

Digital Transformation and Industrial Sustainability

Dr Shivani Taneja

Dr Filip Mandys

Shivani Taneja – School of Economics, University of Kent, Canterbury, UK

*Filip Mandys – Bennett School of Public Policy, University of Cambridge, Cambridge, UK;
Research Institute for Labour and Social Affairs, Prague, Czech Republic*

9th AIEE Energy Symposium – How Industry is Moving Toward Decarbonisation

22nd November 2025

Economic Growth and Sustainability

- Growth in the industrial sector is vital for global economic growth.
- The use of digital technologies in the global industrial sectors has substantially increased since the beginning of the 21st century.
- This has changed the industrial sectors, and the way companies compete in the market.
- However, the industrial sector also contribute to 23% of the global GHG emissions ([Energy and Climate Intelligence Unit, 2021](#)).
- These are primarily caused by burning of fossil fuels, and chemical action and leaks from industrial processes.
- Thus, it is important for policymakers worldwide to balance economic growth and sustainability.

Quantifying the Net Impacts of ICTs on Electricity Consumption

- We quantify the net impacts of ICTs on electricity consumption for different industrial sectors for a range of countries from 1995-2020.
- From one point of view, modern ICTs are energy efficient and reduce relative demand for energy, contributing to green growth ([Taneja and Mandys, 2022](#)).
- However, with the expansion of ICTs and greater number of systems, the overall carbon footprint is also increasing.
- Ultimately, it is an empirical question as to whether ICTs have a positive or negative net effect on energy consumption of businesses and industrial sector in the current digital era.

Research Questions

- We answer the following research questions:
 - **Q1.** Are digital technologies potentially contributing to reducing relative energy consumption in different industries, consequently boosting the decarbonisation of businesses?
 - **Q2.** How are the net energy saving effects of ICTs changing over time for different sectors?
 - **Q3.** To what extent is digitalisation affecting electricity consumption in a range of countries?
- We use an up-to-date data for 14 sectors within 16 countries from 1995 to 2020.
- We apply econometric techniques, i.e., fixed effects OLS on a panel dataset.
- Then, to compute net effects of ICTs on electricity demand, we calculated the average elasticity of electricity demand with respect to ICT capital using the coefficient generated from the regression.

Mixed Results Found for the Impacts of Digital Tech on Energy Use

- Negative association between ICT and energy use in OECD countries was found in [Taneja and Mandys \(2022\)](#) and [Schulte et al. \(2016\)](#).
- [Bernstein and Madlener \(2010\)](#) confirmed electricity-saving effects from communication technologies, for 8 European countries, however, the effect of computing and software was not clear cut.
- [Sadorsky \(2012\)](#) studied 19 emerging economies and found ICTs to increase electricity consumption.
- Other studies with positive impacts, include [Salahuddin and Alam \(2016\)](#), and [Saidi et al. \(2017\)](#).
- Thus, there is evidence of mixed results found in the academic literature, and it is not clear whether investments into ICT capital reduces the carbon footprint of industries or causes hinderance to environmental sustainability.

Balanced Panel Dataset

We construct our dataset from four specific sources:

- 1 EU-KLEMS & INTANprod Data (2023 release):**
 - ICT capital (computing equipment, communication equipment, software).
 - Non-ICT capital (transport equipment, machinery, building).
 - Factor prices (labour wages and total labour cost).
 - Output.
- 2 GGDC Productivity Level Database (2023 release):** Information on Purchasing Power Parity for different sectors and countries for transforming key variables into real-terms and a common currency.
- 3 IEA Energy Prices Data (2023 release):** Information on different energy products for different countries over time.
- 4 IEA Extended World Energy (2024 release):** Information on industrial energy consumption for different sectors and countries.

Balanced Panel Dataset

The final dataset includes the following:

- **Countries:** Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Portugal, Slovakia, Spain, Sweden, UK, and USA.
- **Industrial Sectors:** agriculture, forestry, and fishing, mining and quarrying, food and tobacco (manufacturing), textile (manufacturing), wood, paper and printing, chemical and petrochemical (manufacturing), machinery (manufacturing), transport equipment (manufacturing), other manufacturing, construction, transport, and commerce and public services.
- **Time period:** 1995 to 2020.

Translog Cost Function and Demand Elasticities

- Using a translog cost function, we estimate the share of electricity in variable cost using panel fixed effects regression:

$$S_E = \beta_0 + \beta_1 \ln \left(\frac{P_E}{P_L} \right) + \beta_2 \ln \left(\frac{P_{NE}}{P_L} \right) + \beta_3 \ln \left(\frac{K_{ICT}}{Y} \right) + \beta_4 \ln \left(\frac{K_N}{Y} \right) + \beta_5 \ln Y + \delta t \quad (1)$$

- We then calculate the demand elasticities with respect to ICTs, i.e. the percentage change in electricity use after a 1% increase in ICT capital:

$$\varepsilon_{K_{ICT}}(E) = \frac{\beta_3}{S_E} - S_{ICT} \quad (2)$$

Result 1 – Impact of ICTs on Electricity Use in Industrial Sectors

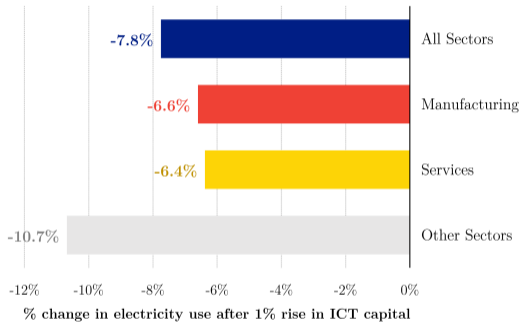


Figure 1: Average elasticities of electricity demand – change in electricity use after a 1% increase in ICT capital.

- We find that industrial sectors are likely to benefit from investments in ICTs reducing electricity consumption.
- Digitalisation can help businesses conserve resources, reduce waste and save energy, by using digital resources.
- Automating processes can result in improved operational efficiency, minimising human error, and increased productivity.
- Industries should invest in digital transformation to remain competitive and, at the same time, achieve sustainability.

Result 2 – Impact of ICTs on Electricity Use Across Sectors

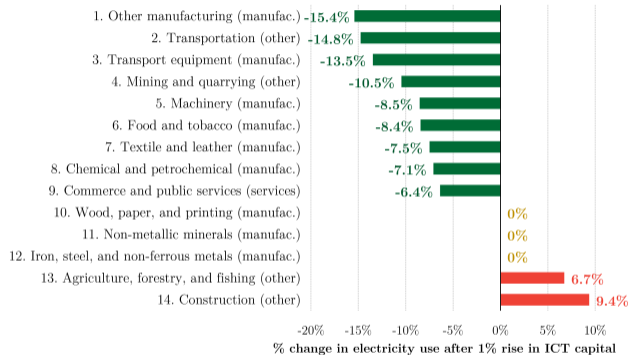


Figure 2: Average elasticities of electricity demand across sectors – change in electricity use after a 1% increase in ICT capital.

- Largest reduction in electricity use is seen in manufacturing.
- Manufacturing relies on large amounts of energy use and contributes to CO₂ emissions.
- ICTs also benefit the commerce and public services sector, e.g., the use of AI can save time, and administrative costs.
- ICTs shown to increase electricity use in the construction sector.

Result 3 – Impact of ICTs on Electricity Use Over Time

- Technological innovation is growing at a fast pace over the years.
- Banking sector was mostly a customer-facing business, but it has changed with the rise of internet banking.
- Similarly, the automotive industry is using more technology in cars, i.e., improved GPS, safety systems, etc.
- Therefore, we report the emerging patterns in the net impacts of ICTs on electricity use from 1995 to 2020.

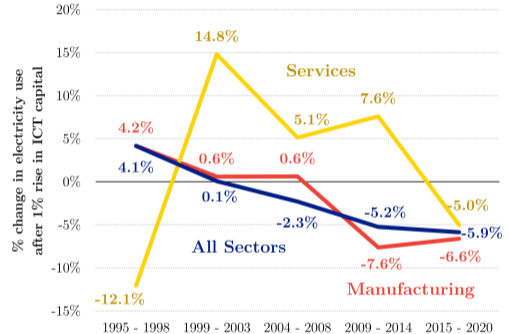
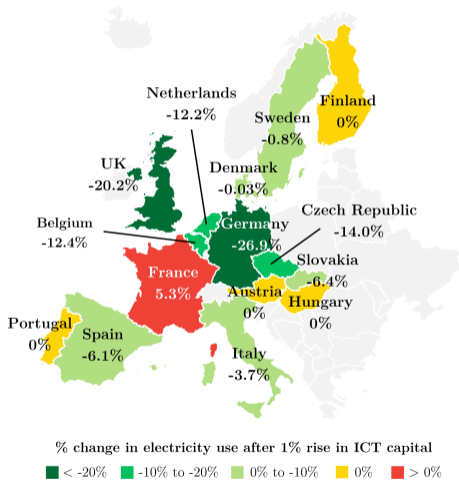


Figure 3: Average elasticities of electricity demand across sectors, over time – change in electricity use after a 1% increase in ICT capital.

Result 4 – Impact of ICTs on Electricity Use in European Countries



- Different level of economic development and focus on different sectors is likely to contribute to the varying ICT effects.
- A 1% increase in ICTs reduces electricity demand by 27% in Germany, 20% in the UK, and around 12% in Benelux.
- Other EU countries, such as Italy, Spain, and Czech Republic also experience a reduction in electricity use with ICTs.
- Thus, businesses within EU should invest more in digital technologies to tackle the issue of climate change.

Digitalisation is Boosting the Decarbonisation of Industries I

- The industrial sectors are the main drivers of economic growth, but they also produce GHG emissions.
- Understanding the association between digital technologies and energy use sheds light on the environmental sustainability efforts within industrial sectors.
- The net impacts of ICTs on electricity consumption are still unclear, and therefore we quantify the net impacts of ICTs on industrial electricity consumption for different sectors.

Digitalisation is Boosting the Decarbonisation of Industries II

- We find that ICTs reduce electricity consumption of industrial sectors, and this effect is stronger in manufacturing than services.
- Across manufacturing sectors, the largest reduction in electricity use is in Transportation, Transport Equipment, and Other Manufacturing.
- A stronger impact of ICTs in reducing electricity use is seen in more recent years compared to earlier time periods.
- Cross-country comparisons revealed that Germany and UK reap the greatest benefits from the net energy-saving effects of ICTs.
- Thus, our results aim to encourage policymakers and businesses to invest more in digital technologies.

Drawbacks of ICTs

- New technologies can be costly.
- Therefore, businesses can invest in technologies more conservatively.
- ICTs come with a risk of data breaches as more business use cloud-based storage systems. Such risks can be prevented by improving cyber security.

Future work

- Although we use the latest data, it would be interesting to see the impacts of different types of technologies, such as AI, robotics, cloud computing, etc., on overall electricity use.
- A more detailed disaggregation of the industrial sector could also be useful in providing recommendations specifically for each of the sectors.

Thank You

References

- Bernstein, R. and Madlener, R. (2010). Impact of disaggregated ICT capital on electricity intensity in European manufacturing. *Applied Economics Letters*, 17(17):1691–1695.
- Energy and Climate Intelligence Unit (2021). Industry and emissions (globally and UK). [Energy and Climate IU](#).
- Sadorsky, P. (2012). Information communication technology and electricity consumption in emerging economies. *Energy Policy*, 48:130–136.
- Saidi, K., Toumi, H., and Zaidi, S. (2017). Impact of information communication technology and economic growth on the electricity consumption: Empirical evidence from 67 countries. *Journal of the Knowledge Economy*, 8:789–803.
- Salahuddin, M. and Alam, K. (2016). Information and communication technology, electricity consumption and economic growth in OECD countries: A panel data analysis. *International Journal of Electrical Power & Energy Systems*, 76:185–193.
- Schulte, P., Welsch, H., and Rexhäuser, S. (2016). ICT and the demand for energy: Evidence from OECD countries. *Environmental and resource economics*, 63:119–146.
- Taneja, S. and Mandys, F. (2022). The effect of disaggregated information and communication technologies on industrial energy demand. *Renewable and Sustainable Energy Reviews*, 164:112518.