Twin Transitions across Enterprises:

Do Digital Technologies and

Sustainability Go Together?

IULIA SIEDSCHLAG, GRETTA MOHAN, WEIJIE YAN

AN INSTITIÚID
UM THAIGHDE
EACNAMAÍOCHTA
AGUS SÓISIALTA

ESRI ECONOMIC & SOCIAL
RESEARCH INSTITUTE

Twin Transitions Across Enterprises: Do Digital Technologies and Sustainability Go Together?

Iulia Siedschlag [a b] 👤 ✉ , Gretta Mohan [a b] , Weijie Yan [c]

Show more ∨

+ Add to Mendeley ⤴ Share 🙶 Cite

Get rights and content ↗

Agenda

- Research and Policy Background

- Research Objectives and Novelties

- Key Findings

- Related Literature and Conceptual Framework

- Empirical Methodology

- Data and Descriptive Statistics

- Results of Econometric Analysis

- Policy Implications

Research and Policy Background

Digital and green transitions - major global trends and important policy objectives of governments and international organisations – Evidence is key to inform policies aimed at enabling and fostering these twin transitions

Del Río Castro et al. (2021); Barteková and Börkey (2022); Guandalini (2022);

Muench et al. (2022); World Bank (2022)

Digital technologies have the potential to enhance innovation, efficiency and productivity (Brynjolfsson et al. 2019) **as well as environmental sustainability**

Broccardo et al. (2023a); Broccardo et al. (2023b); Kristoffersen et al (2020)

Evidence on increasing greenhouse gas emissions associated with the extraction of raw materials for producing ICT, disposal of ICT equipment, energy consumption of data centres

Freitag et al. (2021); Ahmadova et al. (2022); Charfeddine and Umlai (2023)

Research Objectives and Novelties

Research Questions

- Which firms are more likely to adopt ICT-related sustainability measures?

- Is digitalisation linked to the propensity of firms to adopt ICT-related sustainability measures?

- What other factors influence the adoption of ICT-related sustainability practices across firms?

Novelties

- The first to examine **linkages between digitalisation** (the usage of a broad range of digital technologies) and **the adoption of ICT-related sustainability practices** across firms

- **Unified econometric framework** – brings together several literature strands
- **Newly generated data set** obtained by merging five micro-data sets

Definitions and Measurement

Digitalisation
- Usage of **advanced digital technologies:** Artificial Intelligence (AI), Internet of Things (IoT)
- Usage of **digital tools**: Cloud computing services, Software for sharing information electronically within the firm

ICT-related sustainability practices
- Considering the environmental impact of ICT services or ICT equipment
- Measures to reduce the amount of paper used for printing and copying
- Measures to reduce the energy consumption of ICT equipment
- Disposal of or recycling ICT equipment when is no longer used
- Keeping ICT equipment within the firm (e.g. to be used as spare parts)

Key Findings

- **Adoption of ICT-related sustainability measures is uneven** across firms, sectors and regions
  - Adoption rates increase with firm size
  - Most adopted measures: disposal of or recycling of ICT equipment
  - Least adopted measures: measures to reduce the energy consumption of ICT eq.

- **Digitalisation and sustainability are complementary business objectives**

- **Digitalisation is associated with a higher propensity of firms to adopt ICT-related sustainability practices**, over and above **internal firm characteristics** - firm size, age class, higher skills, employing ICT specialists, intensity of investment in intangible assets, speed of internet connection and **external factors** – within industry and international competition, industry-specific and region-specific factors

Related Literature

Linkages between digitalisation and sustainability

Broccardo, Zicari, *et al.* (2023); Niehoff (2022); Di Vaio *et al.*, (2020); Dubey *et al.*(2019); Jabbour *et al.* (2019); Kristoffersen *et al.*(2020); Singh and El-Kassar (2019); Dal Mas *et al.* (2020); Parida *et al.* (2019)

- Digitalisation enables/supports the integration of sustainable business practices
- Digital technologies contribute to sustainability goals
- The level of digitalisation of a firm positively influence implementation of sustainability measures **-** larger firms realise the greatest outcomes

The adoption and diffusion of new technologies

Doms *et al.* (1997); Geroski (2000); Chun (2003); Hollenstein (2004); Battisti and Stoneman (2005); Haller and Siedschlag (2011); Siedschlag and Yan (2021)

- Uneven across firms, industries, time and space
- Adopters of new technologies - more likely to be large, employ highly skilled workers, be part of multinational groups, exposed to domestic competition and international competition through engagement in international markets

ESRI
AN INSTITIÚID
UM THAIGHDE
EACNAMAÍOCHTA
AGUS SÓISIALTA
ECONOMIC & SOCIAL
RESEARCH INSTITUTE

Conceptual Framework

Adoption of ICT-related sustainability measures

Usage of digital technologies

- Advanced technologies (*AI, IoT*)

- Digital tools (*cloud computing services, software for sharing information within firm*)

Internal firm characteristics

- Size (*number of employees*)
- Age
- Skills (*wage per employee, ICT specialists*)
- Ultra-fast internet connection
- Investment in intangibles

External factors

- Within industry competition (*market share*)
- International competition/engagement in international markets (*exporting/importing*)
- Sector-specific effects
- Region-specific effects

Source: Authors' own elaboration.

ESRI | AN INSTITIÚID UM THAIGHDE EACNAMAÍOCHTA AGUS SÓISIALTA
ECONOMIC & SOCIAL RESEARCH INSTITUTE

Empirical Methodology

$$Prob\left(Y_{it} = 1 \middle| \alpha DIGI_{it-1}, \beta X_{it-2}, \sigma_k, \rho_j, \varepsilon_{it}\right) = F(\alpha DIGI_{it-1} + \beta X_{it-2} + \sigma_k + \rho_j + \varepsilon_{it})$$

Y_{it} : 1 if firm *i* adopted a given ICT-related sustainability measure in year *t* (2022) and 0 otherwise;

$DIGI_{it-1}$: variable measuring the usage of digital technologies in year *t-1* (2021);

X_{it-2} : vector of control variables in year *t-2* (2020) for a given firm *i:* firm size, age class, skills, ICT specialists, intensity of investment in intangibles, speed of internet connection, market share, firm engagement in exports/imports

α, β are parameters to be estimated;

σ_k controls for unobserved sector-specific fixed effects;

ρ_j controls for unobserved region-specific fixed effects;

ε_{it}: error term capturing unobserved omitted variables associated with the adoption of digital technologies and ICT-related sustainability measures such as managerial quality
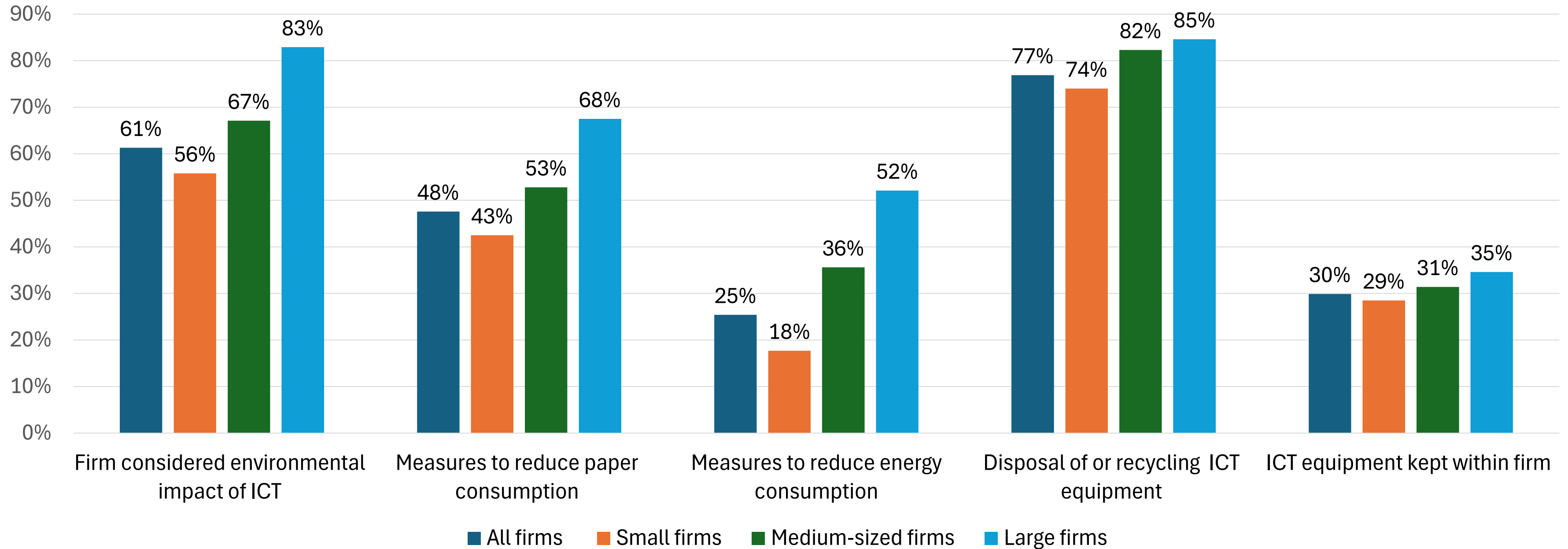
Data

Linked micro-data sets provided by Ireland's Central Statistics Office (CSO)

- **E-commerce and ICT Survey, 2021 and 2022**
  - Data on ICT-related sustainability measures – collected in 2022
  - Data on the usage of AI, IoT, Cloud Computing services, Software for sharing information electronically within the firm - collected in 2021
  - Speed of internet connection, ICT specialists
- **Census of Industrial Production 2020, Annual Services Inquiry 2020**
  - Employment, sales, wages, investment in intangible assets, exports, imports
- **Business Register 2020**
  - Year of establishment, location

Data coverage

- E-commerce and ICT survey 2022: 2041 firms with 10 or more employees
- All linked data sets: 901 firms with 20 or more employees
- Business sectors: manufacturing, utilities, construction and services (financial and insurance services not included)

Adoption of ICT-related sustainability measures across firm size groups in Ireland, 2022

Source: Authors' calculations using RMF data from the Survey on e-commerce and ICT 2022, Central Statistics Office of Ireland.

Adoption of ICT-related sustainability measures across sectors in Ireland, 2022
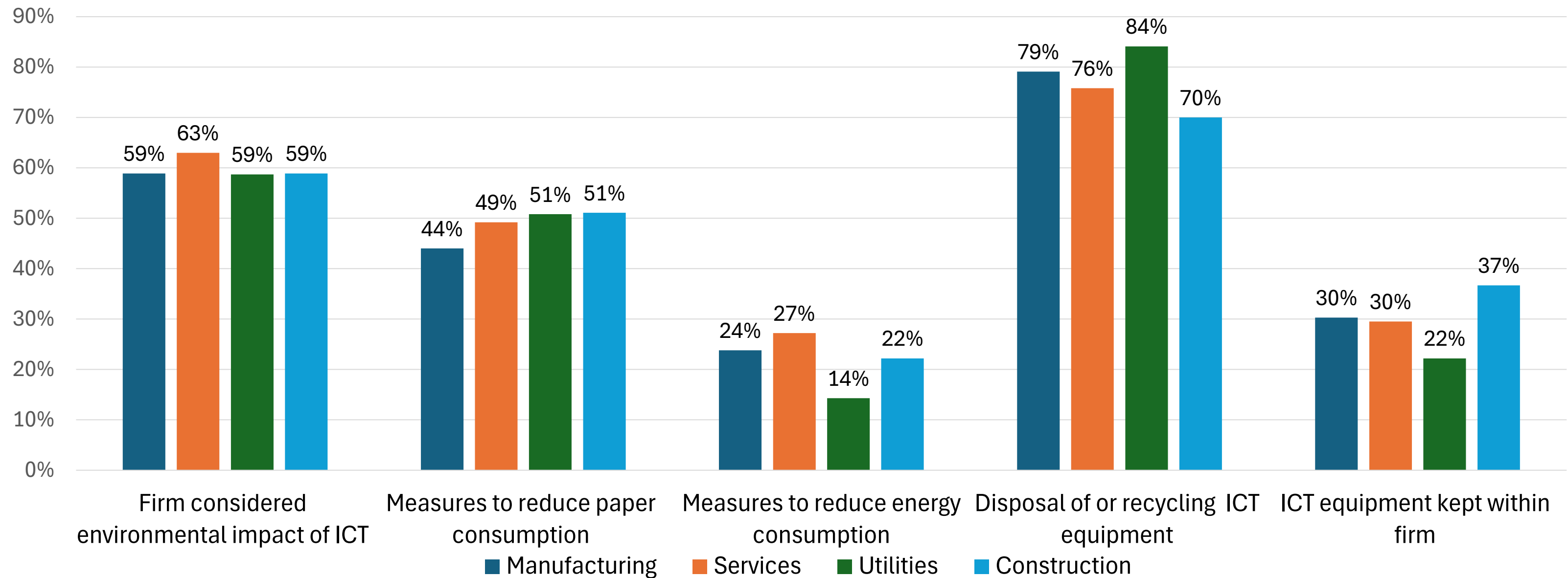
Source: Authors' calculations using RMF data from the Survey on e-commerce and ICT 2022, Central Statistics Office of Ireland.

Adoption of ICT-related sustainability measures across regions in Ireland, 2022

Regions	Firm considered env. impact of ICT services or ICT equipment	Measures to reduce amount of paper for printing and copying	Measures to reduce energy consumption of ICT equipment	Dispose of or recycle ICT equipment	ICT equipment kept
Border	**13.1%**	38.3%	6.9%	**19.5%**	8.6%
West	34.2%	65.1%	**1.4%**	83.3%	**3.0%**
Mid-West	50.7%	47.1%	15.8%	**89.6%**	16.9%
South-East	25.7%	56.4%	4.2%	35.7%	7.4%
South-West	53.6%	33.8%	6.7%	74.5%	15.1%
Dublin	66.5%	50.6%	14.9%	74.0%	21.2%
Mid-East	**89.1%**	**14.7%**	7.6%	81.7%	13.3%
Midlands	53.3%	**84.9%**	**75.2%**	58.6%	**49.1%**

Source: Authors' calculations using RMF data from the Survey on e-commerce and ICT 2022, Central Statistics Office of Ireland.

Results of Econometric Analysis

Digitalisation is associated with a higher propensity to adopt ICT-related sustainability practices, over and above other factors – firm size, age class, skills, ICT specialists, intensity of investment in intangible assets, speed of internet connection, within industry and international competition, industry-specific and region-specific factors

- The adoption of a **greater number of digital technologies** is associated with a higher likelihood of a firm to consider the environmental impact of ICT services or ICT equipment and to have measures to reduce the amount of paper for printing and copying

- **Users of AI technologies** had a higher propensity to adopt ICT-related sustainability measures compared with firms which do not use AI

- **Other factors positively and significantly** associated with the propensity to adopt ICT-related sustainability measures: **firm size, higher skills, employing ICT specialists, intensity of investment in intangible assets**

Policy Implications

To the extent that a wider adoption of ICT-related sustainability measures across firms is desirable:

- **Targeted policy measures** to incentivize and enable more firms, in particular SMEs, to adopt ICT-related sustainability measures
  Raising awareness and identifying barriers firms may experience

- **A holistic approach to enhance and support** complementary investments in other capabilities of firms
  e.g. investment in **human capital** (e.g. up-skilling, employing ICT specialists), **investment in intangibles** e.g. R&D, computer software, big data (crucial input for AI)

Thank you

IULIA SIEDSCHLAG

GRETTA MOHAN

WEIJIE YAN

🌐 ESRI.ie

in Economic and Social Research Institute (ESRI)

▶ Economic and Social Research Institute (ESRI)

✕ @ESRIDublin

Sign up to our Newsletter

AN INSTITIÚID
UM THAIGHDE
EACNAMAÍOCHTA
AGUS SÓISIALTA

ESRI ECONOMIC & SOCIAL
RESEARCH INSTITUTE

Digitalisation and ICT-related sustainability measures

	Firm considered environmental impact of ICT services or ICT equipment	Measures to reduce amount of paper for printing or copying	Measures to reduce energy consumption of ICT equip.	Dispose of or recycle ICT equipment	ICT equipment kept within firm
Number of digital technologies	**0.072**</br>**(0.03)**	**0.050***</br>**(0.028)**	0.023</br>(0.017)	0.027</br>(0.024)	0.023</br>(0.023)
AI user	**0.209**</br>**(0.099)**	**0.170***</br>**(0.102)**	**0.100**</br>**(0.05)**	0.037</br>(0.075)	0.047</br>(0.073)
User of Internet of Things (IoT)	0.079</br>(0.059)	0.042</br>(0.057)	0.011</br>(0.033)	0.044</br>(0.049)	0.053</br>(0.048)
User of cloud computing services	0.059</br>(0.061)	0.015</br>(0.061)	-0.004</br>(0.037)	-0.055</br>(0.058)	0.085</br>(0.054)
User of software for sharing information electronically within firm	0.097</br>(0.064)	0.091</br>(0.058)	0.051</br>(0.035)	**0.132***</br>**(0.050)**	-0.076</br>(0.049)
N	824	824	824	816	816
Log Likelihood	-4400	-4400	-3100	-3700	-4000
Sector-specific fixed effects	Yes	Yes	Yes	Yes	Yes
Region-specific fixed effects NUTS3	Yes	Yes	Yes	Yes	Yes

ESRI
AN INSTITIÚID
UM THAIGHDE
EACNAMAÍOCHTA
AGUS SÓISIALTA
ECONOMIC & SOCIAL
RESEARCH INSTITUTE

Definitions

Artificial Intelligence

- **Systems that use technologies** such as: text mining, computer vision, speech recognition, natural language generation, machine learning, deep learning to gather **and/or use data to predict, recommend or decide**, with varying levels of autonomy, the best action to achieve specific goals.

Internet of Things (IoT)

- **Interconnected devices or systems, often called "smart" devices or systems.** They collect and exchange data and can be monitored or remotely controlled via the internet. Examples are: "smart" meters, thermostats, lamps, alarm systems, smoke detectors, door locks, cameras Sensors, RFID tags connected to a base station that allows them to be managed via the internet

Cloud computing services

- **Paid ICT services that are used over the internet** to access software, computing power, storage capacity, etc. where the services have all of the following characteristics: are delivered from servers of service providers ; can be easily scaled up or down (e.g. number of users or change of storage capability); can be used on-demand by the user, at least after the initial set up (without human interaction with the service provider; are paid for (i.e. per user, by capacity used, or pre-paid). Cloud computing may include connections via Virtual Private Networks (VPN).

Big data analysis

- The use of technologies, techniques or software tools such as data or text mining, machine learning, etc., for analysing big data extracted from enterprise's own data sources or other data sources

Source: E-commerce and ICT Survey Forms 2020 and 2021, Central Statistics Office of Ireland

ESRI
ECONOMIC & SOCIAL
RESEARCH INSTITUTE