

Impact of Broadband Quality on Median Income and Unemployment

Empirical Evidence from Sweden

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- Researcher in digital economics.
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Introduction

Importance of Very High-Speed Broadband

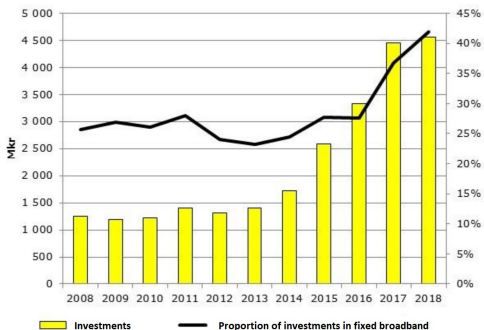
- Very high-speed broadband is seen as a key enabler for socio-economic development.
 - Positive effect on national economic growth;
 - Increase company competitiveness;
 - And attractiveness of territories for companies;
 - Social development (job search, e-government);
 - Progress in AI led to an unprecedented level of development in e-health, transportation, automation...
- Many countries have adopted a national broadband plan to ensure the whole coverage of their territory.
 - Sweden, France, Australia, Japan, Nigeria, ...
- Deployment of public initiative networks to ensure the whole coverage of the territory.

Broadband Development in Sweden

- Sweden is one of the most advanced countries in the EU in terms of very high-speed broadband deployment and adoption.
- Ambitious broadband targets:
 - Completely connected Sweden in 2025;
 - 98% of the population should have access to min 1 Gbit/s;
 - 1.9% to speed of at least 100 Mbits/s;
 - Remaining 0.1% to speed of at least 30 Mbit/s.
- Sweden relies on the commitment of the public sector:
 - Long tradition of public involvement with the roll-out of municipal networks;
 - More than 200 municipal networks.

Broadband Development in Sweden

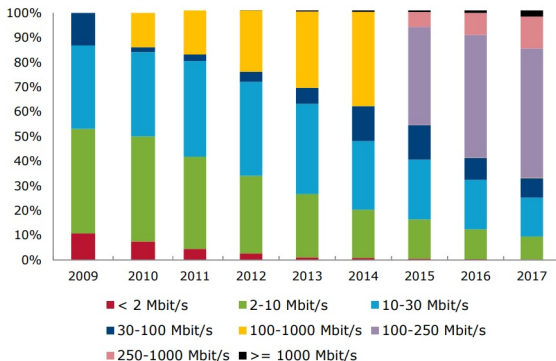
Figure: Municipal broadband investments from 2008 to 2018



Source: 2019 PTS report on investments in broadband roll-out.

Broadband Development in Sweden

Figure: Proportion of fixed broadband subscriptions by speed from 2009 to 2017.



Lack of Empirical Studies

- Lots of papers on :
 - The benefits of broadband for the national economy.
 - Costs/ benefits analysis with different scenarii...
- Not so many empirical studies, at a fine-grained level both on urban and rural areas, to quantify the benefit of broadband quality on local economic growth.
 - Especially, as regards their effects on socioeconomic variables related to the demand.
 - Use of speed
- Based on an unique and rich database, including micro-level cross-sectional data on 23 million observations over nine years, from 2009 to 2017.
 - Quantify the effects of broadband quality on the median income and the unemployment rate.
 - Take into account the educational attainment of the population and the municipality size.

Literature Review

Digital Disruption?

- Numerous macro-level studies bring empirical evidence on the positive impact of broadband adoption on economic growth.
 - Gruber et al. 2014: Economic benefits are only marginally appropriable by firms, they mostly spill over to users.
 - Widely accepted that there is a positive relation between broadband adoption, availability and GDP or employment at the national level (Greenstein et al. 2011, Bertschek et al. 2013, Gillet et al. 2006).
- However, Brynjolfsson et al. 2011 show a weakening in the positive relation between GDP and employment as digital technologies become more prevalent:
 - Great recession 2007-2009 in the US: though the GDP is increasing, no net employment creation;
 - Technological unemployment, Ricardo 1800s concept.

Relation Between Broadband and Income

- Broadband adoption, availability and download speeds have a positive impact on unemployment reduction and on median household income in rural areas. Positive effect of high levels of download speeds (Whitacre et al. (2014)).
- Positive impact of broadband on poverty reduction and income inequality especially in rural areas (Houngbonon et al. 2019).
- Positive impact on income per capita (Czernich et al. 2011).

Job Polarization and Wage Inequality

- Autor et al. (2013) and Akerman et al. (2015) focus on job polarization and wage inequality:
 - Positive impact of broadband on the productivity of high-skilled workers: complement / negative impact for low-skilled workers: substitute;
 - Reallocation of low-skilled workers to the service sector;
 - Polarization of the labour market between high-income cognitive jobs and low-income manual jobs;
 - Hollowing-out of middle-income routine jobs.
- Positive effect of broadband on the creation of companies operating in the service sector in areas with a higher proportion of low-skilled workers (Hasbi 2020).
- Polarization of the market leads to a stagnation of the median income with an increase in wage inequalities (Brynjolfsson et al. 2011).

Relation Between Broadband and Employment

- No evidence of an impact of broadband on employment:
 - (Czernich 2011 and 2014 in Germany; Jayakar et al. 2013 for 8 States in the US and Briglauer et al. 2019 in rural Bavaria);
 - Kolko (2012) finds that broadband expansion is associated with population and employment growth, but no effect on the average wage or on the employment rate;
 - No evidence on employment but positive effect of broadband diffusion on firm performance (Canzian 2015).
- On the contrary, Atasoy 2013 shows that gaining access to broadband is associated with an increase in the employment rate: skill complement.
- Building-up on the advances realised in digital technologies, Frey et al. 2017 show that computer substitution is extended to non-routine cognitive task performed by high-skill workers.

Data

- Use of micro-level cross-sectional data on 23 million observations over nine years, from 2009 to 2017, to assess whether broadband quality has an impact on income and unemployment reduction.
- Data on broadband speed comes from the Swedish Internet Foundation:
 - Download speed in Mbit/s: user-driven database.
 - Bredbandskollen is an online tool, free of use enabling everyone to measure its access connection speed.
 - Collected at an administrative level: localities (tätort). Tätort is defined as urban areas with contiguous buildings with no more than 200 metres between houses and at least 200 residents.
- Sociodemographic data come from the Swedish statistic agency.

Econometric Strategy

Relation Between Broadband and Employment and Income

- Impact of digitalization on the way goods are produced and delivered: the introduction of more automated processes:
 - Lead to productivity gains and an increase in economic growth → positive effect on employment.
 - However, potentially substituted for labour, especially within the low-skilled workforce → negative effect.
- The relation between broadband and income is not straightforward:
 - Skill complementarity between broadband and high-skilled workforce leads to an increase in income inequality.
 - However, the growth of low-skilled jobs in the service sector is likely to have a positive impact on income.

- Factors which can have an impact on income: broadband quality, local characteristics, labour market characteristics:
 - How many people lives in the locality;
 - Municipal population;
 - Density of population;
 - Unemployment;
 - Education level;
 - Number of new companies;
 - Proportion of inhabitants born outside Scandinavia and outside the EU.
- The same factors have an impact on the unemployment rate, income is also a factor.

- The empirical strategy consists in a stratification of broadband speed in 7 categories:
 - No broadband: 0 to 256 Kbit/s;
 - Low speed: over 256 Kbit/s to 5 Mbit/s;
 - Medium speed: over 5 Mbit/s to 10 Mbit/s;
 - Medium speed 2: over 10 Mbit/s to 30 Mbit/s;
 - High-speed: over 30 Mbit/s to 50 Mbit/s;
 - High-speed 2: over 50 Mbit/s to 100 Mbit/s;
 - Very high-speed: over 100 Mbit/s.
- Broadband quality is measured in terms of download speed (technology neutral approach).
 - Broadband speed gives a more accurate information and provides more details on specific areas.

- The model for income could be derived as follow:

$$\begin{aligned} income_{it} = & \alpha + \delta hbb_{it-1} + \beta_1 ln_pop_{it-1} + \beta_2 ln_pop_m_{jit-1} \\ & + \beta_3 density_{it-1} + \beta_4 non_EU_{it-1} + \gamma_1 unempl_{it-1} \\ & + \gamma_2 ln_uni_diploma_{it-1} + \gamma_3 establishment_{it-1} \\ & + \mu year_t + \eta_i + \epsilon_{it}, \end{aligned} \tag{1}$$

- Use fixed effects to avoid some biases.
 - $year_t$ Year fixed effect: measure a time trend, a shock or an event which impacts all the localities independent of their location but only for a specific time period.
 - η_i Localities fixed effect: depends on the localities but not on the year.
 - ϵ_{it} error term.

- The model for unemployment could be derived as follow:

$$\begin{aligned}unempl_{it} = & \alpha + \delta hbb_{it-1} + \beta_1 ln_pop_{it-1} + \beta_2 ln_pop_m_{jit-1} \\ & + \beta_3 density_{it-1} + \beta_4 non_EU_{it-1} + \gamma_1 income_{it-1} \\ & + \gamma_2 ln_uni_diploma_{it-1} + \gamma_3 establishment_{it-1} \\ & + \mu year_t + \eta_i + \epsilon_{it},\end{aligned}\tag{2}$$

Importance of Education and City Size

- A complementary effect between broadband and high-skilled workers or college graduates has been shown in the literature:
 - Asses whether broadband quality affects differently areas with (1) a higher, (2) a lower proportion of college graduates.
- The potential effects of broadband may also differ across municipalities:
 - Political decisions are made at the region or city levels;
 - Cities of different sizes have also different budgets or possibilities to grow and develop.
- Create 5 groups of localities depending on the size of the municipality to which their belong:
 - Take into account the distribution of the population in different percentiles rank 1: pop $\leq 18,937$; rank 2: pop [18,938 - 44,813]; rank 3: pop [44,814 - 132,536]; rank 4: pop [132,537 - 354,349].

Estimation Results

Impact of Broadband Quality on Income - Whole Sample

- First regression: do not distinguish between low and high proportion of college graduates
- The model doesn't show any significant effect of broadband quality on median income.
 - Irrespective of the size of the city to which the locality belongs.
 - We cannot conclude that broadband quality has an effect on the median income
- The results show a positive impact of educational attainment on income
 - Confirms the need to assess whether broadband quality has an impact on income in localities with a high and a low proportion of college graduates separately.

Impact of Broadband Quality on Income in Localities with a High Proportion of College Graduates

- Overall, the model predicts a negative effect from broadband on the median income of high-skilled workers.
 - On average, the median yearly income in localities with speeds between 30 and 50 Mbit/s is about 43 euro lower than in localities without broadband. This difference increases to about 106 euro in localities with speed over 100 Mbit/s.
- Heterogeneous across municipality size: the negative effect holds only for localities belonging to a medium-sized municipality.
 - Positive effect in localities belonging to a small medium-sized municipality.

Impact of Broadband Quality on Income in Localities with a Low Proportion of College Graduates

- Overall, the model doesn't predict any effect from broadband on the median income of low-skilled workers.
 - However, after distinguishing between the different municipality sizes: negative effect for localities belonging to a small municipality.
 - The difference of median income in localities having broadband speed between 5 Mbit/s and 100 Mbit/s is of about 200 euro lower than in other localities of rank 1 without broadband.

Impact of Broadband Quality on Unemployment Reduction

- Whole Sample

- First regression: do not distinguish between low and high proportion of college graduates
- Similarly to income, the model doesn't show any significant effect of broadband quality on unemployment reduction.
 - Irrespective of the size of the city to which the locality belongs.
 - Cannot conclude that broadband has an effect on unempl.
- The absence of effect holds even after distinguishing between the different municipality sizes
 - At one exception: positive effect on localities belonging to a municipality of rank 2 (1.2 to 2.5 pp. lower)
- The results show a positive impact of educational attainment on income
 - Confirms the need to analyse separately areas with a low / a high proportion of college graduates

Impact of Broadband Quality on Unemployment in Localities with a High Proportion of College Graduates

- Overall, the model predicts a negative effect from broadband on unemployment reduction of high-skilled workers.
 - Especially for higher broadband speed.
 - Localities with higher broadband quality are more likely to experience a higher unemployment rate of about 1 to 2.75 pp. than in localities without broadband.
 - In line with the results from Brynjolfsson et al. 2011
- However, after taking into account the different municipality sizes:
 - The model predicts that broadband quality has a complementary effect with high-skill jobs in smaller municipalities and to a lower extent in bigger municipalities (only with speeds over 50 Mbit/s).

Impact of Broadband Quality on Unemployment in Localities with a Low Proportion of College Graduates

- Overall, the model predicts a complementary effect between broadband quality and low-skilled jobs.
 - Localities with broadband (under 100 Mbit/s) have on average an unemployment rate which is 2 to 4 pp. lower than localities without broadband.
 - Confirms the job polarization effect (Autor et al. 2013).
- However, this result holds only for medium-sized municipalities.
 - A substitution effect is highlighted between better broadband quality and low-skill jobs in smaller municipalities.
 - Substitution effect highlighted by Akerman et al. 2015.

Conclusion

A Complex Relation

- We quantify the impact of broadband quality on the median income and on unemployment reduction.
 - Unique dataset including 23 million observations and covering app. 700 localities over 9 years, from 2009 to 2017.
- The relation between broadband quality and income or unemployment is not straightforward.
- While the results for the whole sample do not show any significant effects, within-group analyses highlight heterogeneous effects:
 - Depending on the education level of the local population;
 - Depending on the municipality size.
- On average, broadband quality has an effect for download speeds comprised between 10 and 100 Mbit/s.
 - Highest effects for speeds between 30 and 100 Mbit/s.

Distinction Between High-skills and Low-skills Areas

- Clear distinction between localities having a high and a low proportion of college graduates.
 - High proportion of college graduates: detrimental effect of broadband quality on both the median income and the unemployment rate;
 - Low proportion of college graduates: no significant effect on the median income and a positive effect on unemployment reduction.
- This result provides some evidence of the existence of a substitution effect between new ICT technologies and more complex tasks performed by high-skilled workforce.
 - In line with Brynjolfsson et al. (2011) and Frey et al. (2017).
 - The substitution effect between new broadband technologies and low-skill jobs is only found for localities located in smaller municipalities.
 - In medium-sized municipalities, the results tend to confirm the existence of a job polarization effect.

A Tool to Increase Digital Inclusion

- The relation between broadband quality and income or unemployment is not straightforward but rather is based on complex mechanisms.
- Broadband quality can be seen as a tool to increase digital inclusion and reduce the digital divide:
 - Positive effect on unemployment reduction in medium-sized municipalities, where low-skilled jobs are predominant (digital divide between people);
 - Positive effect on unemployment reduction in smaller municipalities, where high-skill jobs are predominant (digital divide between territories).

Thank you
Any questions?

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