Exploring the impact of twin transition on CO2 emissions. The effects of regional spillovers of green and digital technologies

XXIV Reunión de Economía Mundial
Universidad de Cádiz 27- 28 de mayo de 2024

Manuel Acosta
Daniel Coronado
Esther Ferrándiz
Jennifer Medina

University of Cadiz (Spain)

1. Introduction

Motivations

- CO2 emissions is the primary contributor to global climate change, with 70% of which are linked to excessive energy consumption (IEA, 2017).

- Technological progress, specially green technological progress, is a key factor in reducing energy intensity and environmental impact (e.g. Bianchini, 2022, Pan, 2021, Naqvi, 2021; .Tobelmann and Wendler 2020, Wang et al. 2020; (Ghisetti and Quatraro 2017).

- But it is not clear yet whether digital technologies can help to tackle (see, e.g., Rolnick et al. 2019) or worsen (Bianchini, 2022) environmental problems.

- Little evidence on the effects of the twin transition on emissions. Bianchini (2022) is the only attempt, but he ignores knowledge spillovers and is not focused on energy technologies.

- Knowledge spillovers are a key source of technological progress. Knowledge spills over because it is a noncompetitive and partially exclusive good (Romer, 1990, 1986)

Objective

To analyse the effects of eco-technologies and digital eco-technologies in energy domains on regional CO_2 emissions using patent data.

Our contribution

- We provide quantitative evidence on energy and digital innovation on environmental performance at the regional level.

- We include the effect of national and international knowledge spillovers.

- We rely on an original sample of over 140k patents in the energy eco-technology domain, of which 16K are also related to digital domains.

2. Literature review and hypotheses

2.1. Innovation, knowledge spillovers and emissions

Green & energy technologies

-Green technologies include energy-saving technologies and comprehensive utilization technologies of resources, among others.

-The adoption of green technology itself improves energy efficiency (Chakraborty and Mazzanti, 2020).

-Implementing green technologies can reduce energy use and promote resource conservation and recycling, which will directly affect energy intensity (Pan, 2021) and, thus, CO_2 emissions.

2. Literature review and hypotheses

2.1. Innovation, knowledge spillovers and emissions

Digital technologies

Digital technologies can help to tackle environmental problems (see, e.g., Rolnick et al. 2019). But they can increase emissions for several reasons:

-Digital eco-system is very intensive in energy consumption (Dusik et al. 2018; Jones 2018; Strubell et al. 2019).

-They are heavy intermediate consumers of materials, some of which are rare and have limited reserves.

-The use of plastics for manufacturing and packaging devices raise emissions during the production.

-Most of the materials cannot be re-cycled or re-used—leading to a technological dead end and waste management issues, again increasing emissions (Shift Project 2019; Kunkel and Matthess 2020).

> H1.a: The regional development of eco-technologies reduces regional CO2 emissions.
>
> H1.b: The regional development of digital eco-technologies increases regional CO2 emissions.

2. Literature review and hypotheses

Knowledge spillovers and CO2 emissions

-Knowledge spillovers can expand the use of existing green technologies and improve the utilization of green technologies, thereby affecting energy efficiency (Chakraborty and Mazzanti, 2020), and CO2 emissions.

-A region that absorb knowledge from outside its boundaries increases its available knowledge stock and stimulate further innovation, reducing the associated R&D cost and uncertainties (Pan, 2021).

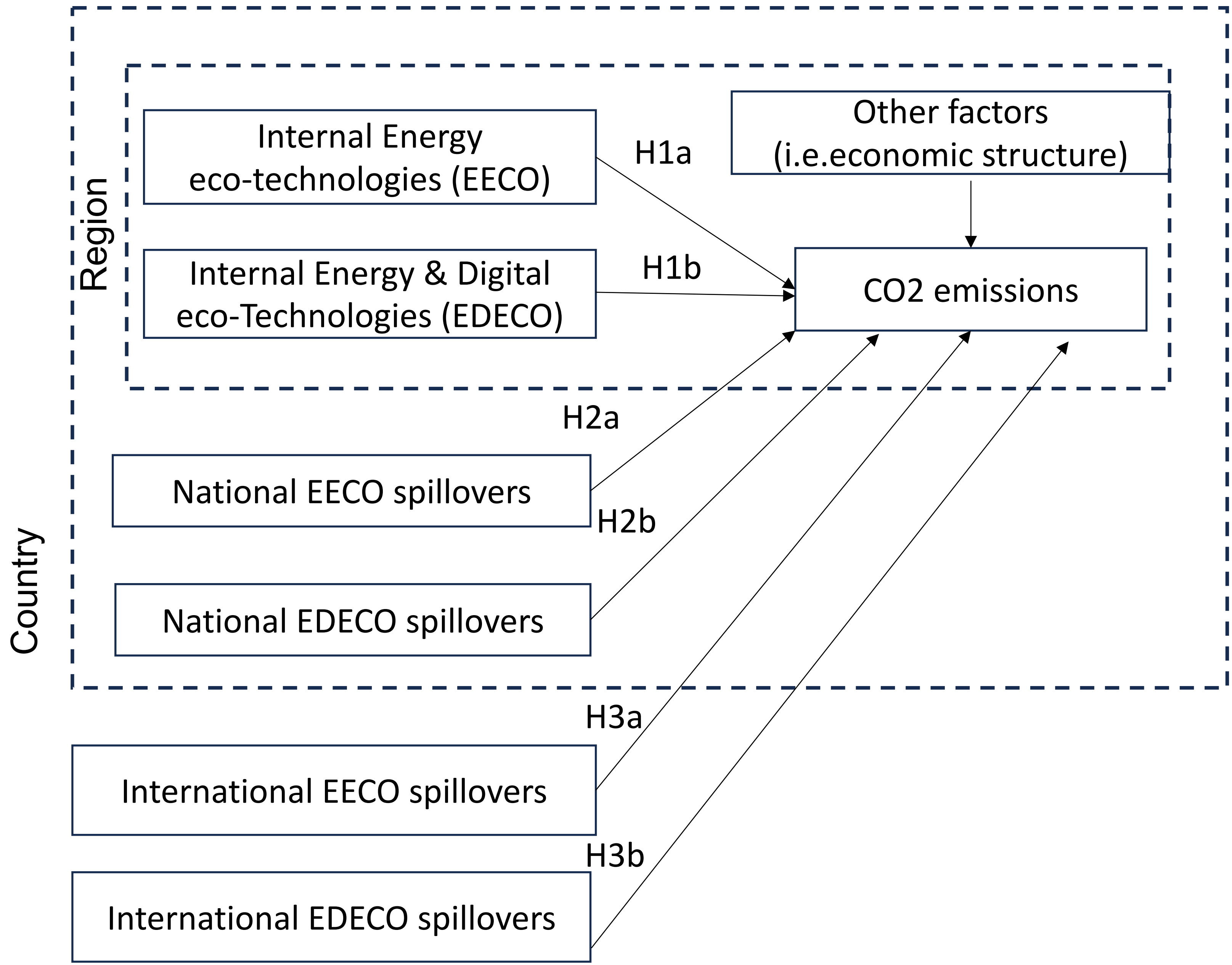
-The effects of national or international knowledge spillovers may differ due to increased technological, cultural, geographic, linguistic distance across countries that can hinder the absorption, and thus the effects, of external knowledge.

H2.a: National eco-technologies spillovers within country reduce regional CO2 emissions.
H2.b: National spillovers of digital eco-technologies increase regional CO2 emissions.

H3.a: International knowledge spillovers reduce CO2 emissions.

H3.b: International spillovers of digital eco-technologies increase regional CO2 emissions.

Figure 1. Theoretical model & hypotheses



3. Data

- Family patents with at least one application to the EPO.
- Period: 1990-2022
- Unit of observation: NUTS 2 regions in Europe.

- Dataset:

1) Identify patents in energy with environmental applications (OECD, 2022). 140,666 patents.

2) From these, identify whether they are also related to digital domains (Baruffaldi et al. 2020; Martinelli et al. 2021 y Ardito et Al. 2018, Bianchini, 2023). 16,937 patents (12,04% of total energy eco-patents)

3) Regionalize patents by NUT2 in EU (or by countries if non-EU).

4) For each EU-region, compute internal, national, and international stocks of knowledge. Perpetual inventory method.

5) Retrieve control variables.

- Sources: EPO Worldwide Patent Statistical Database (PATSTAT, 2023 version). Control variables: Eurostat, ARDECO, others.

4. Variables and model

Variable	Description	Source
Dependent var.		
Co2_emissions_gva	Co2 emission in metric tons/ gross value added (logs)	EDGAR
Main independent var.		
Internal stock eco-tech	Stock per capita of energy eco-patents within región i (logs)	PATSTAT
Regional intensity of digital eco-tech	% of regional stock of energy & digital eco-patents/regional stock of energy eco-patents	
National stock eco-tech	Stock per capita of energy eco-patents in other regions within the same country (logs)	
National intensity of digital eco-tech	% of national stock of energy & digital eco-patents/ national stock of energy eco-patents	
International stock eco-tech	Stock per capita of energy eco.patents in other countries (logs)	
International intensity of digital eco-tech	% of international stock energy & digital eco-patents/ international stock of energy eco-patents	
Control var.		
% Renewable	Renewable energy consumption (% of total final energy consumption)	ARDECO
Share of Industry	Share of industry value added to regional GDP (%)	
Policy strigency	Indicator of stringency of environmental policy. Ranges from 0 to 6.	OECD

5. Results

	MCO (year and country dummies)				MULTILEVEL (nested within countries)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Coef./Std. err.	Coef./Std. err.	Coef./Std. err.	Coef./Std. err.	Coef./Std. err.	Coef./Std. err.	Coef./Std. err.	Coef./Std. err.
L3. l_internal_stock_pc	**-0.0668*** **			**-0.1155*** **	**-0.0682*** **			**-0.1185*** **
	(0.0201)			(0.0203)	(0.0223)			(0.0225)
L3.l_national_spillover_pc		**-0.2377*** **		**0.0172**		**-0.2385*** **		**-0.0279**
		(0.0249)		(0.0513)		(0.0251)		(0.0505)
L3.l_international__spillovers_pc			**-0.3631*** **	**-0.4341*** **			**-0.3621*** **	**-0.3815*** **
			(0.0322)	(0.0653)			(0.0335)	(0.0673)
internal_intensity_deco	0.0036	0.0023	0.0014	0.0019	0.0036*	0.0023	0.0013	0.0020
	(0.0022)	(0.0020)	(0.0019)	(0.0022)	(0.0019)	(0.0017)	(0.0017)	(0.0019)
National_intensity_deco	0.0014	0.0051	0.0004	0.0050	0.0004	0.0044	-0.0006	0.0048
	(0.0060)	(0.0056)	(0.0053)	(0.0060)	(0.0070)	(0.0064)	(0.0063)	(0.0069)
International_intesity_deco	0.0581**	0.0251	0.0122	0.0012	0.0589**	0.0276	0.0126	0.0022
	(0.0271)	(0.0272)	(0.0274)	(0.0274)	(0.0293)	(0.0288)	(0.0290)	(0.0293)
L3.Policy_strigency	-0.0750	-0.0743	-0.0386	-0.0163	-0.0841	-0.0733	-0.0509	-0.0293
	(0.0835)	(0.0822)	(0.0812)	(0.0825)	(0.0772)	(0.0752)	(0.0748)	(0.0766)
Renewable_energy	**-0.0262** **	**-0.0241** **	**-0.0244** **	**-0.0177**	**-0.0252*** **	**-0.0226** **	**-0.0237** **	**-0.0165* **
	(0.0116)	(0.0113)	(0.0113)	(0.0114)	(0.0096)	(0.0092)	(0.0094)	(0.0095)
rate_gva_ind	**0.0239*** **	**0.0286*** **	**0.0262*** **	**0.0263*** **	**0.0242*** **	**0.0287*** **	**0.0265*** **	**0.0270*** **
	(0.0031)	(0.0031)	(0.0031)	(0.0031)	(0.0033)	(0.0032)	(0.0032)	(0.0033)
_cons	2.7405***	1.1856*	1.4519*	0.7391	2.2434***	1.1371	2.3337***	0.4841
	(0.7032)	(0.7147)	(0.8715)	(0.6668)	(0.7655)	(0.7215)	(0.7072)	(0.8344)
lns1_1_1								
_cons					-0.0327	-0.1569	-0.0103	-0.0437
					(0.1740)	(0.1750)	(0.1739)	(0.1791)
lnsig_e								
_cons					0.4366***	0.4244***	0.4209***	0.4218***
					(0.0105)	(0.0103)	(0.0103)	(0.0105)
Observations	4579	4720	4735	4572	4579	4720	4735	4572
R	0.4056	0.4169	0.4212	0.4232				
R_A								
Log likelihood	-8488.05	-8692.12	-8703.12	-8406.91	-8532.84	-8735.38	-8749.02	-8451.95
Wald chi2(7)					154.62***	246.21***	272.32***	299.83***

5. Conclusions

- The production of environmental technologies, not only in the region but also at national and international level contributes to reducing CO_2 emissions by regions (H1a., H2a, H3a supported).

- The size of the effect of international technology>national technology> regional technology.

- The incorporation of a greater proportion of digital knowledge in energy eco-technologies does not affect CO_2 emissions (H1b, H2b, H3b not supported).

- Policy strigency is not apparently relevant for reducing emissions. However, this may be due to little variation in our sample.

- Renewable energy consumption contributes to reducing emissions and the % of industry sector increases emissions.

Policy implications

- Importance of promoting energy eco-technologies for reducing emissions.

- Specially, joint efforts among countries to increase the international available pool of knowledge are particularly recommended to reduce CO_2 emissions.

- Keep fostering renewable energy consumption.

Limitations and extensions

-Next step: weighting spillovers across space, e.g. using citations or geographical distance to weight stocks of knowledge.

-Robustness analysis and deep into multicollinearity issues and solutions.

Many thanks

Universidad de Cádiz

MINISTERIO DE CIENCIA E INNOVACIÓN

Financiado por la Unión Europea NextGenerationEU

Plan de Recuperación, Transformación y Resiliencia

AGENCIA ESTATAL DE INVESTIGACIÓN

Funding: This research is part of the R&D project TED2021-131181B-I00 funded by MCIN/ AEI/10.13039/501100011033/ and by the "Unión Europea NextGenerationEU/PRTR".