About me

- Researcher in digital economics.
  - Use econometrics as a tool to conduct economic analysis.

- 10 years experience of working with telecommunications:
  - Expert in regulatory affairs.

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Dr. Hasbi
Impact of Broadband Quality on Income and Unemployment
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.
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.
**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 scenarios...

- 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, Gilletet 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.
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).
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
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:

\[
\text{income}_{it} = \alpha + \delta \text{hbb}_{it-1} + \beta_1 \ln\text{pop}_{it-1} + \beta_2 \ln\text{pop}_m_{jit-1} \\
+ \beta_3 \text{density}_{it-1} + \beta_4 \text{non-EU}_{it-1} + \gamma_1 \text{unempl}_{it-1} \\
+ \gamma_2 \ln\text{uni_diploma}_{it-1} + \gamma_3 \text{establishment}_{it-1} \\
+ \mu \text{year}_t + \eta_i + \epsilon_{it},
\]

(1)

Use fixed effects to avoid some biases.

- \text{year}_t Year fixed effect: measure a time trend, a chock or an event which impacts all the localities independent of their location but only for a specific time period.
- \eta_i Localities fixed effect: depends on the localities but not on the year.
- \epsilon_{it} error term.
The model for unemployment could be derived as follow:

\[ unempl_{it} = \alpha + \delta\ hbb_{it-1} + \beta_1\ ln\_pop_{it-1} + \beta_2\ ln\_pop\_m\_jit_{it-1} \]
\[ + \beta_3\ density_{it-1} + \beta_4\ non\_EU_{it-1} + \gamma_1\ income_{it-1} \]
\[ + \gamma_2\ ln\_uni\_diploma_{it-1} + \gamma_3\ establishment_{it-1} \]
\[ + \mu\ year_t + \eta_i + \epsilon_{it}, \]

(2)
A complementary effect between broadband and high-skilled workers or college graduates has been shown in the literature:

- Assess 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 they belong:

- Take into account the distribution of the population in different percentiles rank 1: \( \text{pop} \leq 18,937 \); rank 2: \( \text{pop} [18,938 - 44,813] \); rank 3: \( \text{pop} [44,814 - 132,536] \); rank 4: \( \text{pop} [132,537 - 354,349] \).
Estimation Results
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.
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.
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
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).
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.
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.
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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Thank you