Estimating the Historical Impacts of Information and Communication Technologies on Industrial Energy Demand

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Introduction

- Information and communication technologies (ICTs) have complex implications for energy demand.
- On one hand, ICTs can offer many benefits, such as being energy efficient and facilitate a reduction in energy use.
- On the other hand, energy efficiency can result in a rise in energy demand.
- Therefore, the net effect of ICTs is not clear.
- Our research investigates into the overall impacts and addresses the following question: **Is ICT net energy saving?**

Approach

- We estimate the energy cost share equation, based on a translog cost function.
- We derive the elasticity of energy consumption with respect to ICT capital services, to measure the magnitude of the effect.
- We show whether ICTs are related to an increase or decrease in overall energy use.

Our work

- Previous literature has analysed the impacts of ICTs on energy demand, such as Schulte (2016) and Bernstein and Madlener (2010).
- However, our study benefits from using an extensive dataset, covering more countries and industrial sectors (28 sectors, 17 countries, 13 years).
- We also add renewable energy to the energy quantity data.
- Our results are consistent across several samples and robust to different specifications, providing additional confidence in our research outputs.

Data

- We construct our dataset from the following data sources:
- **EU-KLEMS** - Provides harmonised estimates of inputs (capital, labour), value added, and other measures.
- **World Input Output Database** (WIOD) - This has data on disaggregated energy use by industrial sectors and fuel type.
- **International Energy Agency (IEA) Energy Prices and Taxes Database** - Industrial energy prices for each country.
- **OECD Dataset** - We transform the nominal values to real values and a common currency (US Dollars) by using Purchasing Power Parity.

Data

- The sample includes 17 OECD countries, i.e. Australia, Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Japan, Netherlands, Spain, Sweden, UK, and US.
- We include 28 industrial sectors, but we drop two sectors, i.e. “electricity, gas and water” and “coke, refined petroleum and nuclear fuel”, because these are different in their production structures.
- Our sample covers the period of 1995 - 2007.
- The total number of observations is 5109.

Methodology

- We estimate the share of energy in variable costs (S_E):

$$S_E = \beta_E + \beta_{EE} ln\left(\frac{P_E}{P_L}\right) + \beta_{EK_{ICT}} ln\left(\frac{K_{ICT}}{Y}\right) + \beta_{EK_N} ln\left(\frac{K_N}{Y}\right) + \beta^*_{EY} lnY + \delta_{ET} t$$

where $ln\left(\frac{K_{ICT}}{Y}\right)$ = *ICT capital,* $ln\left(\frac{K_N}{Y}\right)$ = *non-ICT capital,* $ln\left(\frac{P_E}{P_L}\right)$ = *relative price,* lnY = *output, t = time*

- Total average elasticity with respect to ICT is calculated using the formula:

$$\eta_{K_{ICT}}(E) = \frac{\beta_{EK_{ICT}}}{S_E} - S_{K_{ICT}}$$

where $S_{K_{ICT}} = \frac{P_{K_{ICT}} K_{ICT}}{VC}$, $P_{K_{ICT}}$ = *price of ICT capital services, VC = variable cost*

Main Results: All sectors

Results using OLS techniques: The effect of ICT on energy demand				
Variables	Model 1	Model 2	Model 3	Model 4
ln (PE index/PL index)	-0.0058	-0.0238***	-0.0279***	-0.0468***
	(0.0042)	(0.0029)	(0.0029)	(0.0038)
Ln (KICT/Y)	-0.0070***	0.0026**	-0.0009	0.0003
	(0.0010)	(0.0011)	(0.0014)	(0.0014)
Ln (Kn/Y)	0.0400***	0.0105***	0.0118***	0.0111***
	(0.0019)	(0.0012)	(0.0012)	(0.0012)
Ln Y	-0.0077***	0.0089***	0.0067**	0.0073**
	(0.0006)	(0.0028)	(0.0030)	(0.0030)
Constant	0.2956***	-0.1696***	-2.5143***	-0.1383**
	(0.0165)	(0.0653)	(0.4926)	(0.0684)
Average elasticity of energy demand with respect to KICT	-0.1937***	-0.0777**	-0.1205	-0.1049
Number of observations	5109	5109	5109	5109
Time trend	No	No	Yes	No
Year DVs	No	No	No	Yes
Country DVs	No	Yes	Yes	Yes
Sector DVs	No	Yes	Yes	Yes

- Using OLS regression techniques, the results show that ICTs do not have a large effect on energy savings across all countries and sectors taken together.

Results by Sectors

Results using OLS techniques: The effect of ICT on energy demand

Variables	Manufacturing	Services	Other sectors
ln (PE index/PL index)	-0.0633***	-0.0227***	-0.0464***
	(0.0065)	(0.0028)	(0.0137)
Ln (KICT/Y)	0.0067*	-0.0066***	0.0117**
	(0.0034)	(0.0012)	(0.0047)
Ln (Kn/Y)	0.0116***	0.0045***	0.0083**
	(0.0026)	(0.0008)	(0.0033)
Ln Y	-0.0007	-0.0100***	0.0185***
	(0.0031)	(0.0017)	(0.0069)
Constant	0.1579**	0.2312***	-0.2325
	(0.0691)	(0.0400)	(0.1671)
Average elasticity of energy demand with respect to KICT	-0.0149*	-0.3509***	0.0337**
Number of observations	2228	2163	718
Year DVs	Yes	Yes	Yes
Country DVs	Yes	Yes	Yes
Sector DVs	Yes	Yes	Yes

- Splitting the sample by sectors, and using the OLS regression techniques, the results show that there is evidence of energy savings within services.
- The average elasticity of energy demand with respect to ICT is very small within manufacturing.
- Other sectors show a positive average elasticity with respect to ICT.

Note: Other sectors include Agriculture Forestry and Hunting, Mining and Quarrying, Construction and Transport and Storage.

Robustness Checks

Results using OLS techniques: The effect of ICT on energy demand			
Variables	Excluding post-communist countries	Excluding countries with missing data	Excluding both
ln (Pe/Pl)	-0.0461***	-0.0477***	-0.0478***
	(0.0051)	(0.0039)	(0.0053)
Ln (KICT/Y)	0.0012	-0.0003	0.0006
	(0.0016)	(0.0016)	(0.0018)
Ln (Kn/Y)	0.0092***	0.0114***	0.0094***
	(0.0013)	(0.0013)	(0.0014)
Ln Y	0.0150***	0.0069**	0.0156***
	(0.0035)	(0.0032)	(0.0038)
Constant	-0.3267***	-0.1140*	-0.3774***
	(0.0815)	(0.0679)	(0.0995)
Average elasticity of energy demand with respect to KICT	-0.0861	-0.1154	-0.0942
Number of observations	4381	4753	4025
Year DVs	Yes	Yes	Yes
Country DVs	Yes	Yes	Yes
Sector DVs	Yes	Yes	Yes

- The results are consistent with the main results and show that ICTs do not have significant effect after including dummy variables for countries, sectors and years.

- Note: Excluded post-communist countries include Czech Republic and Hungary, as both joined EU in 2004. Excluded countries with missing data include Australia, Belgium and Sweden. Excluding both, i.e., Czech Republic, Hungary, Australia, Belgium and Sweden.

Conclusion

- Applying the OLS technique to a cross country and cross sector panel dataset, we find that investments in ICTs have a modest reduction in energy demand across all sectors and countries taken together.
- The effect of ICTs increasing energy efficiency may be offset by greater use of the ICTs themselves.
- We find evidence of energy savings in the service sector. The average elasticity with respect to ICT for services is -0.35 and -0.01 for manufacturing, whereas it is 0.03 for other sectors.
- Robustness checks confirm that ICTs have a modest impact on energy savings, providing additional confidence in our results. We used different samples to confirm these findings.

Policy Relevance

- Our findings show the role that ICTs play in reducing energy use and are important in achieving the government targets of net zero emissions by 2050.
- These results oppose the claims that ICTs are contributing to a green industrial revolution. The effect of ICTs increasing energy efficiency may be offset by greater use of the ICTs themselves.
- Future research can possibly collect a more up-to-date data and draw a comparison with our results.