Broadband Access and its Impact on the Economy, a Swedish Perspective

Marco Forzati, Claus Popp Larsen
Department for Networking and Transmission, Acreo AB, 164 40 Kista, Sweden
Tel: +46 8 632 7753, Fax: +46 8 750 5430, e-mail: marco.forzati@acreo.se

ABSTRACT
In this paper we present an evaluation of the impact of broadband penetration on the economy using regression analysis of international data, and we give an overview of the market in Sweden and Sweden's government policy.
Keywords: broadband access, techno-economic studies.

1. INTRODUCTION

The Internet is perhaps the most revolutionary technological developments that have taken place during this generation. More recently, the advent and quick growth of broadband access has taken Internet connectivity to a new level, and made a large portion of the world population aware of the potential of this technology and its impact on daily life. In some countries this awareness has matured into a political persuasion (see the *broadband-for-all* slogan) that is directly or indirectly driving the development of broadband access. Sweden is probably one the best such examples.

There are various more or less pronounced political ambitions behind increased broadband penetration. An important one is e-government, i.e. the ability to offer online interaction with the citizens, which is believed to simultaneously benefit democracy and significantly reduce the spending within the public administration through higher efficiency. Secondly, broadband penetration leads to ICT maturity, which is believed to benefit industry and trade, through the stimulation of front-edge service and product development, as well as more efficient production, logistics, resource management, etc. Finally, high broadband penetration is argued to lead to a more environmentally sustainable development (e.g. video conferences instead of travelling) and to a lessening of migration from rural areas to large cities.

In this paper we give an overview of the broadband access situation in Sweden, discuss current trends and ambitions and review the technologies deployed. We then turn to the question of whether broadband access actually does deliver the benefits claimed and hoped for (democratic-administrative, economical, and social-environmental). This is a broad and complex task, therefore the paper is limited in scope to the economic effects, and specifically to the impact of broadband access on trade.

2. Broadband and Internet penetration in Sweden

Sweden has a strong tradition within ICT and broadband. Sweden is no. 8 in broadband penetration per 100 citizens worldwide [1]. Broadband is here defined as "always connected" with no bandwidth requirements. Sweden's Internet penetration per household (broadband and not) since the year 2000 is shown in Fig. 1 [2]. Observe that Internet penetration is getting saturated: by Q2 2007 it was 73% and slowly growing. Total broadband penetration however was 54% and still growing fast (this should be compared to Korea's 94% in 2006 which by far is the highest worldwide [1]). In the same period, the portion of Swedish households with a downstream connection of at least a 2 Mbit/ was 41%, while the figure for 10 Mbit/s or more was 16%.

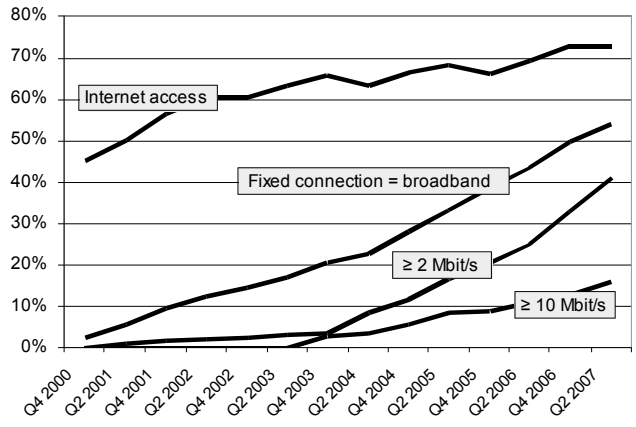

Figure 1. Internet and broadband penetration in Sweden, per household [2]

In the World Economic Forums report "The Global Information Technology Report 2007-2008" [3] different indicators have been measured and compared for 127 economies worldwide. The indicators are the environment for ICT offered by a country or community; readiness of the community's key stakeholders (individuals, business and governments); and usage of ICT among these stakeholders. The report shows that Sweden is in the absolute top, only exceeded by Denmark.

3. Access technologies in Sweden

The first fibre-to-the-home (FTTH) installations in Sweden were rolled out in the late 90's, and in 1999 almost 50% of Swedish broadband households had FTTH, which was world leading by then. Sweden is now surpassed by Korea and Japan that have a much higher FTTH penetration. The dominating access technology in Sweden today is DSL, primarily ADSL and ADSL2+, with a share of 61% of the total broadband subscribers [2]. This is followed by cable with 22% and LAN with 18% (almost exclusively FTTH). There is furthermore a small but rapidly growing share of fixed wireless access, primarily through 3G but also a few Wimax deployments. The tendency is that all access technologies are growing, however at the moment DSL is growing faster than the others. The dominating FTTH technology is active optical network (AON), a.k.a. active Ethernet or point-to-point Ethernet, which offer symmetrical bandwidths. Passive optical network, PON, is only rarely deployed, but is likely to grow.

The majority of Sweden's more than 150 municipality networks and a large fraction of the housing companies are using the so-called "open access network" model where the roles of the service provider and the network owner are separated, and where the service providers should get access to the network and thereby the end customers on "fair and non-discriminatory conditions". This should be compared to the traditional vertically integrated business model where the service provider and the network operator are the same (the case for virtually all incumbent operators). See [4] and the references therein for more information on open access networks.

4. Broadband access development plans in Sweden

There is a lack of specific Swedish national goals today for broadband penetration and build-out, but a recent investigation commissioned by the government, "Broadband to the whole country" [5], gives suggestions for future goals for neglected areas and a national strategy is outlined. The investigation estimates that 10% of people and 12% of the workplaces in Sweden are not connected and do *not* have the possibility to get a broadband connection today. It is proposed to cover these households and businesses, and to aim at supplying households and businesses with 2 Mbit/s symmetrical connections. Furthermore, if an area gets economical support to build-out such an infrastructure, this should be upgradeable to 10 Mbit/s, downstream, by 2013. 100 Mbit/s is also expected to become a mainstream requirement within a foreseeable future. The cost of the 2 Mbit/s connectivity build-out is estimated to 7.3 billion SEK, or 780 million euros at current exchange rate. As this expansion will probably not happen based on market conditions, external funding is required in the period 2009-2013. The share of government funding should be limited to 50%. The rest of the financing should come from operators, municipalities, EU structural funds and regional policy funds.

There are other initiatives ongoing. For instance will Stokab (the municipal company that is responsible for all fibre deployment in Stockholm) expand their open access network so it reaches 90% of all Stockholm's buildings within a few years. Also, many of the major public housing companies have decided that all their households should be offered FTTH – also here through an open access network.

5. Broadband access impact on trade

As discussed in the introduction, one of the perceived benefits of widespread broadband access is an increase in trade. On one hand goods and services directly purchased over the Internet would be traded to a lower extent or not be traded at all if they needed to be physically shipped (e.g. multimedia content or IP telephony), whereas some goods and services that need to be physically shipped or provided (e.g. books, standard consumer electronics, as well as hotels and airline trips) see their cost of marketing, transportation and distribution reduced thanks to improved communications, improved logistics and reduced need for intermediaries between producer and consumer.

One obvious way to examine the effect of broadband penetration on trade is to follow the evolution of trade and broadband penetration in time. This however has the disadvantage not to take into account other factors that may have an impact on trade. Moreover the statistical significance of the data would be compromised by the limited number of years during which broadband access has been around. Finally, a correlation between broadband penetration and trade is not per se sufficient to establish a causal link. A method that solves the first two problems is cross-country regression analysis, in which bilateral trade between a large number of countries is measured, as well as indicators for number of factors which are suspected to have an impact on trade (among which broadband penetration). A general equation is then written to model the impact of these factors on trade and when this equation is evaluated against the measured data for each country pair, the relative importance (if any) of each specific factor is estimated. This method has the advantage of separating the effect of broadband on trade from other factors, and moreover it allows collecting a very large number of samples. In the following sections it is shown how regression analysis can be successfully applied to estimate the correlation of broadband penetration and trade. The causality problem, however, has to be dealt with using other tools, as discussed in section 7.

6. The effects of broadband penetration on trade: the gravity equation

There is a model in international economics, which predicts that the amount of trade between two counties be directly proportional to their respective gross domestic product (GDP) and inversely proportional to their geographical distance, according to a so-called gravity equation [6]. This makes easy sense: the larger the economy of two countries, the larger their mutual trade, but the farther away they are from each other, the more costly this trade will be, and therefore the smaller its size. An extended version of the model allows for economic size and distance to weigh differently and if one recognises that other factors such as cultural and political ties/differences may also have an impact, the gravity equation takes the form (in logarithmic terms)

$$T_{ij} = K_{ij} + \beta_Y \cdot Y_i + \beta_Y \cdot Y_j + \beta_D \cdot D_{ij}, \tag{1}$$

where T_{ij} = ln(TRADE$_{ij}$), Y_i = ln(GDP$_i$), D_{ij} = ln(DISTANCE$_{ij}$), and the coefficients $\beta_Y > 0$ and $\beta_D < 0$ determine how important economic size and geographical distance are with respect to each other ($\beta_Y = 1$ and $\beta_D = -1$ in the basic model). K_{ij} is a proportionality constant accounting for all other factors. Beside broadband penetration, other factors likely to be correlated with trade include whether two countries speak the same language, whether they share a border. The proportionality factor can then take be written as $K_{ij} = \beta_P (P_i + P_j) + \beta_l l_{ij} + \beta_b b_{ij}$, where P_i is the logarithm of broadband penetration in country i, while l_{ij} and b_{ij} are binary (dummy) variables for common language and border respectively. Other factors such as common free-trade area, and political relations can also have an impact but are neglected in the first version of the study.

7. A regression study

The model presented in the previous section can be estimated against data if all the variables can be measured for a number of country pairs. Large databases with such measurements are available online. We used the World Bank's WDI database [7] to obtain broadband penetration in terms of connections per thousands inhabitants, and Prof. Rose's online database at Berkeley University [8] for the remaining data (trade and GDP are expressed in US dollars, broadband penetration in terms of number of connections per 1000 inhabitants). The time chosen is the year 2000, which had the richest set of data (29 countries, giving more than unique 400 country pairs, or samples). For each country pair we can then write:

$$T_{ij} = \beta_0 + \beta_{Y_i} \cdot Y_i + \beta_{Y_j} \cdot Y_j + \beta_{P_i} \cdot P_i + \beta_{P_j} \cdot P_j + \beta_D \cdot D_{ij} + \beta_b \cdot b_{ij} + \beta_l \cdot l_{ij} + \epsilon_{ij} \tag{2}$$

where ε_{ij} is the prediction error of the model for country pair i,j, and β_0 is the intercept (the trade value predicted when all independent variables are zero). An ordinary least square (ols) regression can then be run, producing a value for each β coefficient, which minimises the average of $|\varepsilon_{ij}|$. The results are shown in Table 1.

It can be seen that all parameters included in the model are significant, except for the shared border indicator, for which a T-statistic of 0.2 is obtained. In particular β_Y is found to be close to one and it is highly significant (it is in fact slightly less than one, which can be explained by the fact that smaller economies have to rely more on specialisation and therefore on trade than bigger ones [6]). In the table two values are found for β_Y: one for countries entering the first position in the pair i,j and one for the second position. Obviously, because countries happen to enter first or second position randomly in each pair, there is no reason for the two coefficients to be different. The same holds for β_P. Indeed it can be seen that the difference is small in both cases. It can be observed that distance does have a large and negative impact ($\beta_D = -0.99$) and it is very highly significant. Common language is found positive ($\beta_D = 0.33$): within the 95% confidence interval, speaking the same language statistically increases trade between two countries by 39% ($e^{0.33}-1$).

We can now turn to the effect of Internet penetration on trade. It can be seen that this is positively correlated with trade ($\beta_P \approx 0.25$). In Fig. 2 the correlation is shown graphically. Naturally, the existence of a correlation is per se not enough to establish a link of causality. Three possibilities exist. The first is that broadband penetration causes an increase in trade, specifically a four-fold increase in broadband penetration in both trading partners leads to a doubling of trade. The second is that larger volumes of trade lead to an increase in broadband penetration, specifically a doubling in

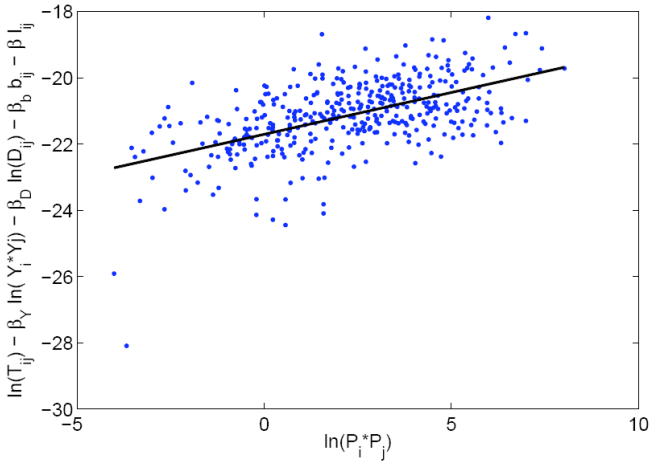

Fig. 2 – Correlation between broadband penetration and trade (controlled for economy size, distance, common language, and shared border).

trade causes a 4-fold increase in broadband penetration in both trading partners. Finally one can assume that there is an unknown factor, causing both broadband penetration and trade to increase.

The last option can not be safely rejected, and neither can the second one. One could argue that most Internet traffic is generally not directly linked to trade: peer-to-peer file-sharing applications such as Bit Torrent, Kazaa, Direct Connect, and E-Mule dominate Internet traffic volume (see for instance traffic measurements for a high speed symmetric access network in Sweden [9]), while video services such as YouTube, and social networks such as FaceBook and MySpace are maintained to dominate number of Internet sessions (though no clear numbers are available in this respect), so the need to make trade easier does not seem to be major driver for the demand of Internet connectivity. In summery, it is most reasonable (though by no means proven) to conclude that it is high broadband penetration that causes increased trade and not vice versa.

A next step would be a more direct study of the economic impact on economic wealth would be very interesting. However this remains a difficult task. Although a correlation between e.g. GPD per capita and broadband penetration is easy to find in the data, the strongest link of causality is arguably wealth->broadband penetration. Proving the possible existence of a broadband->wealth link of causality requires advanced regression techniques and may be hard to achieve.

Table 1. Result of regression study of trade determinants for 29 countries.

Number of observations: 405 R-square: 0.88038 Adj. R-square: 0.87827					
	β	std. err.	T-stat	95% conf. int.	reg. par. name
Y_i	0.90923	0.031397	28.959	0.84751 0.97095	lngdp1
Y_j	0.9398	0.027332	34.385	0.88607 0.99353	lngdp2
D_{ij}	–0.99311	0.04588	–21.646	–1.0833 –0.90292	lndist
b_{ij}	0.044924	0.22437	0.20022	–0.39615 0.486	border
l_{ij}	0.3328	0.15256	2.1815	0.032897 0.63271	comlang
P_i	0.26584	0.027813	9.5582	0.21116 0.32051	lnp1
P_j	0.23802	0.026889	8.8521	0.18516 0.29088	lnp2
T_0	–21.707	1.1329	–19.16	–23.934 –19.48	ones(405,1)

8. CONCLUSIONS

Previously only the most visionary saw broadband as an infrastructure of the same importance as other infrastructures such as roads and railways, water and electricity supply. Now these visions have reached the decision makers, and concrete goals and strategies in terms of increased broadband-access penetration start to be defined at the political level, and there is reason to believe that this will lead to proper action and funding for further broadband roll-out.

In this paper we have given an overview of the broadband access situation in Sweden, from the technological and policy point of view. We have identified a number of potential advantages of increased broadband penetration and studied its impact on trade by using regression analysis of international data. We have found that high broadband penetration and high levels of international trade are highly correlated, giving support (though not proof) to the idea that high-speed Internet access has a positive impact on the economy in terms of increased trade.

REFERENCES

[1] OECD Broadband Statistics, www.oecd.org

[2] Svensk Telemarknad första halvåret 2007, report PTS-ER-2007:27, Dec. 2007, retrieved from www.pts.se

[3] The Global Information Technology Report 2007-2008, retrieved from www.weforum.org

[4] C. P. Larsen, Access Network Technologies: Deployments in Sweden, in *proc. ECOC 2007*, *BAT symposium*, Berlin, Germany, Sept. 2008

[5] Bredband till hela landet, report sou 2008:40, April 2008, retrieved from www.regeringen.se

[6] P. R. Krugman and M. Obstfeld, "International economics: theory and policy," 2000.

[7] Bank, "World Development Indicators (WDI) - Broadband and Internet Penetration, available at www.worldbank.org/data/," retrieved February 2008.

[8] A. K. Rose, "Does the WTO Make Trade More Stable?" – Bilateral and multilateral data sets in STATA 8 format, 2005, available from http://faculty.haas.berkeley.edu/arose/RecRes.htm, retrieved February 2008.

[9] A. Aurelius, et al., "Traffic Measurements and End User Behavior in the Acreo National Broadband Test Bed," presented at Broadband Europe 2006, Geneva, Switzerland.