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Measuring the Economic Benefits of Broadband

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Introduction: ICTs and Broadband Networks

"Broadband connectivity is a key component for the development, adoption and use of information and communication technologies (ICT) in the economy and in society. Broadband is of strategic importance because of its ability to accelerate the contribution of these technologies to growth and innovation in all sectors of the economy and to social and territorial cohesion. The [European] *Commission actively supports the widespread*

availability of broadband services for all European citizens as laid down in the Lisbon strategy and subsequent Communications."[1]

As is also illustrated by the above quote and many similar remarks, in broadband strategic plans and policy documents approved or issued by governments, it is widely believed that broadband networks (and Information and Communication Technologies [*ICTs*] in general) have the potential to contribute to economic growth.

According to a Ministerial Background Report by the OECD, ICTs have the potential to "create spillovers throughout the economy" leading to "product, process and organisational innovations;" the role of broadband networks is important mainly because they act as "the required infrastructure enabler."[2] ICTs are "expected to raise productivity, and give rise to network economies with network effects expanding over time," unless the low penetration of broadband networks inhibit these network economies.[2] On the other hand, measuring the contribution of broadband networks is problematic, partly because it is "very difficult to disentangle" their effects "from those of the ICTs," and because the effects of ICTs "are likely to build up over time," only increasing total factor productivity (*TFP*) in ICT-using sectors "with considerable time lags."[3] According to the OECD industry experts, "ICT investment could even be associated with initial declines in total factor productivity as reorganisation and learning require resources," therefore the quantification of the economic impact of broadband networks is a challenging problem.[3]

Probably because of these characteristics, in the early years of the computer age, empirical studies could not detect the contribution of ICTs towards increasing TFP. As Nobel Laureate Robert Solow quipped in 1987, "*You can see the computer age everywhere but in the productivity statistics*."[4] The apparent contradiction between increasing computerisation and

slow productivity growth is usually referred to as the "Productivity Paradox of Information Technology" after a 1993 article by Brynjolfsson.[5] In this article, Brynjolfsson opined that the most likely cause of this paradox was the "mismeasurement" of productivity gains. This "paradox" has been interpreted and explained in various ways, but several more recent studies (including some by Brynjolfsson himself)[6] have succeeded in finding a positive link between IT investments and productivity, owing to a larger body of evidence and improved measurement (or econometric) methods. A few studies have also attempted to investigate the economic impact of internet availability and even broadband in particular. Nevertheless, the extent to which broadband networks contribute to productivity gains and how these translate into economic growth or how they affect employment is still far from being well understood. Consequently, my first research question was the following: How can we quantify (measure) the economic impact of broadband deployment and use on economic growth and employment? Do the benefits justify subsidisation (state aid) as envisioned by interest groups of telecommunications companies (and partly supported by the European Commission)?

A second issue is related to the quality of broadband networks. In the richest Western European countries, "traditional" broadband penetration has almost reached saturation levels, but the European Commission and incumbent telecommunications companies emphasize the need for the rapid roll-out of very high speed, next-generation access networks (NGAs). My corresponding research question was the following: Can their point (that faster broadband networks boost economic growth) be tested (and verified) empirically?

The Effects of Broadband Deployment on Output and Employment

The majority of the existing literature has focused on the economic impact of broadband access at the micro-level, mostly in the form of case-studies or surveys, and the results have been almost unanimous: higher bandwidths provided by broadband networks had enhanced

productivity or increased sales figures, especially in the ICT sector.[7] On the other hand, the few econometric studies focusing on the macro-level effects have produced mixed results: while most research groups have found a positive relationship between broadband penetration and output (or employment), in many cases, the coefficients were statistically insignificant (or weak) and in at least one case, subsequent studies have failed to replicate these positive results using the same methodology.

One of the most prominent papers in a growing body of literature is "The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data" by Crandall, Lehr and Litan (hereafter referred to as "*Crandall et al.*").[8] This study was also cited by Ferenc Baja, the State Secretary of the Hungarian Prime Minister's Office (MEH) in his presentation at a conference on the "National Digital Utility" project to justify state aid for a Hungarian broadband project.[9] To estimate the effect of broadband penetration (*BBLINES/CAP*) on state employment and output between 2003 and 2005, the authors used ordinary least squares regression analysis (as this had "the virtue of being straight forward and simple"),[10] controlling for other variables (average taxes, wages, tertiary education, union membership share of employment and annual temperatures) that could explain growth in employment or output. According to some of their most important results "an increase in broadband lines of 0.01 lines per capita, from its average value of about 0.12 in 2004, increases the growth in employment between 2004 and 2005 by 0.00223, or 0.2 percentage points."[11] When they analyse a longer period, the results are even more impressive: "the estimated effect on employment growth of an increase of 0.01 lines per capita is almost 0.6 percent between 2003 and 2005."[11] Mr. Baja has used this coefficient in his calculations to support his claim that a 15 percentage point increase in broadband penetration (provided by the "National Digital Utility") would increase employment by 9 % in three years and the Hungarian GDP by 4 percentage points. The BBLINES/CAP variable was significant in two

of *Crandall et al.*'s aggregate models (variants with nine regional variables) explaining growth in employment (between 2004 and 2005; and between 2003 and 2005), but it was insignificant in the models where the dependent variable was GDP growth (nonfarm private sector, current dollars). The authors speculated that this failure might be "because of noise in the underlying data" (the government's estimates of GDP by individual states).

Mayo and Wallsten attempted to replicate the study by Crandall et al. using more recent data and tried to extend their models by including download speed as an explanatory variable.[12] Perhaps surprisingly, in all of their eight models (explaining growth in employment or output) the BBLINES/CAP variable had a negative coefficient, and in two models the coefficients were even statistically significant. The new variable for download speed was "consistently insignificantly different from zero."[13] Unlike Crandall et al. they did not attribute these unsettling results to imprecise data, suggesting instead that the "methodology [used by both studies] is insufficiently grounded in the theory of either microexternalities" or "network growth externalities."[14] They have also pointed out some econometric issues, such as "potential omitted variable bias, possible endogeneity between economic growth and broadband penetration, the prospect of lagged relations between growth and broadband penetration, heteroscedasticity, and variable measurement issues," that might be responsible for this failure.[14]

A European Version of the Model

In order to assess whether the methodology and results by Crandall et al. could support the European Commission's claims (e.g. that the widespread availability of broadband services would accelerate economic growth) or justify subsidies to broadband infrastructure projects, I have attempted to test *Crandall et al.*'s models on European (Eurostat) data (from 2010-2011).[15] Instead of U.S. member states, I have applied *Crandall et al.*'s methodology to 25

EU member states (EU-25, all current member states excluding Romania and Bulgaria), and to account for the fact that (unlike their American counterparts) these are all sovereign states, I have included additional controlling variables. "General government gross debt (% of GDP)" was included as excessive government debts might hinder economic growth,[16] and because European countries with high debt levels were severely affected by the European sovereign debt crisis. I have also added "balance of trade" and "direct investment flows" as explanatory variables since these might be related to competitiveness and economic growth; and "current GDP per capita", because poorer European countries are eligible for additional EU funds (net transfers). I have also defined some regional dummy variables as the European countries are more heterogeneous than the U.S. states and some have only recently joined the EU.

My baseline model included the explanatory variables defined by Crandall et al. (except their regional dummies) and my additional variables, and real GDP growth rate as a dependent variable. In this model, the variable for broadband penetration was insignificant, just like some regional dummy variables and the controlling variables included in the original models by Crandall et al. In a second ("slim") version, I had tried to improve the model by successively omitting the most insignificant variables (except broadband penetration) until all of the remaining controlling variables were significant. In this model, all coefficients had the expected sign, except the variable of specific interest which was negative and insignificant (at any reasonable confidence level; see Table 1).

It could be argued that in 2010-2011, the effects of the Eurozone debt crisis were simply too dominant, but before and after the crisis, broadband penetration should be a more important determinant of economic growth. In order to examine this possibility, I have also applied my models to data from 2006-2007. Most of my new controlling variables (and those already included by Crandall et al.) were insignificant in both the baseline and the "slim" variants, but

the coefficient of broadband penetration was negative and the variable was even statistically significant, although only at the 10% level (in the slim version, see Table 2).

Table 1: European model (model 1) based on Crandall et al. (slim version, 2010-2011)

Dependent variable: Real GDP growth rate (percentage change on previous year) in the EU-25 (in 2011). The values used for the explanatory variables are from 2010. (OLS estimates, 25 observations; R-squared = 0.729854; adjusted R^2 = 0.618618)					
Explanatory variables	**Coefficient**	**Std. Error**	**t-ratio**	**p-value**	
Constant	19.6006	5.79399	3.3829	0.00354	***
Broadband access lines per 100 inhabitants	-0.026426	0.0995658	-0.2654	0.79388	
General government gross debt (% of GDP)	-0.064855	0.0184046	-3.5238	0.00261	***
GDP per capita in PPS	-0.107614	0.0444416	-2.4215	0.02693	**
Balance of international trade in goods (% of GDP)	0.138036	0.0565277	2.4419	0.02583	**
Direct investment flows as % of GDP	0.0424517	0.0214751	1.9768	0.06452	*
Former Warsaw Pact countries (V4 countries, Baltic states, Slovenia), dummy variable (8 countries)	-5.06078	2.35264	-2.1511	0.04614	**
PIGS (Portugal, Italy, Greece, Spain), dummy variable (4 countries)	-3.18308	1.36533	-2.3314	0.03230	**
*statistically significant at the 10% level **statistically significant at the 5% level ***statistically significant at the 1% level					

Table 2: European model (model 2) based on Crandall et al. (slim version, 2006-2007)

Dependent variable: Real GDP growth rate (percentage change on previous year) in the EU-25 (in 2007). The values used for the explanatory variables are from 2006. (OLS estimates, 25 observations; R-squared = 0.681976; adjusted R^2 = 0.575968)					
Explanatory variables	**Coefficient**	**Std. Error**	**t-ratio**	**p-value**	
Constant	10.2595	1.87205	5.4803	0.00003	***
Broadband access lines per 100 inhabitants	-0.121702	0.0650874	-1.8698	0.07786	*
General government gross debt (% of GDP)	-0.0595203	0.0164999	-3.6073	0.00201	***
GDP per capita in PPS	-0.0099633	0.0223677	-0.4454	0.66132	
Balance of international trade in goods (% of GDP)	-0.028972	0.0464574	-0.6236	0.54070	
Direct investment flows as % of GDP	0.00462566	0.017169	0.2694	0.79067	
PIGS (Portugal, Italy, Greece, Spain), dummy	-0.895088	1.15971	-0.7718	0.45024	
*statistically significant at the 10% level **statistically significant at the 5% level ***statistically significant at the 1% level					

The situation is not really different if the explanatory variables of the baseline model are used to explain growth in employment: "broadband penetration" has a negative coefficient and the variable is statistically insignificant, even if the other irrelevant variables are omitted. Moreover, if the dependent variable is changed to GDP growth over two years, the variable of specific interest has a negative coefficient and is not significant in any of the models. In some additional variants of my models, I have also included fibre penetration as an explanatory variable, but it was likewise consistently insignificant.

Different Approaches

These results can be interpreted in many different ways. One possible interpretation is that these models (and the re-evaluation of *Crandall et al.*'s model by Mayo and Wallsten) challenge the notion that broadband networks have a significant (positive) impact on the economy, although the lessons of the "Productivity Paradox" suggest that a more likely reason for these unexpected results was the inadequate methodology. One particular weakness of this approach, already identified by Mayo and Wallsten, is that it estimates the effects of broadband penetration over only one or two years, while it could take more time for an ICT investment to increase productivity.

The economic significance of broadband networks was also analysed in a frequently cited study by Qiang, Rossotto and Kimura.[17] The authors have used an endogenous growth-model to quantify the long-term impact of broadband penetration on economic growth (average growth rate of per capita GDP between 1980 and 2006) in 120 countries (both developing and developed countries). According to their results, broadband had a positive and significant growth-impact in high-income economies, a 1.21 percentage point increase in economic growth per 10 percentage point increase in broadband penetration, a value that would confirm the strategic importance of these networks. On the other hand, as they tested the impact of

broadband on average growth rates using period averages and initial values of the explanatory variables, there is no way to tell whether increasing broadband penetration would still contribute to the growth and competitiveness at near-saturation levels in some developed countries or if it was only relevant for early adopters. Furthermore, since fibre-optic technology is a relatively recent phenomenon even in the richer European countries, and this model uses a very long time period, it could not be easily extended to verify whether high-speed networks really matter as much for the economy as claimed by the incumbent telecommunications companies and the European Commission.

Some further recent studies employ more sophisticated econometric methods (e.g. simultaneous equations models,[18] instrumental-variable models,[19] etc.) and longer time periods (panel data) to identify the causal effects of broadband. Most of these studies confirm the hypothesis that broadband networks significantly contribute to economic growth, especially if the initial penetration is sufficiently high ("critical mass" hypothesis). The main problem is that the extension of these models to include download speed (bandwidth) or the penetration of NGA networks is not as easy or straightforward as in a simple model like the one used by Crandall et al.

Conclusion

In conclusion, the findings presented in this study clearly question the robustness of the methodology first used by Crandall et al. and the validity of its citation by the proponents of the National Digital Utility, but they should be interpreted with caution. Although I was unable to confirm the hypothesis that broadband networks contribute significantly to economic growth or employment, the negative coefficients in most of the models may only indicate that these estimates are unreliable, and at best they provide some weak evidence that ICT investments might cause initial (short-term) declines in productivity. In the light of the

findings of some recent studies using different econometric techniques and earlier compelling evidence that the introduction of broadband technology significantly increases productivity and profitability at a firm level, it would be unreasonable to suggest that the use of broadband services negatively affects economic growth. On the other hand, the question whether faster broadband networks (higher download speed) would provide additional benefits (significant growth externalities) still remains open.

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[1] Communication from the European Commission, "Community Guidelines for the application of State aid rules in relation to rapid deployment of broadband networks," *Official Journal* C 235, 7.

[2] OECD (Organisation for Economic Co-operation and Development), "Broadband and the Economy," *OECD Ministerial Meeting on the Future of the Internet Economy,* Seoul (Korean Republic), 17-18 June 2008, 8.

[3] *Ibid*., 9.

[4] Robert Solow, "We'd better watch out," *New York Times Book Review*, 12 July 1987, 36.

[5] Erik Brynjolfsson, "The Productivity Paradox of Information Technology," *Communications of the ACM*, Volume 36, Issue 12, December 1993, 66-77.

[6] E.g., Erik Brynjolfsson and Lorin Hitt, "Paradox lost? Firm-level evidence on the returns to information systems spending," *Management Science*, Volume 42, Issue 4, April 1996, 541-558.

[7] E.g., Arthur Grimes et al, "The need for speed: impacts of internet connectivity on firm productivity," *Journal of Productivity Analysis*, 37 (2), 187-201.

[8] Robert Crandall, William Lehr and Robert Litan, "The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data," *Issues in Economic Policy*, The Brookings Institution, Number 6, July 2007

[9] Ferenc Baja, "Mi a Nemzeti Digitális Közmű? A Nemzeti Digitális Közmű közpolitikája," *Conference on the National Digital Utility at the Hungarian Academy of Sciences*, 26/01/2009, Budapest, http://www.niif.hu/files/Baja_Ferenc_MTA_prezentacio_0125.ppt (accessed: 05/04/2012, in Hungarian)

[10] Crandall et al., *The Effects of Broadband Deployment on Output and Employment*, 33.

[11] *Ibid.*, 9.

[12] John W. Mayo and Scott Wallsten, "From Network Externalities to Broadband Growth Externalities: A Bridge not yet Built," *Review of Industrial Organization*, Volume 38, Issue 2, March 2011, 173-190.

[13] *Ibid*., 186.

[14] *Ibid*., 185.

[15] Source: http://ec.europa.eu/eurostat (accessed: 21/06/2012)

[16] Carmen M. Reinhart and Kenneth S. Rogoff, "Growth in a Time of Debt," *American Economic Review*, American Economic Association, vol. 100 (2), May 2010, 573-78.

[17] Christine Zhen-Wei Qiang and Carlo M. Rossotto with Kaoru Kimura, "Chapter 3: Economic Impacts of Broadband," in: "*Information and Communications for Development 2009: Extending Reach and Increasing Impact*," (Washington, DC: World Bank Publications, May 26, 2009)

[18] Pantelis Koutroumpis, "The economic impact of broadband on growth: A simultaneous approach," *Telecommunications Policy*, 33 (2009), 471–485.

[19] Nina Czernich et al., "Broadband Infrastructure and Economic Growth," *The Economic Journal*, Volume 121, Issue 552, May 2011, 505–532.