., 2009), US $ 7.5 billion for Liebenau et al. (2009) (needed to complete broadband deployment in the United Kingdom), US $ 45 billion for Katz et al. (2010) (required to implement Germany's National Broadband Strategy).

Since these studies were triggered by the consideration of countercyclical plans devised to face the economic crisis, they tend to focus primarily on gauging the ability of broadband jobs to create jobs. All studies calculate multipliers, which measure the total employment change throughout the economy resulting from the deployment of a broadband network. Beyond network construction (direct employment), broadband deployment has two additional employment effects. Network deployment will result in indirect job creation (incremental employment generated by businesses selling to those that are directly involved in network construction) and induced job creation (additional employment induced by household spending of the income earned from the direct and indirect effects) (see Table 1).

Table 1. Broadband Construction Impact on Job Creation

Country	Study	Objective	Results
United States	Crandall et al. (2003)	Estimate the employment impact of broadband deployment aimed at increasing household adoption from 60% to 95%, requiring an investment of US $ 63.6 billion	• Creation of 140,000 jobs per year • Total jobs: 1.2 million (comprising 546,000 for construction and 665,000 indirect)
	Atkinson et al. (2009)	Estimate the impact of a US $10 billion investment in broadband deployment	• Total jobs: 180,000 (including 64,000 direct and 116,000 indirect and induced
	Katz et al. (2009)	Estimate the impact of a US $6.3 billion investment in the BTOP program	• Total jobs: 127,800 (comprising 37,300 direct, 31,000 indirect, and 59,500 induced)
Switzerland	Katz et al. (2008)	Estimate the impact of deploying a national broadband network requiring an investment of CHF 13 billion	• Total jobs: 114,000 (including 83,000 direct and 31,000 indirect)
United Kingdom	Liebenau et al. (2009)	Estimate the impact of investing US $ 7.5 billion to achieve the target of the *"Digital Britain*" Plan	• Total jobs: 211,000 (including 76,500 direct and 134,500 indirect and induced)
Germany	Katz et al. (2010)	Estimate the impact of a US $45 billion investment in the National Broadband Strategy	• Total jobs: 541,000 (comprising 281,000 direct, 126,000 indirect, and 75,000 induced

Source: Compiled by the author

Multipliers are of two types. Type I multipliers measure the direct and indirect effects (direct plus indirect divided by the direct effect), while Type II multipliers measure Type I effects plus induced effects (direct plus indirect plus induced divided by the direct effect). Cognizant that multipliers from one geographic region cannot be applied to another, it is useful to observe the summary results for the multipliers of the four input-output studies (see table 2):

Table 2. Employment Multiplier Effects of Studies relying on Input-Output Analysis

Country	Studies	**Type I**	**Type II**
EE.UU.	Crandall et al. (2003)	N.A.	2.17
	Atkinson et al. (2009)	N.A.	3.60
	Katz et al. (2009)	1.83	3.42
Switzerland	Katz et al. (2008)	1.38	N.A.
United Kingdom	Liebenau et al. (2009)	N.A.	2.76
Germany	Katz et al. (2010)	1.45	1.92

Note: Crandall et al. (2003) and Atkinson et al. (2009) do not differentiate between indirect and induced effects, therefore we cannot calculate Type I multipliers; Katz el (2008) did not calculate Type II multiplier because induced effects were not estimated.

Source: Compiled by the author

According to the sector interrelationships depicted above, a European economy appears to have lower indirect effects than the US. Furthermore, the decomposition also indicates that a relatively important job creation induced effect occurs as a result of household spending based on the income earned from the direct and indirect effects.

2.2. Impact on GDP growth and employment through externalities

The study of the impact of broadband covers numerous aspects, ranging from its aggregate impact on GDP growth, to the differential impact of broadband by industrial sector, the increase of exports, and changes in intermediate demand and import substitution. While the research on the contribution of broadband to GDP growth has confirmed its positive impact, it has also yielded results that vary widely. Constrained by data availability, the analyses have primarily focused on OECD countries (generally Western European and North American) and states in the United States (see table 3).

Table 3. Research results of Broadband Impact on GDP growth

Country	Study	Data	Effect
United States	Crandall et al (2007)	48 States of US for the period 2003-2005	Not statistically significant results
	Thompson and Garbacz (2009)	46 US States during the period 2001-2005	A 10% increase in broadband penetration is associated with 3.6% increase in efficiency
OECD	Czernich et al. (2009)	25 OECD countries between 1996 and 2007	The adoption of broadband raises per-capita GDP growth by 1.9-2.5 percentage points
	Koutroumpis (2009)	2002-2007 for 22 OECD countries	An increase in broadband penetration of 10% yields 0.25% increase in economic growth
High Income Economies	Qiang et al. (2009)	1980-2002 for a high income subset of 120 countries	10 % broadband penetration yielded an additional 1.21 percentage points of GDP growth
Low and Middle income economies	Qiang et al. (2009)	1980-2002 for the remaining 120 countries (low and middle income)	10 % broadband penetration yielded an additional 1.38 in economic growth

Source: Compiled by the author

As the data in table 3 indicates, most studies conclude that broadband penetration has an impact on GDP growth. However, one observes that such a contribution appears to vary widely, from 0.25 to 1.38 percent for every increase in 10 % of penetration[5]. Explanations for this variance are manifold. Clearly, some of the discrepancies come from the usage of different datasets as well as model specifications. However, in some cases differences may be due to methodological shortfalls. For one, at very high levels of data aggregation, such as country data, the econometric models do not account for the wide discrepancy between regions that are caused by fixed effects. For example, a large portion of the variance in the study by Qiang et al. (2009) is explained by dummy variables for Africa and Latin America (nearly 10 times as much as the estimate given by Barro (1991) in the original formulation of the model). This probably suggests that the preferred method of analysis is to perform differences-in-differences. It also justifies the need to conduct the analysis at lower levels of aggregation such as states and, where data is available, even counties or postal codes.

Beyond the contribution to GDP growth, researchers have studied the impact of network externalities on employment variously categorized as "innovation", or "network effects" (Atkinson et al., 2009). The study of network externalities resulting from broadband penetration has led to the identification of numerous effects, such as 1) innovative applications and services, such as telemedicine, Internet search, e-commerce, online education and social networking (Atkinson et al., 2009), 2) new forms of commerce and financial intermediation (Atkinson et al., 2009), business revenue growth (Varian et al., 2002; Gillett et al, 2005), and growth in service industries (Crandall et al. (2007).

[5] Or .36% if we make the standard assumption that 1% increase in productivity or efficiency results in 1% increase in GDP.

Most of the research regarding the impact of broadband externalities on employment has been conducted using US data. There are two types of studies of these effects: regression analyses and top down multipliers. The first ones attempt to identify the macro-economic variables that can impact employment[6], while the second ones rely on top-down network effect multipliers. After examining the conclusions of the regression studies, the evidence regarding broadband employment externalities appears to be quite conclusive (see table 4).

Table 4. Research results of Broadband Impact on Employment

Country	Study	Data	Effect
United States	Crandall et al. (2007)	48 States of US for the period 2003-2005	For every 1 % point increase in broadband penetration in a state, employment is projected to increase by 0.2 to 0.3 percent per year "assuming the economy is not already at 'full employment'"
	Thompson and Garbacz (2009)	46 US States during the period 2001-2005	Positive employment generation effect varying by industry
	Gillett et al. (2006)	Zip codes for the US for the period 1999-2002	Broadband availability increases employment by 1.5%
	Shideler et al. (2007)	Disaggregated county data for state of Kentucky for 2003-4	An increase in broadband penetration of 1% contributes to total employment growth ranging from 0.14% to 5.32% depending on the industry

Source: Compiled by the author

Again, the impact of broadband on employment creation appears to be positive. However, as the data indicates, the impact on employment growth varies widely, from 0.2 % to 5.32 % for every increase in 1% of penetration. There are several explanations for this variance. As Crandall indicated, the overestimation of employment creation in his study is due to employment and migratory trends which existed at the time and biased the sample data. In the case of Gillett et al. (2006), researchers should be careful about analyzing local effects because zip codes are small enough areas that cross-zip code commuting might throw off estimates on the effect of broadband. For example, increased wages from broadband adoption in one zip code would probably raise rent levels in neighboring zip codes prompting some migration effects. Finally, the wide range of effects in the case of Shideler et al. (2007) is explained by the divergent effects among industry sectors.

Beyond regression studies, "network effect" multipliers have been used to assess the impact of broadband on job creation in a top down fashion. Within this group, key studies are Pociask (2002), Atkinson et al. (2009) and Liebenau et al. (2009). Pociask (2002) and Atkinson et al. (2009) studies relied on an estimated "network effect" multiplier, which is applied to the network construction employment estimates. For example, Pociask relied on two multiplier estimates (an IT multiplier of 1.5 to 2.0 attributed to a think tank and

[6] In general, studies based on regression analysis do not differentiate between construction and spill-over effects.

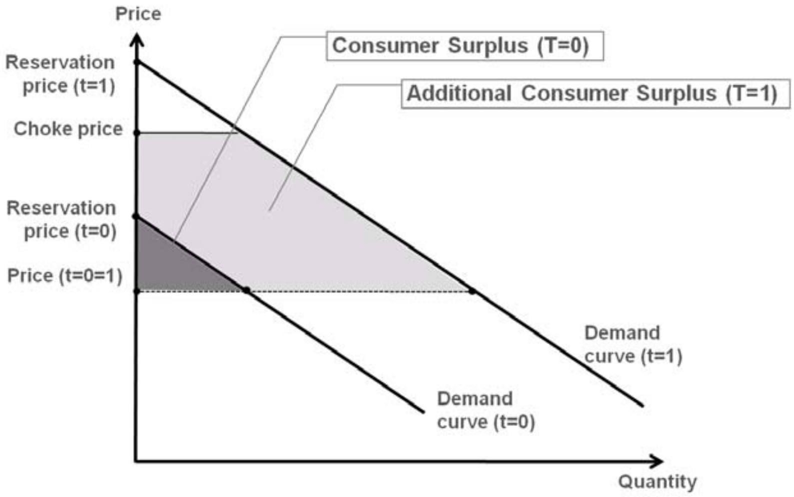
another multiplier of 6.7, attributed to Microsoft) and calculated an average of 4.1. Similarly, Atkinson et al. (2009) derived a multiplier of 1.17 from Crandall et al. (2003). Though the top-down approach allows estimation of the broadband impact, it does not have a strong theoretical basis. Network effects are not built on interrelationships between sectors. They refer to the impact of the technology on productivity, employment and innovation by industrial sector.

2.3. Creation of consumer surplus

This analysis allows estimating the utility gains of consumers generated through the rollout of broadband. Consumers have a utility gain because they can purchase a product at a lower price than they were willing to pay. To compare the gains in consumer surplus by an investment one has to compare the initial (before the investment) consumer surplus with the consumer surplus at the end of the investment. During an investment period consumer surplus may change because of two reasons. The first one is an outward-shift of the demand curve and the second is a price reduction. The shift of the demand curve can occur because of the broader penetration of high speed broadband. The price reduction is a result of productivity gains and competition. In the case of deployment of high speed broadband infrastructures, competition becomes effective at the applications layer. This development is responsible for an increase in consumer surplus in future periods compared to former periods.

Consumer surplus is the utility gain by consumers due to prices that are lower than their reservation prices. In figure 2 the consumer surplus is the area between the demand curve and the market price. Consumers gain utility because they can purchase a product at a lower price than they are willing to pay. The larger the area under the curve is, the more utility that consumers derive.

Figure 2. Consumer surplus



Consumer surplus may change because of two reasons. The first one is an outward-shift of the demand curve, and the second is a price reduction. The price reduction may result from productivity gains and competition. More competition and market saturation force producers to reduce prices. These two developments are responsible for increases in consumer surplus. As indicated in figure 2, the dark grey area represents the initial consumer surplus at t = 0. The shift of the demand curve at t = 1 results in an additional consumer surplus (light grey area). The whole consumer surplus in period 1 is the sum of the dark and light gray areas.

The estimation of consumer surplus resulting from broadband penetration is important, but this economic benefit is not captured by GDP. This approach has been utilized by Crandall and Jackson (2003) to estimate the US consumer surplus derived from new services like shopping, entertainment and telemedicine enabled by broadband infrastructure. Similarly, Lee and Lee (2006) relied on regression techniques to estimate the consumer surplus for the Korean telecommunications market.

Greenstein and McDevitt (2009) estimated the consumer surplus generated by broadband adoption in the United States. In their analysis for the period between 1999 and 2006, the authors determined that in 2006 the consumer surplus generated by broadband represented US $ 7.5 billion (or 27 % of the total US $ 28.0 billion in broadband surplus). This was calculated on the basis of what users would be willing to pay to adopt broadband and substitute narrowband access. The authors also recently estimated the surplus generated as a result of broadband adoption in Canada, United Kingdom, Spain, Mexico, Brazil and China (Greenstein & McDevitt, 2010). In this case, due to the data limitations, they restricted their analysis to the benefit derived from price declines, which necessarily underestimates its total impact.

Nevertheless, the researchers determined that for 2009, the total Brazilian broadband surplus represented US $ 7.03 billion, of which 22 % should be considered to be consumer driven. In the case of Mexico, the total surplus is US $ 2.30 billion, and the consumer portion was 8%. In general terms, the authors concluded that the total broadband surplus is directly related to broadband penetration.

Consumer surplus can also be conceptualized in terms of the benefits that broadband represents to the end user. The variables driving willingness to pay include the rapid and efficient access to information, savings in transportation for conducting transactions, and benefits in health and entertainment

3. METHODOLOGIES AND DATA UTILIZED IN MEASURING BROADBAND ECONOMIC IMPACT

3.1. Input/output analysis to measure multipliers of broadband deployment

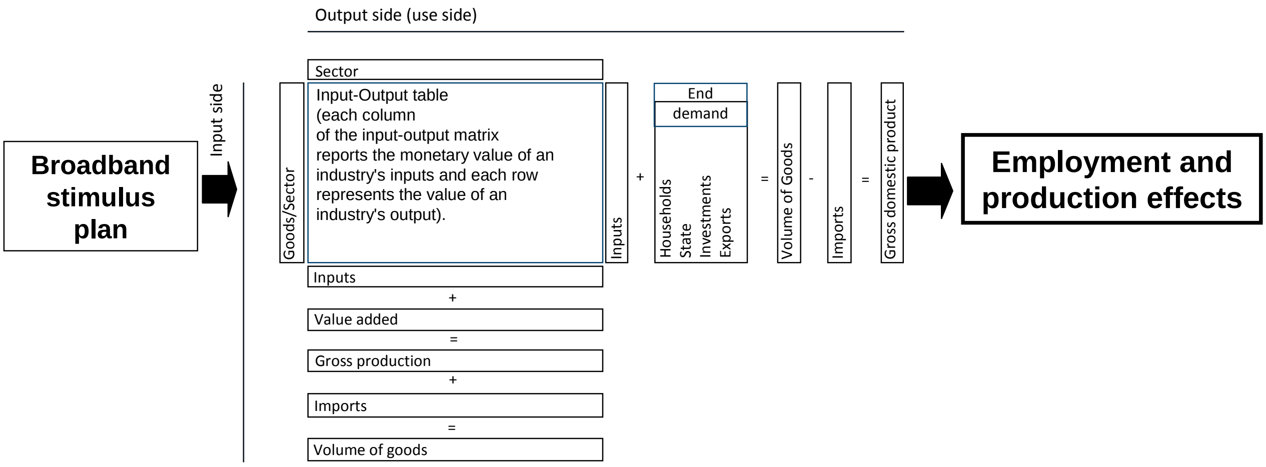
This approach focuses on determining how much value added and employment is generated through the national rollout of high speed broadband services in the access network. The importance of a sector can be measured by direct and indirect effects on the whole economy. The direct effects can be expressed in terms of indicators like the sector’s contribution to total value added, growth or its importance as an employer. However, these single indicators do not represent the full importance of a stimulus program. Complex relationships develop between industries because each sector sources goods and services from other sectors. In consequence, investments in one sector trigger demand indirectly in other sectors as well. These networked relationships mean that the effect of investment of a high speed broadband rollout program is greater than the direct effects would suggest. The indirect effect can be measured using parameters known as multipliers; they estimate the factor by which the direct effect must be multiplied to determine the total impact of investment in a single sector on the national economy. It is important to mention, however, that, in some cases, investment does not fully materialize in job creation. First, a portion of the investment can be "leaked" to other economies due to the fact that some intermediate inputs, such as equipment, are manufactured in other countries. Second, while the models might predict that investment leads to job creation in a fairly deterministic way, a number of institutional factors could stand in the way of this effect to happen. For example, the public funds could be available for investment but bureaucratic impediments act as obstacles for networks to be deployed.

Input-output tables enable the calculation of the impact of additional inputs in specific sectors on the economy as a whole. The relationships between the sectors at the inputs stage trigger additional demand and thus increase production in other sectors. The sum of all these effects is the multiplier for the total volume of goods. Multipliers can be calculated in several ways and also for several economic dimensions. There are, for example, goods-related multipliers for the total volume of goods in an economy, for the value of total production or for the value added. There are also multipliers for labor market parameters such as the size of the workforce or the number of hours worked.

3.1.1. Methodology:

The estimation of countercyclical effects comprises two steps: the estimation of investment required to fulfill the targets of the broadband stimulus plan, and the calculation of resulting economic effects through input-output analysis (see figure 3).

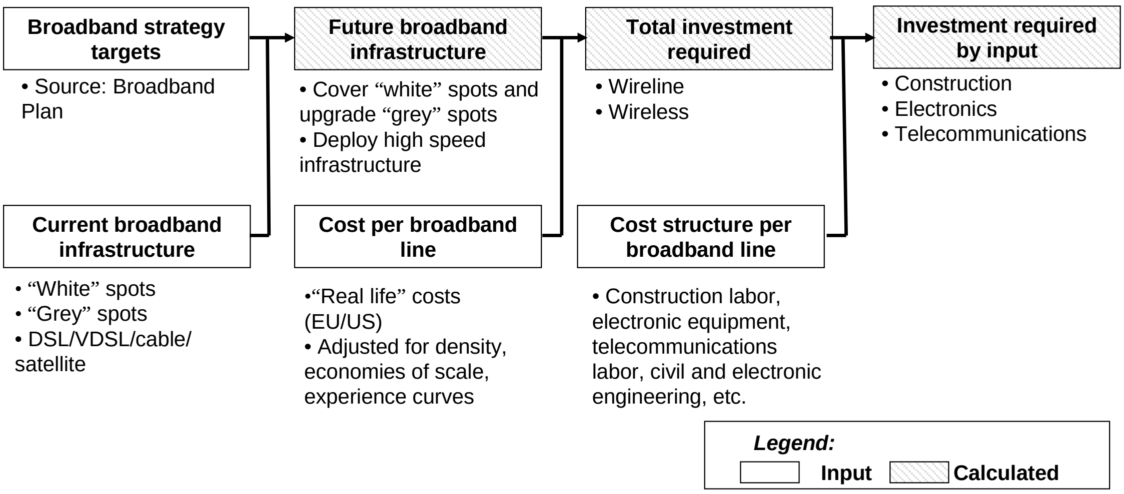
Figure 3. Structure of Input-output table



The coverage and service targets established by the broadband stimulus plan are used to estimate the investment required to deploy the broadband infrastructure. These targets were compared against the current situation of broadband deployment. The comparison between the current situation and the targets allows estimating the deployment objectives in terms of number of lines to: 1) cover the "white" spots (unserved areas), 2) upgrade the "grey" spots (areas with inferior service measured by low access speeds), and 3) deploy additional lines for different type of platforms (wireless, DSL, VDSL and FTTH).

Once the number of lines by service target is estimated, they are multiplied by the costs per broadband line by type of platform. In order to determine the costs per line, the costs from deployment experience in Europe and the United States were relied upon, adjusted for factors such as urban density, economies of scale, and experience curve. This calculation yields the total investment required for wireless and wireline technologies. The total investment is then split according to three cost categories: 1) construction labor, 2) electronic equipment, and 3) telecommunications labor. These splits are based on cost allocations based on "real life" deployment data furnished by operators. The resulting process yielded the amount of total investment by cost category (see figure 4):

Figure 4. Methodology for Estimating Broadband Deployment Costs



Once the investment input is calculated, the estimation of employment and output effects can be done. Input-output tables help calculating the direct, indirect, and induced effects of broadband network construction on employment and production. The interrelationship of these three effects can be measured through multipliers, which estimate how one unit change on the input side affects total employment change throughout the economy.
To calculate employment effects resulting broadband deployment, one relies on input-output matrices published by government census and Statistics departments (see below). However, in order to be utilized in this analysis, the input-output matrices need to be formatted to calculate the employment multipliers.

Once the table is reformatted, one calculates the multipliers. From the I/O-table it is possible to obtain multipliers for total industry supply and additional variables as value added and employment. The calculation of the multipliers for the total industry supply uses the direct requirement table which is also called Leontief-Inverse. The direct requirement table (DR) is calculated by the following formula:

$$DR = (I - A)^{-1}$$

with A = I/O-table / total industry supply (division of each cell of intermediate domestic supply by total industry supply)

I = Identity matrix

The sum of the columns per industry reflects the increase of the total industry supply by one additional unit of demand in this specific sector. A correction for the share of imports on total industry supply results in the total domestic production of the industries. The multiplying of the share of value added of total domestic industry production results in the value added multiplier. Using labor productivities it is possible to calculate the job effects now.

3.1.2. Data utilized for input/output analysis:

The following data sets are needed to conduct the input-output analysis (see Table 6):

Table 6. Data utilized in input-output studies

Data	Remarks	Availability	Rationale
Investment in broadband program	Breakdown of investment by sectors (i.e. manufacturing of electronic equipment, construction, telecommunication)	To be calculated based on benchmarks	This is the investment input that will trigger growth in output and/or jobs
Input-output-table		To be supplied by government statistical units and/or Central Banks	Required to understand inter-sectoral relationships
# of employed persons	In the same classification as the input-output-table	To be supplied by government statistical units	Required to calculate employment effects

To calculate investment inputs, data on current broadband coverage and service quality is required. Data on current coverage is typically difficult to find from public sources, although it is available through the service providers in each country[7]. In other cases, the regulatory authority might have information regarding broadband coverage.

Once the investment input is calculated based on the methodology described in section 3.1.1., one needs to move to measuring the broadband construction effect. The starting point is a make-use table from input-output statistics, from which imports are excluded to reflect domestic production. In addition, as mentioned above, the matrix might need to be consolidated in a more reduced number of industries to reflect sector codes of the country

[7] Some countries, however, have up to date information on broadband coverage. For example, Germany possesses the Broadband Atlas produced by the Federal Ministry of Economics and Technology (BMWi 2009). As part of its National Broadband Plan, the United States is conducting an effort at developing its broadband map.

being analyzed. For the US study, Katz and Suter (2008) relied on three original matrices and data sources:

- Bureau of Economic Analysis: Make table from 2002_IOMakeUse_summary.xls; Use table from 2002_IOMakeUse_summary.xls; Import Matrix from the 2002 Benchmark Input-Output Accounts
- Bureau of Labor Statistics: Employment by Industry ("Employment and Earnings Online," January 2008 issue)
- Oxford Economics: Sector share of employed persons by sector in the USA

The I/O-table was built based on the BEA make- and use-tables using a methodology from Chamberlain Economics LLC. To obtain an I/O-table that can be used to calculate multipliers that reflect domestic production it is necessary to exclude imports from the make-table. The resulting I/O-table from BEA data has the dimension of 133*133 industries. Due to the fact that the employment data used for further calculations is in a NACE code with 28 industries the I/O-matrix is transformed to a 28*28 industries matrix.

In their study of Germany, the input-output matrix supplied by Eurostat (Eurostat 2009), and originally developed by the Federal Statistical Office (Destatis 2009) was utilized.

Beyond developed countries, input-output matrices might not be available and therefore, the possibility of conducting this kind of analysis might be greatly limited.

3.1.3. Advantages and disadvantages of input/output analysis:

Input-output analysis to assess broadband deployment impact has certain advantages. Input-output tables are easy to communicate and are based on proven interlinks between sectors. The results of the analysis are particularly robust in terms of estimating short-term direct and indirect effects of broadband investment on employment and value added.

However, while input-output tables are a reliable tool for predicting investment impact, two words of caution need to be given. First, input-output tables are static models reflecting the interrelationship between economic sectors at a certain point in time. Therefore, they cannot measure dynamic processes of sectoral adjustment in response to changing demand. Since those interactions may change, the matrices may lead us to overestimate or underestimate the impact of network construction. For example, if the electronic equipment industry is outsourcing jobs overseas at a fast pace, the employment impact of broadband deployment will diminish over time and part of the counter-cyclical investment will "leak" overseas. Second, it is critical to break down employment effects at the three levels estimated by the input-out table in order to gauge the true direct impact of broadband deployment. Having said that, all these effects have been codified and therefore, with the caveat of the static nature of input-output tables, we believe that the results are quite reliable. Third, induced effects are calculated based on numerous assumptions, which need to be carefully formulated. For example, under close to full employment conditions, induced effects do not materialize.

3.2. Econometric analysis to measure externalities of broadband

This approach for measuring the impact of broadband on economic growth and job creation entails specifying regression models where GDP growth, employment and other output metrics are a function of broadband deployment and broadband penetration. A number of econometric studies have been generated to measure broadband's impact on GDP growth and employment. Because of limited data availability, most studies tend to focus on the developed countries (see table 7).

Table 7. Econometric studies of broadband externalities

Author	Year	Title	Area	Period	Aggregation
Crandall et al.	2007	The Effects of Broadband Deployment on Output and Employment	48 US States	2003-05, 04-05	State
Czernich et al.	2009	Broadband Infrastructure and Economic Growth	20 OECD	1996-07	National
Ford & Koutsky	2005	Broadband and Economic Development	Lake County, FL	1999-04	County
Katz et al.	2010	The Impact of Broadband on Jobs and the German Economy	Germany	2003-06	County
Kolko	2010	Does Broadband Boost Local Economic Development?	US	1992-06	Zip Code, County, Individual
Koutrompis	2009	The economic impact of broadband on growth: A simultaneous approach	22 OECD	2002-07	National
LECG	2009	Economic Impact of Broadband: An Empirical Study	15 OECD	1980-07	National
Gillett et al	2006	Measuring Broadband's Economic Impact	US States	1999-02	State/Zip
Qiang & Rossotto	2009	Economic Impacts of Broadband	120 Countries	1980-06	Country
Shiedeler, et al.	2007	The Economic Impact of Broadband Deployment in Kentucky	Kentucky Zips	2003-05	Zip Code
Thompson & Garbacz	2009	Broadband Impacts on State GDP: Direct and Indirect Impacts.	48 US States	2001-06	State
Waverman et al.	2005	The Impact of Telecoms on Economic Growth in Developing Countries	102 Countries	1980-03	Country
Katz	2010	The impact of broadband on the economy	Latin America	2004-09	Country
			Brazil	2006-07	State
			Chile	2003-08	Region
			India	2007-08	Telecom Circles
			Malaysia	2007-08	States
			S. Arabia	2007-08	Provinces

Source: Compiled by the author

3.2.1. Methodology:

Econometric studies rely on regressions and therefore necessitate historical datasets to determine the effect of broadband on GDP, employment and other economic indicators. In order for these studies to investigate causal effects (rather than correlations), models are developed that account for factors, other than just broadband, that may influence economic indicators. In slightly more technical language, a regression is informed by the historical levels of an economic indicator and the factors that influence it. Then, given a certain model, it assigns coefficients that maximize the amount of explained variance: that is to say it assigns the set of relationships between factors and the indicator that will cause the projected value of the indicator to most closely mimic what happened historically. For example, level of education in a given country drives GDP growth as well as broadband usage; thus it is important that this variable is present in a regression model, because if it does not, we may attribute the effects of education to broadband. In that vein, economists specify models that account for each of the factors that influence economic indicators. An optimal regression breaks up the variation of an indicator, such as GDP. It assigns a set of coefficients which measure how important each factor is in determining the indicator, or how much a change in each of the factors caused the economic indicator to change. Hence, we are left with the effects of broadband keeping other factors constant. This is why broadband effects are conceptualized in terms of, all other variables (education, fixed capital investment, infrastructure) being constant, the change in broadband penetration that would explain GDP growth.

There are three types of model estimation procedures used to assess the economic impact of broadband: cross-sectional regression; panel data and simultaneous equations. The cross-sectional procedure relies on one observation per unit (country, county, region, etc…) and in the case of studying change in variables; at least two points in time are needed. It includes independent variables such as broadband penetration, level of tertiary education, fixed capital investment (see below) and the dependent variables (such as GDP growth and employment and unemployment growth). This methodology is the most commonly used because it is rare the case when more than two years worth of data across variables is available. Given the issue of carefully estimating the direction of causality (what drives what), it is advisable to lag the variables collecting data for independent variables in year 1 and regressing them against dependent variables in year 2 or more.

Panel data and simultaneous equations are two techniques that further help econometric analyses study causation rather than correlation. They are among the most successful techniques that have been employed in the papers that analyze broadband's economic effects.

Panel data is a time series for multiple geographic areas, (i.e., it is both a time series and a cross-sectional dataset). This allows researchers to account for time fixed effects and geographical fixed effects. For example, if a dataset were confined only to 2008, it would be extremely difficult for researchers to separate the effects of the recession from their growth models. The reliance on the panel data approach is to allow unobserved differences in preferences and technology across regions or countries, differences that if were not taken into account in a cross-sectional regression could cause biased estimators (omitted variable bias).As these differences are not easily measurable, they can be treated as unobserved individual effects in the panel data regression framework. From an econometric point of view, the panel data model will correct the omitted variable bias, where the omitted variable captures the differences across countries. The panel data approach requires the compilation of time series for multiple geographic areas, (i.e., it is therefore, both a time series and a cross-sectional dataset).

The third methodology -simultaneous equations- is used to deal with endogeneity—or a cycle where factors cause the indicators to change and vice versa. This problem is particularly pronounced in the study of broadband's effect on GDP, GDP per capita and income. Research unilaterally agrees that broadband increases GDP and income. However, numerous studies on broadband demand have also shown that broadband is income elastic (or that an increase in income substantially increases broadband demand). Therefore, when we model the effect of broadband on income (or GDP, etc.) we must have a way to account this reverse effect (income elasticity), or our estimate will be biased. Simultaneous equations do just this: regressions are performed that simultaneously estimate broadband demand, supply and impact on income, solving the problem of endogeneity. The key disadvantage of this approach, particularly for developing countries, is the lack of data availability (particularly, prices and supply side variables).

3.2.2. Data utilized for econometric analysis:

The econometric methods require the gathering of data for both dependent and independent variables in terms of their rate of change in order to determine to what extent changes in broadband penetration affects the economy. The dependent variables that are required for this analysis are GDP per capita and employment or unemployment rate. In some cases, when it comes to regional studies, analysis has been conducted considering Gross sales (see table 8).

Table 8. Data utilized in econometric studies

Dependent Variables	Independent Variables	Control Variables
• Annual or quarterly rate of change of GDP • Annual or quarterly rate of change of employment • Annual or quarterly rate of change of unemployment • *Annual number of SME's*	• Annual or quarterly rate of change of broadband penetration	• GDP at starting time of period • Level of education: Percent of population with tertiary degrees; Illiteracy rate; Years of schooling; participation rate in secondary school • *Regional Investment as percentage of regional GDP* • Percent of households with electricity or running water • Number of projects and added value of construction projects financed by the state • Number of hospitals per inhabitant; number of beds in hospitals per inhabitant • Access to financial services: Number of banking offices and bank credit per capita • Industry concentration: Contribution of financial services, commerce and manufacturing sectors to regional GDP • Importance of tourism in the region (number of domestic tourism trips) • Cost index for interstate trade costs • Cost to create new business • Regional Gini Coefficient • Percentage of people living in urban centers • Total road length per hundred sq. Km by area; Road development index • Population growth rate • Globalization Index; *Globalization Index per region*

A number of observations need to be made regarding this list:

- *Level of education:* in countries where the minimum level of education is secondary school, tertiary education is determining variable
- *Regional investment as percent of regional GDP:* It is critical to understand if the increase in employment or GDP is driven by investment other than broadband; this is why analyses consider several control variables that measure not only the pre-existing quality of infrastructure, but also the change in infrastructure deployment as a proxy of investment
- *Number of projects and added value of construction projects financed by the State:* In the case of countries where the economy is run by the government, it is imperative to introduce this variable as a way for not over-estimate the effect of broadband

Appendix A presents the variables utilized by the most important econometric studies.

3.2.3. Advantages and disadvantages of econometric analysis:

The primary advantage of the econometric modeling is its capacity to link projections of broadband penetration, growth and productivity by relying on macro-economic causal models that rely on historical time series and cross-sectional analysis. More specifically, the methodology can provide estimates on employment growth and productivity based broadband network externalities, and generates results and identifies productivity and employment effects at the industry sector level.

On the disadvantage side, since the impact of investment on productivity is generally lagged, time series data sets need to be somewhat long for reliability. Furthermore, the analyses require data at a fairly granular level (e.g. postal code). Finally, it is more difficult to identify effects at the regional level, although this can be addressed with disaggregated data

3.3. Measuring consumer surplus of broadband

The measurement of broadband consumer surplus is not as common as the econometric studies discussed above. Shane Greenstein and Ryan McDevitt, from Northwestern University, pioneered this methodology for the United States broadband sector and have recently replicated this analysis for a number of selected countries: Canada, the UK, Spain, Mexico, Brazil and China. The authors' theoretical framework is based on the notion that a new good (broadband) provides benefits that are additional to the old (dial-up access). The objective is, therefore, to calculate those benefits, which they call "the broadband bonus".

The approach the authors used was to rely on price declines to “trace out demand curve for broadband”. In doing so, they assume constant/falling nominal prices (falling real prices), which explains growing use at households.

3.3.1. Data utilized in measuring the consumer surplus of broadband:

The data required for conducting the assessment of consumer surplus of broadband for the United States comprised the following sets:

- Number of broadband subscriptions
- CPI for Internet access
- Household use of dial-up and broadband
- Price of broadband service
- Estimation of revenues of household broadband services

In extending the analysis to other countries, the authors needed to gain access to data on number of broadband and dial-up subscribers broken down between residential and enterprise users extending back to at least 2002. In addition, residential and enterprise data series for the equivalent period is required.

3.3.2. Methodology:

The objective of this methodology is to calculate a metric similar to the estimate of the broadband bonus developed by Greenstein and McDevitt (2009) for the United States: consumer surplus and net gain in producer revenue (broadband revenue minus lost dial-up revenue), expressed in a single currency for comparability.

The first step is to calculate broadband revenues for the whole country. This is done by multiplying the number of subscribers by a price index for the given country, expressed in real terms for the last year of the series. Estimates are calculated for each year of the series.

The second step is to estimate the consumer surplus. The basic methodological premise in measuring consumer surplus is that a decline in real prices, resulting from the combination of general price inflation with flat or no growth in nominal prices generates consumer surplus. Such declines are common in all these economies for broadband. By analyzing the historical trend, one can observe the growth in consumer surplus, whose vector depends on the change in prices levels and change in revenue.

The third step adjusts the estimates for the replacement of dial-up by broadband, presuming that dial-up would have been used, had broadband never diffused. Since prices for dial-up service might not be available, Greenstein and McDevitt rely on estimates of cannibalized dialup revenue using OECD's figures for dial-up use and an estimate of the price of dial-up service, also from OECD, whose latest published number was for the year 2000. This allows seeing the size of dial-up revenue cannibalized by broadband. The calculation of the so-called "broadband bonus" is done by adding broadband revenue to consumer surplus and subtracting cannibalized dial-up revenue.

3.3.3. Advantages and disadvantages:

The model measuring consumer surplus originated from broadband services presumes a stable demand, since core factors shaping demand do not change substantially. In that sense, results are quite valid for the short run.

On the other hand, the analysis can yield conservative estimates. These might exclude gains to early adopters, shifts in demand linked to GDP growth, falling prices of PCs, greater capability of online system, and changing user willingness to pay. Furthermore, the methodology excludes indirect benefits. Having said that, the authors argue that given data availability internationally, there does not really exist an alternative approach for comparing countries.

4. PROPOSED SET OF INDICATORS FOR MEASURING BROADBAND IMPACT

The following chapter includes a proposed set of indicators for measuring the economic impact of broadband. Data requirements range from the aggregate macro-indicators to the micro-data that provide an indication of consumption patterns and user needs.

4.1. Disaggregated data for ICT, broadband and economic indicators

The foremost need is for data on all indicators to be disaggregated at the regional level within a country (county, canton, department, even postal code). The lower the level of aggregation is, the more data points there are and, with more data points, the effects of broadband can be estimated more precisely. In addition, the more variables that are used, the more points are needed to obtain an adequate level of precision. Since growth models rely on at least 5 or 6 variables, it is necessary to have a large number of observations (at least 30-40) to estimate the effects of broadband.

The second reason for disaggregated data needs is that it allows research to deal with local fixed effects. Even with a rich set of controls, it is hard to measure the effects of broadband using large levels of aggregation. All sorts of questions arise as to how comparable the data are. For example, it is difficult to compare penetration rates or education (which are two variables used in growth models), across countries, or even between cities and rural areas. Quality may differ tremendously between countries, therefore two people with the number of years of education or both with broadband internet may be getting very different services if one is in a developed and another is in a developing country. Therefore, the lower the level of aggregation is, the more accurate results will be.

4.2. Quarterly data

Quarterly data is another way to increase the number of observations and thus the accuracy of estimations of broadband effects. In many countries employment is reported on a quarterly basis. Therefore, if broadband subscriptions are also reported quarterly, it will be possible to estimate the relationship between broadband and employment more accurately.

For one, the amount of time required for broadband to impact employment will be known with greater specificity. At the moment, research indicates that there is a lag period between network construction and the moment where indirect employment effects kick in. However, whether this lag is one quarter or two years long is currently unknown. Quarterly data is the only way to observe this phenomenon. More accurate estimations of the effect of broadband on employment are also needed because the relationship is complex and also subtler than that of broadband on GDP. While employment is clearly raised by network construction, the long-term effects on employment are less clear. For example, broadband may enable outsourcing or online shopping could hurt employment at local commercial businesses.

From an economic point of view, in the short-run, increases in labor productivity may lead businesses to substitute capital for labor. While there are also many positive effects of broadband on employment, the relationship is very subtle and more precise estimates are needed to quantify it; as of now the results of research vary, some papers find no relationship, (the negative and positive effects are balanced), while others find a positive effect. Quarterly data will allow for more precision, which will go a long way towards solving this problem.

Finally, growth models necessitate data from at least two points in time per country, state or other unit of observation. Therefore, if data is collected quarterly, research may be conducted as soon as one year after regulators begin releasing new time series. However, with annual data, two years is the absolute minimum needed for researchers to use new data.

4.3. Range of broadband download speed

Policy makers and researchers agree that the speed of internet access matters. So far, research has proven that the move from dial-up to broadband (be it DSL or cable modem) has a positive impact on productivity. However, it is yet unclear whether there is a linear relationship between speeds and economic impact. The question is: at how much speed should broadband be offered in order to maximize economic impact?

In order to answer this question, regulators need to keep data on the number of subscriptions by speed. For one, this would greatly facilitate cross-country comparisons. It is unrealistic to assume that the average broadband customer in a developed country has the same service quality as his counterpart in a developing nation. Yet, because these data are not available economic studies are forced to make this assumption. This may have created a large range of problems. For example, studies disagree whether broadband is more useful to urban areas and developed countries. However, more developed countries often offer faster broadband services, so it is difficult to tell whether the effects increase because the impact of increasing access speeds is very large or developed countries can more successfully use broadband services. Data compiled on the number of subscriptions by range of speed will help researchers quantify the marginal returns on speed. In turn, this will help countries optimize their broadband plans. For example, it will become clear whether policy should focus on the development of new technologies (such as fiber to the home deployment) or increasing coverage of basic technologies. There is no point in investing in 100 MB services if they don't offer any socio-economic gains relative to 10 MB services.

4.4. Data on wireless broadband Internet

Wireless Internet represents the platform of choice for meeting the demand for broadband in developing countries. It is also increasingly important for developed countries in terms of the shift to wireless of a great deal broadband usage. Wireless data plans are becoming increasingly sophisticated and as a result their speeds and capabilities are comparable to fixed-line broadband plans. In light of the surge in wireless data plans, (which is expected to continue through the next few years), developed countries will experience a substantial increase in broadband subscriptions, even though the fixed line market is in some cases saturated. Without data on wireless data plans, socio-economic benefits will be wrongly accounted for. This problem is only exacerbated in developing countries, where, due to lack of infrastructure, the majority of Internet connections are through wireless networks. Fixed-line broadband and wireless data subscriptions simultaneously increasing and therefore without data on mobile broadband subscriptions the economic benefits will be attributed solely to fixed line broadband. This will severely influence estimations on the importance of broadband, because mobile data plans are just as if not more important than fixed lines.

4.5. Data measuring the demand gap

There is much debate over the short-term and long-term effects of broadband networks. From an econometric point of view homes passed allows us to differentiate between direct effects of roll out and other effects. At the moment econometric models have a great amount of difficulty measuring direct effects because if subscribers rise during one year it is usually as a result of construction in the previous year. However, we tend to measure the effects of subscriber gains on the next year. Because homes passed are a more accurate measure of network construction, the confounding effect would be solved if this data were collected. Differentiating between short-term and long-term effects would be especially useful for understanding the relationship between broadband and employment. As mentioned above, the long term effects of employment are the most controversial. However, when the both short and long term effects are measured at the same time, we risk overlooking the subtleties of the long term effects.

In addition, homes passed would allow researchers to gauge the demand gap, defined as the population that could subscribe to broadband but do not. This is critical since in many cases, broadband policies are primarily focused on supply stimulation (e.g. how to stimulate further investment in unserved and underserved regions) when the first and easiest problem to be tackled to increase penetration would be the demand side (e.g. what type of education programs, digital literacy campaigns, and potential subsidies could be implemented to stimulated adoption).

In that sense, it is critical to gather data in terms of coverage, quality and speed by region of a given country. In addition, survey data on household and enterprise broadband utilization should be extremely useful to determine policies tackling the demand gap.

4.6. Variables for income endogeneity

There is good reason to believe that, like most other goods, broadband is income elastic. That is to say broadband not only drives income growth, but income also drives broadband demand. This two-way relationship is termed endogeneity and is very difficult for researchers to deal with. It may severely impact estimations of the impact of broadband on GDP. The most convincing econometric tool to deal with this is to rely on a system of equations. However, this process is not feasible for most countries because of data availability. The following variables would greatly enhance researcher's capabilities for using systems of equations. They allow the estimation of broadband supply and demand, which solves the problem of income endogeneity.

4.6.1. Prices/competition:

Both supply and demand are functions of price. Therefore, in order to make use of simultaneous equations, it is necessary to have a measure of price (such as average or median price paid), for each geographical unit of observation. Though it is far less desirable, if price is unavailable, competition can be used as a proxy. This can be measured by the number of providers serving a certain area (however this is obviously only useful at small levels of aggregation such as the zip code or county). Competition is also useful because it can be used as a proxy for subscription rates. For example FCC only collects data on the number of firms that offer broadband in a given zip code, not the penetration level.

4.6.2. Government incentives/investment:

A large amount of broadband ventures are supported by government. This share is so large that is problematic to broadband supply without government incentives. Government surplus is not a good enough proxy - in fact it is misleading. One would think that governments with greater surpluses would be able to offer more incentives, but research such as Koutrompis (2009) has observed the opposite effect in OECD countries. It would seem that large deficits are indicative of big spenders. However, it is very likely that this would not hold up if we analyzed developing countries where broadband plans might be the first to be cut in a situation of financial need. Clearly, in order to adequately describe supply, researchers need direct data on government incentives and investment.

5. CONCLUSION

The assessment of economic impact of broadband technology should be considered an emerging area of research, which is critical in providing evidence in defining policies. The broadband policy arena has been advancing very rapidly since the inception of the technology prompted by the shift of information flows to data communications from voice, and the consequent growing amount of investment from the private sector. Unfortunately, it would be fair to say that economic impact studies have not developed at a step commensurate to that of the policy development domain. Yet, triggered by the growing availability of data series, new studies have been completed recently, shedding some light on under which conditions, and to what extent, can broadband contribute to economic growth and job creation. At the same time, the studies have allowed to identify the gaps in data availability. Governments, especially regulatory authorities, should emphasize the gathering of data in order to facilitate the analysis of economic impact, a key cornerstone of policy making.

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APPENDIX A. VARIABLES UTILIZED IN ECONOMETRIC ANALYSES

Table A.1. Dependent Variables in econometric studies

Author	Employment	GDPC
Crandall et al.	Yearly Growth Rate	Wages
Czernich et al.	-	GDPC
Katz et al. (2010)	Period Growth Rate	-
Kolko	Period Growth	Median Income
Koutrompis (2009)	-	GDPC
LECG	-	-
Lehr et al	Period Growth of Employment Rate, and Number Employed 1994-98	Average Salary and Median Income
Qiang & Rossotto	-	-
Shiedeler et al.	Yearly Growth Rate	-
Thompson & Garbacz	Yearly Growth Rate	-
Waverman et al.	-	Income
Katz (2010) – Latam		
Katz (2010) – Brazil	Yearly Unemployment Growth 07/06	Growth Rate Regional GDPC 07/06
Katz (2010) – Chile	Quarterly Rate 09/02	Growth Rate Regional GDPC 08/09
Katz (2010) – India	Yearly Growth Rate	Growth Rate Regional GDPC 07/08
Katz (2010) – Malaysia		
Katz (2010) – S. Arabia	Yearly Unemployment Growth 08/07	

On the independent variables side, in addition to change in broadband penetration, a number of variables are utilized both in the economic and technology domain (see tables A.2 and A.3).

Table A.2. Economic Independent Variables in Econometric Studies

Author	GDP	Establishments	Investment	Labor Force
Crandall et al.	Growth Rate 05/03 or 05/04	-	-	-
Czernich et al.	GDPC	-	-	Working Age Population
Ford & Koutsky	Gross Sales (Monthly) as a proxy	-	-	Population
Katz et al.	Period Growth Rate	-	-	Pop. Growth 2000-6
Kolko	-	Average Size	-	Pop. Density
Koutrompis	Millions $	-	-	Employed Pop age 15-64
LECG	Per Hour Growth Rate	-	-	-
Lehr et al	-	Period Growth (99-02) and also 94-98 growth for General, ICT and Small	-	Number Employed
Qiang & Rossotto	Period Growth Rate	-	Period Average	Working Age

				Population
Shiedeler et al.	-	-	-	-
Thompson & Garbacz	Yearly Growth Rate	-	-	per Capita Participation
Waverman et al.	Period Growth Rate	-	Period Average	Working Age Pop
Katz (2010) – Latam	Growth Rate 06/04 or 09/07		Avg Invest. 03/01 or 06/04	
Katz (2010) – Brazil				
Katz (2010) – Chile				
Katz (2010) – India				
Katz (2010) – Malaysia	Growth Rate 08/07			
Katz (2010) – S. Arabia				

Table A.3. ICT Independent Variables in Econometric Studies

Author	Broadband	BB Saturation	Telephone Penetration	Cable Penetration	PC Penetration
Crandall	Lines Per Capita	-	-	-	-
Czernich et al.	Yes or No (Dummy)	-	1996	1996	-
Ford & Koutsky	Yes or No Availability	-	-	-	-
	Dummy, 2002				
Katz et al	Penetration Growth 02-03	-	-	-	-
Kolko	Number of Providers (Proxy for Penetration) 2006, 1999	-	-	-	-
Koutrompis	Penetration	-	-	-	-
LECG	2007 Penetration	-	2007-1980	-	2007 Penetration
Lehr et al	Zip: Yes or No Availability Dummy, 1999 also State: Penetration	Square Penetration (State)	-	-	-
Qiang & Rossotto	Broadband subscribers per 100 people, Internet users per 100 people	-	Period Average Penetration, mobile and fixed	-	-
Shiedeler et al	Coverage Area/Total	BB squared	-	-	-
Thompson & Garbacz	Lines Per Thousand People	-	-	-	-
Waverman et al.	-	-	Period Avg. Penetration, mobile and fixed	-	-
Katz (2010) – Latam	Penetration Growth 03-06				
Katz (2010) – Brazil	Penetration Growth 05-06				

Katz (2010) – Chile	Penetration Growth 03-07				
Katz (2010) – India	Penetration Growth 07-08				
Katz (2010) – Malaysia	Penetration Growth 06-07				
Katz (2010) – S. Arabia	Penetration Growth 07-08				

Among control variables, the following are being utilized (see Table A.4).

Author	Education	Union Membership	Climate	Roads	Dummys	Rent	Country Size	Time Trend	Urbanizat.	Racial Compos	Other
Crandall et al	College Grads/ Pop	Union Share of Employment	Temperat. (mean) 1971-01	-	Census Regions	-	-	-	-	-	-
Czernich et al.	Years	-	-	-	-	-	-	-	-	-	-
Ford & Koutsky	-	-	-	-	-	-	-	-	-	-	-
Katz et al.	-	-	-	-	-	-	-	-	-	-	-
Kolko	Bachelor's Degree Percent	-	Climate Index	Density	-	-	-	-	Metropolitan Pop	Dummy Black	Vacat. houses, Terrain slope, Family Structure, Age
Koutrompis	% GDP spent on education	-	-	-	-	-	-	-	% pop living in areas with 500+ people/sq km	-	Regulation, Research and Development, Competition (HH Index), Broadband Investment, Industry shares
LECG	-	-	-	-	-	2002 Median	-	-	-	-	-
Lehr et al	College Grads/ Pop	-	-	-	-	2000 Median	-	-	Dummy (local), also Percentage State	-	-
Qiang & Rossotto	Primary Education in 1980	-	-	-	Latam and Sub Saharan Africa	-	-	-	-	-	-
Shiedeler, et al.	College Grads/ Pop	-	-	-	Rural	-	-	-	-	-	-

Thompson & Garbacz	High School	-	-	-	-	-	-	-	2000, % pop living in urban areas	% Black	-
Waverman et al.	Primary Education in 1980	-	-	-	-	-	-	Yes	-	-	Rule of Law
Katz (2010) - Latam	Tertiary education in 2002										Globalization Index, Population Growth,
Katz (2010) – Brazil	Illiteracy Rate in 2002, Years of schooling										Gini, Interstate trade costs, Cost to create new business, Pop Growth
Katz (2010) – Chile	Schooling Years, population with some level of tertiary education						Region population as a percent of country population		People living in urban centers by region		Contribution of Mining, finance, agricultural and trade sectors, Pop Growth
Katz (2010) –India	Participation rate in secondary schooling		Total road length per hundred sq. Km by area								Number of enterprises, banking offices, Pop Growth
Katz (2010) –Malaysia	Literacy Rate		Road development Index								Hospital, beds in hospital, Construction projects,
Katz (2010) –S. Arabia											Facilities authorized to provide health services, Tourism, Access to potable water, Number

										and value of projects funded by Gov.,