Telecommunications Policy 33 (2009) 575–581

Contents lists available at ScienceDirect

Telecommunications Policy

URL: www.elsevierbusinessandmanagement.com/locate/telpol

Broadband and contributions to economic growth: Lessons from the US experience

Lynne Holt *, Mark Jamison

Public Utility Research Center, University of Florida, PO Box 117142, Gainesville, FL 32611, USA

ARTICLE INFO

Keywords:
Broadband
Communications
Economic growth
Federal Communications Commission

ABSTRACT

The connection between broadband deployment and economic prosperity in the United States has garnered public attention due to stimulus plan funding authorized in February 2009 for broadband planning and deployment initiatives. The importance of innovation for a nation's economic well-being is fairly well understood. Through a literature survey, this article analyzes the connection between information and communications technologies and economic growth, as well as the connection between broadband and economic growth. There appears to be a positive economic impact from expanded broadband deployment and adoption. However, various research challenges including methodological problems and access to sufficiently granular data have prevented the authors from drawing more definitive conclusions from the US broadband experience. Another finding is the time lag for businesses to effectively exploit innovative broadband applications.

1. Introduction

President Obama has repeatedly emphasized the importance of broadband for economic growth in the United States. As president-elect, he mentioned broadband rollout as one of his top priorities. He also proposed funding in his stimulus package for broadband deployment in unserved and underserved regions of the nation. Congress subsequently approved funding of $7.2 billion for broadband planning and deployment initiatives in the American Recovery and Reinvestment Act of 2009.[1] Particularly because so much faith resides in the potential contributions of broadband for renewed economic growth, it is a good time to consider the following questions: to what extent does broadband really contribute to economic prosperity in the United States? Is the claimed connection between broadband and economic growth supported by facts, or is it simply political rhetoric? How important is innovation for economic growth, and what is the connection between broadband use and innovation?

This survey attempts to respond to these questions by first examining the connection between information and communications technologies (ICT) and economic growth and then the connections between broadband, a subset of ICT, and economic growth. The discussion begins with ICT because more research has been done on this broader indicator than on broadband specifically and much of the ICT research predated the research on broadband. In addition, there has been more international research on ICT impacts than specifically on broadband. The ICT experience is used to draw lessons for broadband with a focus throughout this article on the US experience.

* Corresponding author. Tel.: +1 352 273 1077; fax: +1 352 392 7796.
E-mail addresses: lynne.holt@cba.ufl.edu (L. Holt), mark.jamison@cba.ufl.edu (M. Jamison).

[1] See Pub. L. 111-5.

0308-5961/$ - see front matter
doi:10.1016/j.telpol.2009.08.008

2. The broader context: ICT and the innovation economy

There are many ways of examining how ICT relates to economic development. One is a country's global competitiveness, which is based on the country's capacity for exploiting ICT for innovative applications (Osorio-Urzua, 2008). An index for measuring such competitiveness, the *Global Competitiveness Index*, ranks business competitiveness across 134 countries with the US ranked first in 2008–2009 (Porter & Schwab, 2008). The index's treatment of competitiveness is not confined to technology: technological readiness is one of the 12 attributes (called ''pillars'') of a country's relative competitiveness. To better understand the effects of ICT, including broadband, on economic growth and productivity, one might consider the broader context in which ICT is deployed and the conditions under which it has most effectively contributed to economic growth.[2] The measure for economic development, as used in the *Global Competitiveness Index*, is gross domestic product (GDP) per capita, adjusted for purchasing power parity because it is considered the most comprehensive measure of national economic activity and is strongly correlated to a nation's living standard over time (Porter & Schwab, 2008). GDP per capita is not a complete measure of the well-being of a country because this metric does not necessarily take into account factors that are often difficult to quantify. Nonetheless, GDP per capita is commonly measured across nations and commonly used as a means of comparing economic development, those limitations notwithstanding. Because the private sector is arguably the most effective means of wealth creation, an index that attempts to measure economic competitiveness of the private sector in terms of GDP per capita seems an appropriate place to begin the analysis.

A country's GDP may not capture the full benefits of ICT investments immediately because there is a time lag for the impact of ICT investments to be realized in a country's economy. One might view these effects in terms of short-term and long-term horizons. In the short term, the relative prices of ICT are reduced and investment in ICT increases (i2010 High Level Group, 2006). In the longer term, new technologies are adopted and new products are developed; then new ways of business operation evolve (i2010 High Level Group, 2006).

Yet, ICT adoption appears to occur in a more complicated manner than is suggested by this two-stage progression. In their study on productivity growth, Van Ark and Inklaar (2005) find that the effects of ICT investments on productivity growth in Europe lagged behind the US from 1995–2004. Indeed, the efficiency gains in productivity in the non-ICT segment of Europe's economy amounted to only 2% from 2000–2004, compared to 50% in the US The question is as follows: what explains this divergence in efficiency gains between Europe and the US during that time period? The Van Ark and Inklaar study suggests that the effects of ICT investments within a country are actually U-shaped. The initial investments in ICT typically result in ''hard'' savings as the technology becomes increasingly diffused throughout the country. This upswing in productivity is followed by a period of negative productivity growth, as businesses within the country experiment with the technology and learn how to exploit it. During that period, businesses invest in human capital and organizational changes, which do not immediately translate into added productivity. Following this learning phase, there is an increase in productivity when the impact of those new technological applications becomes evident. The US completed this productivity cycle by 2004, whereas the European Union (EU) countries had not within that timeframe.[3] According to Van Ark and Inklaar, the market services sector (trade and finance) within the US was the biggest investor in ICT services and was more adept than the EU countries in using investments in ICT to develop new ICT-related services. Another study (Organisation for Economic Co-operation and Development (OECD), 2008 citing Clayton, 2006) compares the impact on productivity of ICT investments in US subsidiaries in the United Kingdom with domestic and other multinational firms in the United Kingdom. Once again, the impact on productivity is found to be substantially larger in US subsidiaries, perhaps due to a better use of ICT-generated information or so-called ''US management practices'' (OECD, citing Clayton, p.12).

The Van Ark and Inklaar (2005) study suggests that ICT investments in marketing (part of the service sector) contributed to greater productivity and possibly also explain the more competitive stance of the US relative to that of European countries. Benefits derived from ICT investments are different in manufacturing and services. Increased productivity in manufacturing comes mostly from procurement and supply chain management, whereas in the service sector those gains come largely from connections to customers (OECD, 2008 citing Clayton, 2006). In the US, the private service sector in recent years has generally outpaced the goods-producing sector, including manufacturing, in GDP growth.[4] Therefore, it appears that economic growth from ICT investments in the future will depend increasingly on service-related companies whose customers can interact effectively with the technology. However, while the national economy might experience greater GDP growth in services relative to manufacturing, it is also more difficult to measure outputs from the service sector than from the manufacturing sector. The ICT-producing segment of the manufacturing sector has been a particularly robust segment of the goods-producing industries in the US, and its contributions have greatly exceeded its proportional share of GDP. ICT-producing companies in the US represented only 4% of GDP but contributed more than 11% annually to

[2] The Organisation for Economic Co-operation and Development's (OECD's) commodity-based definition of the ICT sector includes the following broad categories: telecommunications equipment, computer and related equipment, electronic components, audio and video equipment, and other ICT goods. See http://fiordiliji.sourceoecd.org/pdf/factbook2008/302008011e-07-03-01.pdf.

[3] Like Europe, Japan also lagged behind the US in using ICT innovatively, a factor that might have contributed to slower labor productivity in Japan than in the US. See Information and Communications in Japan, 2007.

[4] This was true in 2003, 2005, and 2006. In 2004, the goods-producing sector reported slightly more robust growth than the private service sector in GDP.

GDP growth from 2004–2006 and accounted for 15% of real GDP growth during that period (US Department of Commerce, 2008).

Another index, the *Connectivity Scorecard*, ranks countries' innovation in terms of both the supply and use of ICT and supports the global competitive index finding. The *Connectivity Scorecard* ranks the US first among 25 developed countries (Waverman & Dasgupta, 2009). Despite the favorable ranking, the scorecard findings suggest that the US could still expand its broadband deployment and use its technology more intensively.

The *State New Economy Index* (Atkinson & Andes, 2008) measures the global competitiveness of states within the US. According to this index, the "new" economy and the one toward which states should strive (along the same lines as Porter's "innovation-driven" economy) is described as "a global, entrepreneurial, and knowledge-based economy in which the keys to success lie in the extent to which knowledge, technology, and innovation are embedded in products and services" (Atkinson & Andes, 2008, p.3). This is another way of describing an economy that makes extensive and intensive use of ICT-enhanced products and processes. A metric used in the *State New Economy Index* to capture the degree to which traditional industries, such as marketing, make use of information technology (and by extension contribute to greater innovation) is the percentage of information technology jobs in non-information technology-related industries.

Innovation is not an objective for a competitive economy but a means of adding value to products or processes: it is through the creative use of labor and other organizational assets that a product or process is improved. And this explains part of the problem in measuring with any precision the economic impact of ICT for the economy of an entire nation. The International Telecommunication Union (ITU) uses the analogy of electricity to make the point: "part of the difficulty is that both ICTs and electricity are 'enabling' or 'general purpose technologies', which means their use and their impacts, are ubiquitous yet difficult to measure because they are mainly indirect. It is not electricity or ICTs as such that make the (bulk) impact on economy and society but how they are used to transform organization, processes, and behaviours" (OECD, 2008, p. 7). Because people's skills and their ways of interacting may be affected by ICT, it is difficult to tease out the actual cause of greater productivity or GDP growth. The challenges of what economists call "endogeneity" notwithstanding, recent studies cited by Crandall, Lehr, and Litan (2007) offer corroborative support that ICT contributes to productivity growth, especially when ICT is used more intensively and in conjunction with skilled labor and intangible assets. Much of the research also suggests that past experiences with process innovations made firms more likely to be successful in using ICT (Hempell, 2002). Moreover, the innovation strategy used by firms really appears to affect the extent to which ICT is used: productivity gained by one firm has spill-over effects for new entrant firms that likewise may adopt similar production processes (Röller & Waverman, 2001).

3. The impact of broadband on economic growth

The discussion now turns to broadband, for which lessons may be drawn from both research on ICT and research specific to broadband. Like ICT applications, broadband applications can potentially substitute for labor, make the use of labor more efficient, and change the way work is done and the products that are produced. As with assessing the economic impact of investments in ICT, determining the economic impact of broadband is not simple or straightforward. Several studies attempt to estimate the economic impact of broadband deployment in the US but suffer from data that are insufficiently granular and that lack detail on use and speed. These data limitations stem in part from reporting requirements of the Federal Communications Commission (FCC). The FCC collects data through its standardized Form 477 filings, which were initiated in 2000. The FCC requires broadband providers to report twice a year in Form 477 information about their services and customers. In initial filings, broadband providers were required to report a single list of zip codes per state in which they had at least one broadband subscriber. The FCC modified this requirement in a 2004 order by mandating broadband providers to report technology-specific lists by zip codes.

The problem with this methodology is that some studies have relied upon it to examine determinants of broadband penetration or availability even though the data represents at best a monotonic transformation of the underlying reality. Improperly understood, the data could overstate broadband subscription or availability and, in the latter stages of development, broadband growth.[5] Data of a more granular nature should be forthcoming as the result of an order issued by the FCC on March 19, 2008 and released on June 12, 2008. In that proceeding (Federal Communications Commission, 2008), private providers are directed to report to the FCC the number of broadband subscribers by census tract, disaggregated by detailed speed tiers and technology platforms. Another development that may accelerate state data gathering initiatives is the Broadband Data Improvement Act (now P.L. 110–385). Among its provisions, the Act authorizes the US Department of Commerce to award grants for state broadband mapping initiatives. Funding is authorized for that purpose in the American Recovery and Reinvestment Act of 2009.

A study prepared for the US Department of Commerce (Gillett, Lehr, Osorio, & Sirbu, 2006) was one of the first to use the FCC data. The study uses a cross-sectional panel data set of communities, disaggregated by zip code, to analyze the effects of broadband on communities throughout the US between 1998 and 2002. The analysis is based on communities with broadband availability in December 1999, and does not distinguish between the type of provider, technology, or speed level. The study finds that broadband contributed to greater job growth and a greater number of businesses than otherwise

[5] Flamm, Friedlander, Horrigan, and Lehr (2007) elaborate on the problems associated with zip code usage for estimating broadband adoption.

would be expected in the absence of broadband. The study also finds no significant impact on average wages; nevertheless, there appeared to be some increase in property value in 2000 attributable to broadband availability in 1999. The authors acknowledged, however, that because they relied upon the FCC data they were only able to analyze broadband availability, not actual use, which would have been their preference.

The finding that broadband adoption leads to job growth in the study by Gillett et al. (2006) and in other studies merits further analysis. While it seems reasonable that broadband adoption should improve productivity and economic growth – otherwise it is unlikely that businesses and certain households (those that use broadband primarily for work) would adopt broadband technologies – effects on job growth should depend on employment and population trends. By definition broadband adoption would not lead to a net increase in jobs in an economy that had full employment because with full employment there is no slack in the labor market. Full employment means that there is no cyclical unemployment, which is the unemployment that results from low economic activity. However, with full employment there is frictional unemployment (unemployment that results from normal changing of jobs) and structural unemployment (unemployment that results from changes in the economy, such as a change in consumer preferences) (Brux, 2005). If broadband adoption stimulates economic activity, it might reduce cyclical unemployment, but by definition this is a temporary impact. Broadband adoption could decrease frictional and structural unemployment by improving the efficiency of the labor market, but it may also increase structural unemployment by causing changes in the demand for particular labor skills. More research is needed to separate out these potential effects. There are two important caveats with such an approach. First, for cross-sectional studies in countries like the United States where the workforce can move across regions, inter-regional technology advantages could result in workforce migration among regions, making an expansion in workforce in a given region endogenous to the broadband analysis. Second, following Van Ark and Inklaar (2005), there may be situations where broadband has a negative impact on employment because adoption leads to a reorganization of work that increases structural unemployment at least temporarily but not necessarily in the long term.

In a similar vein to the Gillett et al. study (2006), Crandall et al. (2007) apply a cross-sectional data analysis using the FCC penetration data to determine the economic impact of broadband on growth in jobs and state output measured as state level GDP. The research question in the Crandall study may be posed as follows: what are the effects of increasing the number of broadband lines per capita on employment growth and state GDP growth? The study's results for state GDP growth are less precise than its results for employment growth, perhaps because the federal government estimates GDP data by individual state which are less precise than state employment data. The study also has an endogeneity problem – meaning that causation could run both ways – because state GDP growth probably stimulates demand for broadband. If one were to apply the same analysis for 2008, state GDP growth would go down, and the number of broadband lines per capita would likely increase. The study provides some empirical support for the conclusion that expanded broadband capacity led to an increase in the number of jobs and an increase in GDP, particularly in the service sector, such as finance, real estate, and educational services. According to the Crandall study, an estimated increase of 1.0% in a state's broadband penetration would yield an increase of approximately 300,000 jobs. The study also shows that the magnitude of the impact of broadband on job growth increases over time as capacity is added. In a recent newspaper article, Crandall explained that the projections made in the 2007 study would no longer be applicable because of different trends in employment and migration at that time (Dixon, 2009). Another criticism of the Crandall 2007 projections came from Professor Shane Greenstein, Northwestern University, who raised concerns with extrapolating state-wide data for the nation as a whole (Dixon, 2009).

Connected Nation, Inc. (2008) released an economic impact study for the entire nation that was extrapolated from an analysis it had done for Kentucky (discussed below). The job growth calculation makes use of the study results of Crandall et al. (2007) and uses average annual wages for each state in 2006, as reported by the US Bureau of Labor. The study estimates that $92 billion would be realized through the addition of 2.4 million jobs created or retained although the methodology used to capture retention is not explained.[6] In contrast to Gillett et al. (2006) and Crandall et al., the Connected Nation study adds estimated savings from online activities involving health care, less time in cars, reduced environmental pollution, and online transactions. In short, this study attempts to address the limitations of job growth measurements by taking into account money saved through broadband users' behavior changes.

Connected Nation's projected economic impact for Kentucky applies the Crandall et al. (2007) results to job growth in Kentucky. However, the Crandall et al. estimate is an average nationwide estimate based on an employment mix for the entire nation, and the coefficient used by Crandall et al. might not be transferable to Kentucky's particular employment profile in 2005–2007. (The Crandall et al. study was for 2003–2005). There is also a mismatch between the timeframe used for measuring change in the percentage of household penetration in Kentucky and the timeframe used in the US, giving Kentucky five more months than the US which would therefore tend to overstate Kentucky's broadband adoption increase. Moreover, the same concerns with endogeneity in the Crandall et al. study would apply to the Connected Nation study. The Connected Nation's survey upon which the cost savings analysis was based relies on a sample size of less than 200 respondents for most questions.

[6] The estimate for jobs created or retained is also hard to understand because total employment in Kentucky in 2007 was slightly more than 1.9 million, which is less than the estimated 2.4 million jobs created or retained. See Kentucky Office of Employment and Training, available at http://www.workforcekentucky.ky.gov/. Retrieved February 10, 2009.

Some of the questions were also phrased in such a manner that any findings would be debatable. For example, respondents were asked: ''obtaining health care information online has empowered me to remain healthier?''[7] The connection between online access to health care and improved health is unclear at best. And the responses came from those surveyed and not their physicians. The question ''about how much money would you estimate you have saved by becoming healthier in this way?'' again suggests a connection that may not exist, and it is unclear on what basis these savings determinations have been made because respondents apparently provide the estimates and their definition of what, in their view, constitutes improved health.

Another economic impact study on broadband in Kentucky was conducted by Shideler, Badasyan, and Taylor (2007). Like Gillett et al. (2006) and Crandall et al. (2007), this study does not deal with broadband use but rather broadband deployment and makes no distinction in broadband speeds, both caveats acknowledged by the authors. Nonetheless, the deployment data in the Shideler et al. study appear to be more granular than data collected from zip codes in the FCC's Form 477: the study relies on the aggregation of county-level data from ConnectKentucky's Geographic Information System database, which consists of proprietary data from broadband providers in the state. In contrast to the other studies discussed above, the Shideler et al. study focuses solely on employment growth. However, the impact of broadband on employment growth may not be adequate to fully capture broadband's benefits because employment growth may be due to multiple factors, and the factors used in the paper for measuring impact appear to have a fairly low level of explanatory power.[8] The Shideler et al. study analyzes the impact of broadband on employment growth in various industries and finds that broadband availability contributes to employment growth in most industries to some degree. Only one industry – accommodations and food services – realized reduced employment due to broadband deployment. For example, people can make their own arrangements online for accommodations, and broadband connectivity enables technology to be used instead of employees for various accommodation, and restaurant, related service transactions. Finally, the study suggests that a certain level of broadband infrastructure is needed to significantly affect employment growth. Too much or too little broadband infrastructure saturation portends lower returns on investment. Another state-specific study by Ford and Koutsky (2005) compares the economic impact on economic growth of a municipally owned broadband system in a Florida county, Lake County, to that of comparable Florida counties without municipally owned broadband systems. Broadband services through Lake County's municipal network were made available to businesses and government institutions. The economic growth in this context is measured by gross sales per capita. The comparison years are the three years prior to and the three years after 2001—the year the broadband network was first used extensively throughout the county. The findings suggest that Lake County experienced from January 2002 through November 2004 more than twice the growth rate in gross sales per capita compared to its peers. Studies of this sort, no matter how well conceived, raise questions about the selection of comparable counties. For example, the economies of Florida's counties were affected differentially by a lower level of tourism and snowbird migration in the aftermath of 9-11 and by a spate of hurricanes in 2004 which devastated several counties, including Charlotte—one of the comparison counties in the study. The study assumes that the comparison counties had some private broadband network presence and speculated that the incentives of the private sector may have been less geared to deploying broadband as extensively. Hauge, Jamison, and Gentry (2008) show that municipalities were more likely than private operators to compete with incumbents in rural and low-income areas, but were deterred from entering where the incumbent already faced competition. The Ford and Koutsky study does not appear to account for the increase in taxes or fees in Lake County to recover the infrastructure investment.

A study prepared by the Sacramento Regional Research Institute for AT&T (Van Gaasbeck, et al., 2007) analyzes the economic impact of broadband on 39 California counties from 2001 to 2006. Because these counties during that period accounted for approximately 92% of the state population, that coverage served as a proxy for the entire state. In contrast to the nationally based studies and the Kentucky studies previously cited, the California study measures broadband use and not deployment. The data for broadband use come from a proprietary database consisting of survey results that reflected the extent to which adults accessed the Internet in their homes. To determine effects, the Van Gaasbeck et al. study disaggregates the 39 counties into 24 regions. It also assesses the degree of migration from dial-up connectivity to either DSL or cable during the six-year period. In general, the study finds that broadband deployment appeared to contribute to employment and total payroll growth but not to an increased number of physical business establishments.[9] Indeed, the broadband rollout appeared to have had a negative impact on such growth.

In contrast to the findings of the California study, Gillett et al. (2006) find that broadband contributed to a positive increase in the number of firms. Van Gaasbeck et al. speculate that the difference in findings may be due to attributes of California counties related to those of counties elsewhere. Perhaps telecommuting is more prevalent in California than elsewhere; it might be more expensive to rent buildings for businesses in California than elsewhere; and the way businesses were defined to measure growth is different in the California study than in the study by Gillett et al. While not passing judgment on these hypotheses, there exists another possibility for the divergent findings: the Gillett et al. study

[7] For example, patients may read about treatments online that do not necessarily apply to them, and the information on web sites may not be accurate. These were the findings of a University of Texas study on breast cancer. ('Healthy Skepticism', 2008). Likewise, one might expect the same problems to apply to other health conditions because there is no quality control on much of the information posted on the Internet.

[8] The study uses four models to estimate broadband's contributions toward total employment. This impact ranges from 0.14% to 5.32%.

[9] The California study (Van Gaasbeck et al.) is somewhat cautious about the negative impact on business establishment growth, noting mixed results once robustness is checked.

spanned an earlier period, 1998–2002, and the California study covered for most of the part a later period, 2001–2006, when broadband was much more widely deployed and accessed. For example in early 2003, broadband service was used by only 23.8% of adult Californians, but in the latter part of 2006, the percentage grew to 53.5% (Van Gaasbeck, et al., 2007, fig. 2). It seems reasonable that the impacts of broadband will change as deployment and subscription increase.

Noting a deficiency in the debate on the economic impacts of broadband, namely a failure to recognize that broadband often substitutes for other business inputs, such as dial-up Internet access, a recent study by Greenstein & McDevitt (2009) finds a smaller economic impact from the diffusion of broadband than some previous studies. Higher-speed connectivity enabled by broadband has the same Internet functionality as dial-up but makes labor more efficient. This increased efficiency adds to both measured and unmeasured GDP, including new GDP. The authors estimate that broadband accounted for $28 billion of GDP in 2006, with an estimated $20–$22 billion attributable to household use. Only $8.3–$10.6 billion of this amount was new GDP because the remainder would have been generated if dial-up connectivity and second line use for that purpose had continued and had not been replaced by broadband. The lower economic impact estimate in this study derives from several factors: first, the demand for broadband is estimated by measuring what consumers are willing to pay for upgrading to broadband. This demand level would be lower than a demand level that assumes that dial-up users, had they continued to use dial-up connectivity, would lose all the benefits of Internet access they share with broadband users. The study appropriately assumes that absent a migration to broadband, dial-up connectivity would have still contributed a considerable amount to measured total GDP. Second, the study does not take into account impacts of externalities, which some authors view as significant for broadband. Third, the estimates used in this study are calibrated against eight years of actual broadband diffusion, 1999–2006. The authors consider this approach to be more grounded than a forecasting approach. Using simulations, the authors estimate the decline in the price of Internet access (1.6–2.2% per year) to explain the number of households that opted for broadband access (new users and former dial-up users). The authors find that companies received incremental returns that were sufficiently large to spur major investments in broadband infrastructure, largely without relying on subsidies.

The findings of Van Ark and Inklaar (2005) support the notion that impacts change over time. The authors note that there appears to be a time lag between the adoption of ICT and productivity growth. For an interval after adoption, there may even be a loss in productivity when businesses experiment with the technology. If one assumes, as was assumed in the California study, that household Internet access is indeed a good proxy for business use, it may take some time for individuals to gain sufficient technological aptitude to become more mobile in their working habits. The movement away from traditional office designs is becoming more acceptable as workers' habits change, and they find they can work from anywhere aided by new technologies ("Labour Movement," 2008). This transformation in work habits could portend the need for less physical office space and very different office designs where work could be more easily mixed with other non-work activities ("The New Oases," 2008). However, there are detractors to this way of thinking: *The Economist* concludes that while bandwidth is continuing to expand, the relationship between greater speeds and innovations still remains unclear ("The Broadband Myth," 2008).

4. Conclusion

The lesson from the US appears to be that broadband has a positive economic impact, but that impact cannot be analyzed with any precision. One of the difficulties learned from studies of the effects of ICT is that impacts evolve, perhaps even going through periods of negative growth, while businesses experiment with applications and reorganize their operations. This implies that time series studies used to analyze the impact of broadband on economic growth should consider non-linear effects.

Another difficulty is endogeneity of workforce change, broadband adoption, and other metrics, which would imply that a single model is unlikely to reveal all that should be explained about the impacts of broadband. Studies also suffer from data limitations resulting at least in part from the FCC's historical data gathering practices, but also from the rapid evolution of technologies, such as mobile broadband, which are difficult to quantify. Due to heterogeniety in broadband products, indices using only one metric, such as the much cited per subscriber broadband rankings put forth by the OECD,[10] are particularly problematic for use in economic impact studies.

Moreover, an emphasis on job creation without consideration of effects of broadband deployment on productivity, outsourcing, and innovation may be misleading. A recently released study by Katz and Suter (2009) takes into account these three effects in an impact analysis of the broadband stimulus plan using three scenarios: pessimistic, mid-course, and optimistic. For the years 2009–2012, jobs gained and lost could range from 1000 foregone jobs under the pessimistic scenario to a gain of 273,000 jobs under the optimistic scenario. Whereas jobs would be lost from improved productivity and potentially from outsourcing, jobs would clearly be gained from projected increases in innovation.

Finally, economic impact analyses should recognize that broadband replaces other communication modes, such as dial-up modems, and that the net effect of broadband may be less than a simple study might otherwise find.

[10] In those rankings, the United States placed 15th among 30 developed countries in June 2008. See http://www.oecd.org/document/54/0,3343,en_2649_34225_38690102_1_1_1_1,00.html. Retrieved February 23, 2009.

Acknowledgements

We would like to thank Scott Wallsten for insights, suggestions, and thoughtful review of an earlier version of this paper. An expanded version of this paper was presented at a conference on Telecommunications Infrastructure and Economic Development that was held in Paris on October 16–17, 2008. This meeting was sponsored by the Innovation & Regulation, ENST.

References

Atkinson, R. D., & Andes, S. (2008). *The 2008 State new economy index: Benchmarking economic transformation in the States* (November). Retrieved February 23, 2009, from The Information Technology and Innovation Foundation Web site: ⟨http://www.itif.org/files/2008_State_New_Economy_Index.pdf⟩.

The broadband myth (2008). *The Economist* (May 23). Retrieved February 23, 2009, from the Economist.com Web site: ⟨http://www.economist.com/science/displaystory.cfm?story_id=11434920⟩.

Brux, J.M. (2005). *Economic issuesandpolicy* (3rd ed.). Mason, Ohio:Thomson South-Western.

Connected Nation, Inc. (2008). *The economic impact of stimulating broadband nationally*, February 21. Retrieved February 23, 2009, from ⟨http://www.connectednation.org/_documents/Connected_Nation_EIS_Study_Full_Report_02212008.pdf⟩.

Crandall, R., Lehr, W., & Litan, R. (2007). The effects of broadband deployment on output and employment: A cross-sectional analysis of US data. *Issues in economic policy*, *6*(July), 1–34. Retrieved February 23, 2009 from The Brookings Institute Web site: ⟨http://www3.brookings.edu/views/papers/crandall/200706litan.pdf⟩.

Dixon, K. (2009). *Broadband link to US jobs exaggerated* (January 30). Retrieved February 23, 2009 from the Benton Foundation Web site: ⟨http://benton.org/node/21439⟩.

Federal Communications Commission (2008). *The deployment of nationwide broadband data to evaluate reasonable and timely deployment of advanced services to all Americans, improvement of wireless broadband subscribership data, and development of data on interconnected Voice Over Internet Protocol (VoIP) subscribership*. WC Docket No. 07-38, Report and order and further notice of proposed rulemaking (rel. June 12). Retrieved February 23, 2009, from the Federal Communications Commission Web site: ⟨http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-08-89A1.pdf⟩.

Flamm, K., Friedlander, A., Horrigan, J., & Lehr, W. (2007). *Measuring broadband: Improving communications policymaking through data collection* (November). Retrieved February 23, 2009, from The Pew Research Center Web site: ⟨http://www.pewinternet.org/pdfs/PIP_Measuring%20Broadband.pdf⟩.

Ford, G. S., & Koutsky, T. M. (2005). Broadband and economic development: A municipal case study from Florida. *Review of Urban and Regional Development Studies*, *17*(3), 216–229.

Gillett, S., Lehr, W. H., Osorio, C., & Sirbu, M. (2006). *Measuring broadband's economic impact*. Final Report, prepared for the US Department of Commerce, Economic Development Administration, February. Retrieved February 23, 2009, from ⟨http://www.eda.gov/ImageCache/EDAPublic/documents/pdfdocs2006/mitcmubbimpactreport_2epdf/v1/mitcmubbimpactreport.pdf⟩.

Greenstein, S., & McDevitt, R. C. (2009). *The broadband bonus: Accounting for broadband Internet's impact on US GDP*. Working Paper, Northwestern University Kellogg School of Management, January. Retrieved February 23, 2009, from ⟨http://www.kellogg.northwestern.edu/faculty/greenstein/images/htm/Research/WP/Broadband%20Bonus%20-%20Greenstein&McDevitt.pdf⟩.

Healthy Skepticism Advised for Online Medical Information. (2008). *Hospital & Health Networks*, *82*(3), 59.

Hauge, J. A., Jamison, M. A., & Gentry, R. J. (2008). Bureaucrats as entrepreneurs: Do municipal telecom providers hinder private entrepreneurs?. *Information Economics and Policy*, *20*(1), 89–102.

Hempell, T. (2002). *What's spurious, what's real? Measuring the productivity impacts of ICT at the firm-leve*l. Zentrum für Europäische Wirtschaftsforschung (ZEW) Discussion Paper 02-42, Mannheim, Germany.

Information and Communications in Japan. (2007). *White Paper*. Ministry of Internal Affairs and Communications, Japan (Chapter 1).

i2010 High Level Group. (2006). *The economic impact of ICTs: Evidence and questions* (April 20). Retrieved February 23, 2009, from the European Commission, i2010 (Information Space Innovation & Investment in R&D Inclusion) European Information Society Web site: ⟨http://ec.europa.eu/information_society/eeurope/i2010/docs/high_level_group/note_on_economic_impact_of_ict.pdf⟩.

Katz, R., & Suter, S. (2009). *Estimating the economic impact of the broadband stimulus plan* (February). Retrieved February 23, 2009, from the Columbia Institute for Tele-Information, Columbia Business School Web site: ⟨http://www.elinoam.com/raulkatz/Dr_Raul_Katz_-_BB_Stimulus_Working_Paper.pdf⟩.

Labour movement: The joys and drawbacks of being able to work from anywhere. (2008). *The Economist*, April 10. Retrieved February 23, 2009, from the Economist.com Web site: ⟨http://www.economist.com/specialreports/displaystory.cfm?story_id=10950378⟩.

The new oases: Nomadism changes buildings, cities, and traffic. (2008). *The Economist* (April 10). Retrieved February 23, 2009, from the Economist.com Web site: ⟨http://www.economist.com/specialreports/displaystory.cfm?story_id=10950463⟩.

Organisation for Economic Co-operation and Development. (2008). *Measuring the impacts of ICT using official statistics, working party on indicators for the information society* (January 4). Retrieved February 23, 2009, from ⟨http://www.oecd.org/dataoecd/43/25/39869939.pdf⟩.

Osorio-Urzua, C. (2008). The missing link: Why does ICT matter for innovation? Exploring the effect of information technology on innovation-based competitiveness. *Global Information Technology Report 2007–2008*, World Economic Forum (pp. 39–56).

Porter, M. E., & Schwab, K. (2008). *The global competitiveness report 2008–2009*. Geneva, Switzerland: World Economic Forum. Retrieved February 23, 2009, from ⟨⟩http://www.weforum.org/documents/GCR0809/index.html⟩.

Röller, L. H., & Waverman, L. (2001). Telecommunications infrastructure and economic development: A simultaneous approach. *The American Economic Review*, *91*(4), 909–923.

Shideler, D., Badasyan, N., & Taylor, L. (2007). The economic impact of broadband deployment in Kentucky. *Regional Economic Development*, *3*(2), 88–118. Retrieved February 23, 2009, from the Federal Reserve Bank of St. Louis Web site: ⟨http://research.stlouisfed.org/publications/red/2007/02/Shideler.pdf⟩.

US Department of Commerce, Bureau of Economic Analysis, (2008). Private services-producing sector continued to lead growth in 2006: Revised statistics of gross domestic product by industry, 2004–2006, January. Retrieved February 23, 2009, from ⟨http://www.bea.gov/newsreleases/industry/gdpindustry/gdpindnewsrelease.htm⟩.

Van Ark, B., & Inklaar, R. (2005). *Catching up or getting stuck? Europe's troubles to exploit ICT's productivity potential* (September). Retrieved February 23, 2009, from the Groningen Growth and Development Centre, University of Groningen Web site: ⟨http://ggdc.eldoc.ub.rug.nl/FILES/root/WorkPap/2005/GD-79/gd79online.pdf⟩.

Van Gaasbeck, K., Perez, S., Sharp, R., Schaubmayer, H., Owens, A., & Cox, L. (2007). *Economic effects of increased broadband in California* (December). Research Report. Prepared for AT&T. Retrieved February 23, 2009, from the Sacramento Regional Research Institute Web site: ⟨http://www.srri.net/AboutUs/EconEffectsBB_Research.pdf⟩.

Waverman, L., & Dasgupta, K. (2009). *Connectivity Scorecard 2009*. Retrieved February 23, 2009, from ⟨http://www.connectivityscorecard.org/images/uploads/media/TheConnectivityReport2009.pdf⟩.