

The Impact of Digital Technologies on OECD Energy Demand

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Introduction

- ▶ ICTs offer many opportunities for energy savings, such as optimising energy use in buildings and industrial processes.
- ▶ However, the continuing increases in the number, power and range of applications of ICTs may act to increase energy demand.
- ▶ Hence, the overall net effect of ICTs on energy demand is ambiguous.
- ▶ We examine the net effect of digital technologies on OECD energy demand.

Research questions

- ▶ What is the overall impact of ICTs on industrial energy demand?
- ▶ Splitting the sample by sectors, what is the net impact of ICTs on energy demand for manufacturing, services and other sectors?
- ▶ What is the net effect of ICTs on electric and non-electric energy demand?

Our research

- ▶ Previous works have examined the effects of ICTs on energy demand.
- ▶ However, our research benefits from the following:
 - I. Our dataset includes more countries. We have data on 17 countries (EU countries, Japan, USA, Australia).
 - II. Our dataset includes 28 sectors.
 - III. Renewable energy data is added to the energy quantity data.
 - IV. We have 13 years of data.

Dataset

- ▶ The following data sources are used for the empirical analysis:
 - I. **EU-KLEMS, November 2009 release** - includes information on inputs (capital, labour), value added, and other measures.
 - II. **World Input Output Database, 2013 Environmental Accounts** - includes data on disaggregated energy use by sectors and type of fuel.
 - III. **International Energy Agency, Energy Prices and Taxes Database** - industrial energy prices by country.
 - IV. **Organisation for Economic Co-operation and Development:** information on purchasing power parity for transforming nominal to real values and a common currency, i.e. US dollars.

Data

- ▶ The sample includes the following 17 countries: Australia, Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Japan, Netherlands, Spain, Sweden, UK, and US.
- ▶ We drop following two sectors “electricity, gas and water” and “coke, refined petroleum and nuclear fuel”.
- ▶ The time period is from 1995 - 2007.

Methodology

- ▶ Based on a translog cost function, we estimate the share in energy in variable cost, using ordinary least squares (OLS) regression techniques.
- ▶ Furthermore, to measure the size of the impact, we report the average elasticity of energy demand with respect to ICT capital services.

Methodology

- ▶ We estimate the following equation:

$$S_E = \beta_E + \beta_{EE} \ln\left(\frac{P_E}{P_L}\right) + \beta_{EK_I} \ln\left(\frac{K_I}{Y}\right) + \beta_{EK_{NI}} \ln\left(\frac{K_{NI}}{Y}\right) + \beta_{EY}^* \ln Y + \delta_{ET} t$$

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

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

$$\eta_{K_I}(E) = \frac{\beta_{EK_I}}{S_E} - S_{K_I}$$

where $S_{K_I} = \frac{P_{K_I} K_I}{\text{VarCost}}$, P_{K_I} = price of ICT capital services, VarCost = variable cost

Results: Total energy demand- whole sample

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 (0.0042)	-0.0238*** (0.0029)	-0.0279*** (0.0029)	-0.0468*** (0.0038)
Ln (KI/Y)	-0.0070*** (0.0010)	0.0026** (0.0011)	-0.0009 (0.0014)	0.0003 (0.0014)
Ln (KNI/Y)	0.0400*** (0.0019)	0.0105*** (0.0012)	0.0118*** (0.0012)	0.0111*** (0.0012)
Ln Y	-0.0077*** (0.0006)	0.0089*** (0.0028)	0.0067** (0.0030)	0.0073** (0.0030)
Constant	0.2956*** (0.0165)	-0.1696*** (0.0653)	-2.5143*** (0.4926)	-0.1383** (0.0684)
Average elasticity of energy demand with respect to KI	-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

Results: Total energy demand 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*** (0.0065)	-0.0227*** (0.0028)	-0.0464*** (0.0137)
Ln (KI/Y)	0.0067* (0.0034)	-0.0066*** (0.0012)	0.0117** (0.0047)
Ln (KNI/Y)	0.0116*** (0.0026)	0.0045*** (0.0008)	0.0083** (0.0033)
Ln Y	-0.0007 (0.0031)	-0.0100*** (0.0017)	0.0185*** (0.0069)
Constant	0.1579** (0.0691)	0.2312*** (0.0400)	-0.2325 (0.1671)
Average elasticity of energy demand with respect to KI	-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

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

Results: Electric energy demand

Results using OLS techniques: The effect of ICT on electric energy demand				
Variables	Model 8	Model 9	Model 10	Model 11
Ln (ElectricPI / PLIndex)	-0.0100*** (0.0025)	-0.0072*** 0.0017	-0.0026 (0.0018)	-0.0037 (0.0025)
Ln (NonelecPI / PLIndex)	0.0139*** (0.0026)	0.0058*** 0.0018	-0.002 (0.0020)	0.0019 (0.0020)
Ln (KI/Y)	-0.0059*** (0.0005)	-0.0011 0.0007	-0.0045*** (0.0009)	-0.0028*** (0.0008)
Ln (KNI/Y)	0.0198*** (0.0008)	0.0024*** 0.0006	0.0035*** (0.0006)	0.0030*** (0.0006)
Ln Y	-0.004*** (0.0004)	-0.0047*** 0.0012	-0.0066*** (0.0013)	-0.0056*** (0.0013)
Constant	0.1367*** (0.0083)	0.1160*** 0.0290	-2.5142*** (0.3196)	0.1371*** (0.0295)
Average elasticity of energy demand with respect to KI	-0.2687***	-0.1396	-0.2308***	-0.1863***
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

Results: Non-electric energy demand

Results using OLS techniques: The effect of ICT on non-electric energy demand				
Variables	Model 12	Model 13	Model 14	Model 15
Ln (ElectricPI/PLIndex)	0.0204*** (0.0038)	0.0107*** (0.0026)	0.0114*** (0.0026)	0.0063* (0.0037)
Ln (NonelecPI/PLIndex)	-0.0186*** (0.0028)	-0.0179*** (0.0024)	-0.0192*** (0.0025)	-0.0199*** (0.0026)
Ln (KI/Y)	-0.0008 (0.0008)	0.0046*** (0.0010)	0.0040*** (0.0013)	0.0047*** (0.0012)
Ln (KNI/Y)	0.0207*** (0.0016)	0.0076*** (0.0010)	0.0078*** (0.0011)	0.0075*** (0.0011)
Ln Y	-0.0039*** (0.0005)	0.0147*** (0.0028)	0.0144*** (0.0030)	0.0146*** (0.0029)
Constant	0.1667*** (0.0129)	-0.3115*** (0.0646)	-0.7562* (0.4495)	-0.3091*** (0.0665)
Average elasticity of energy demand with respect to KI	-0.1251	-0.0097***	-0.0219***	-0.006***
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

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/PI)	-0.0461*** (0.0051)	-0.0477*** (0.0039)	-0.0478*** (0.0053)
Ln (KI/Y)	0.0012 (0.0016)	-0.0003 (0.0016)	0.0006 (0.0018)
Ln (KNI/Y)	0.0092*** (0.0013)	0.0114*** (0.0013)	0.0094*** (0.0014)
Ln Y	0.0150*** (0.0035)	0.0069** (0.0032)	0.0156*** (0.0038)
Constant	-0.3267*** (0.0815)	-0.1140* (0.0679)	-0.3774*** (0.0995)
Average elasticity of energy demand with respect to KI	-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

- 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 OLS regression techniques to a dataset of 17 countries, 28 sectors and 13 years, our results confirm that investment in ICTs have a modest reduction in energy demand across all sectors and countries taken together.
- ▶ There is evidence of energy savings in the service sectors, but ICT capital services do not contribute much to energy savings in the manufacturing sectors.
- ▶ And ICT capital services reduce electricity demand whereas it has a negligible impact on non-electric energy demand.
- ▶ Robustness checks confirm that ICTs do not have a large impact on energy savings, providing additional confidence in our results. We used different samples to confirm these findings.

Policy relevance and future research

- ▶ Our findings demonstrate the role that ICTs play in reducing energy use and are important in achieving the government targets of net zero emissions.
- ▶ The impact of digital technologies increasing energy efficiency may be offset by greater usage and applications of the ICTs themselves.
- ▶ Future research can aim to study the effect of ICTs on energy use in more recent years and draw a comparison with our research outputs.