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Green FDI and Technological Spillovers in the Host Economies

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MNEs and green innovation: 2 key facts

- ➔ **Multinational enterprises (MNEs) are big players in global innovation:** according to the 2023 Industrial R&D Investment Scoreboard, the world top 2,500 companies have invested more than one trillion euros in R&D.
- ➔ **Green innovation is fundamental to address climate change:** we need cheaper, more efficient and less impactful renewable energies.
- ➔ Whether and how MNEs can contribute to diffuse environmentally friendly knowledge and promote green innovation?

Focus on green technological spillovers in the host countries

The literature

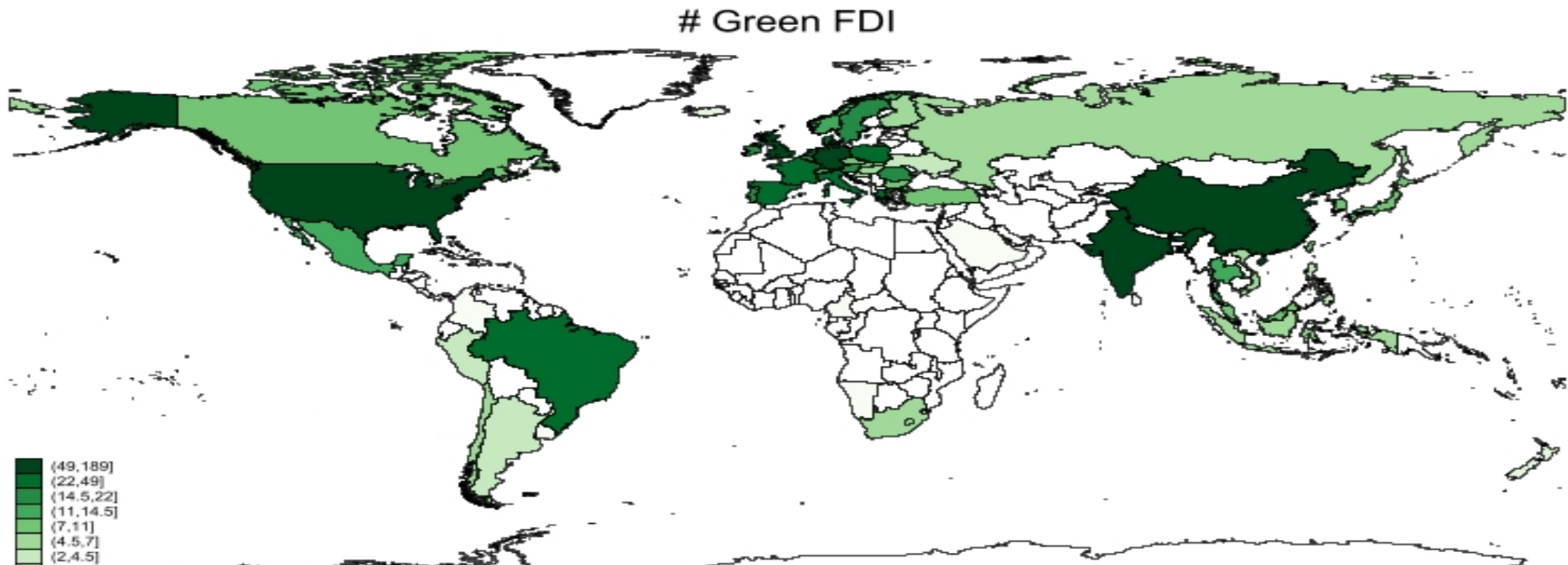
- **FDIs can generate spillovers** in host economies, boosting **productivity** (Javorcik, 2004; Gong, 2023) and **innovation** (Branstetter, 2006; Grafstrom, 2018; Tan et al., 2022).
- **Green technologies generate larger technological spillover** than non-green technologies because of their pervasiveness (Dechezleprêtre et al., 2014; Barbieri et al., 2020).
- **Green FDI enhance the green innovative specialization of MNEs** (Amendolagine, Lema & Rabellotti, 2021) and **foreign subsidiaries of green MNEs undertake more green innovation than domestic firms with similar characteristics** (Amendolagine; Hansen, Lema, Rabellotti & Ribaudó, 2023).

¡ PART 3 !

***Do green FDIs boost technological spillovers
in the host countries?***

How green FDI are identified

- In ORBIS, we identify “green” MNEs as companies with at least one green patent (Y02E: renewable energies) and one foreign subsidiary (Amendolagine et al. 2021 & 2023);
- The database includes **1261 green FDI** from 1997 to 2020



Green technological spillovers

- **Forward citations to green patents owned by green MNEs and their green subsidiaries** (excluding self-citations);
- For each investor i in every year t , we consider all the countries j where there are **foreign citations to its green patents**, according to the address of the first inventor (Bacchiocchi and Montobbio, 2009, 2010; Branstetter, 2006).

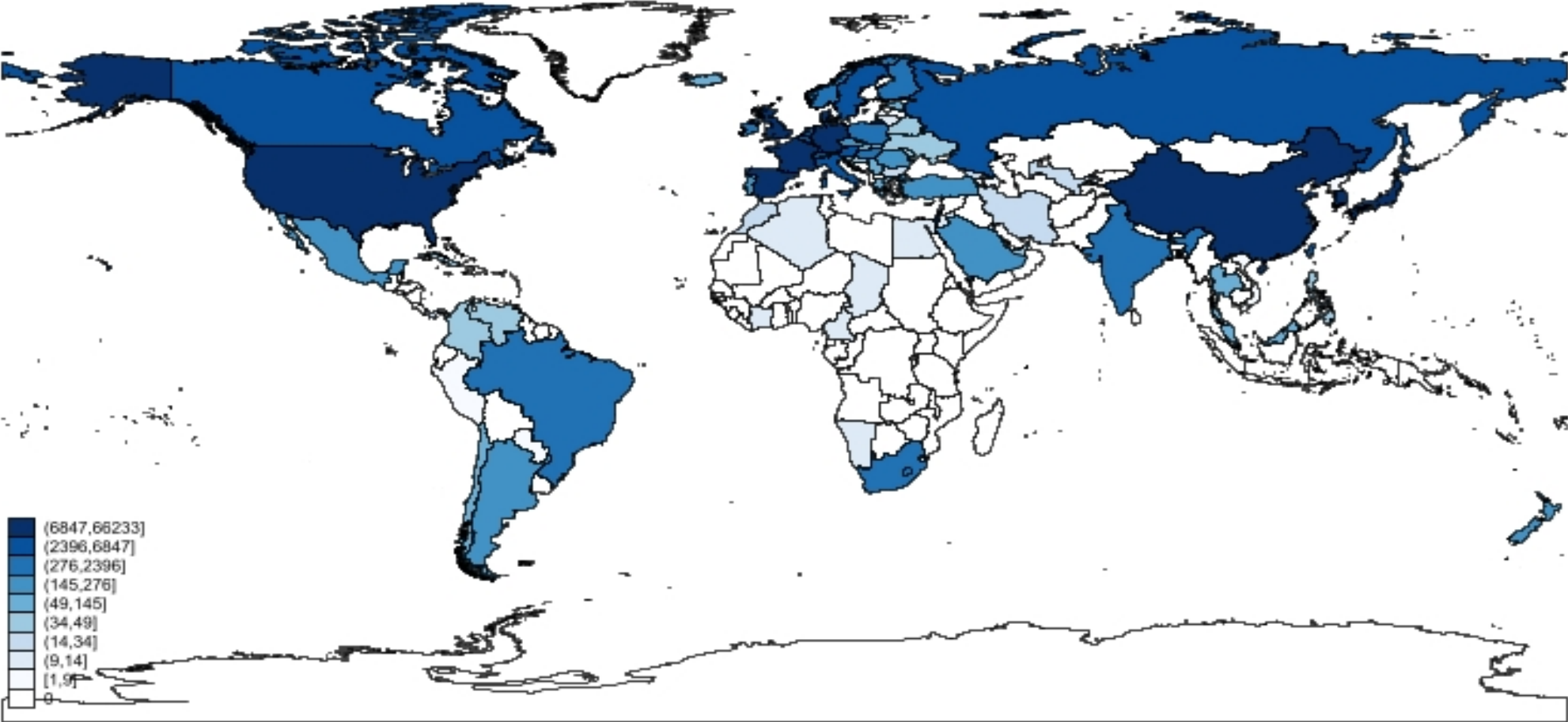
An example

- α ' patents are cited in 43 countries;
- From 1997 to 2020 α has undertaken 37 green FDIs in 21 countries;
- In 1998
 - α has undertaken 2 investments in country A and 0 in country B;
 - α ' green patents have received 3 citations in country A and 2 citations in country B.

Investor (i)	Country (j)	Year (t)	#Forward Citations	FDI
α	A	1997	1	0
α	A	1998	3	2
α	A
α	A	2020	7	0
α	B	1997	1	0
α	B	1998	2	0
α	B
α	B	2020	4	0

Forward citations of MNEs green patents (94 countries)

Foreign forward citations to MNEs' green patents



$$\text{Forward Citations}_{i,j,t} = \alpha + \beta_1 \text{Cumulative Green Patents}_{i,t} + \beta_2 \text{Green Patents Age}_{i,t} + \beta_3 \text{FDI}_{i,j,t-s} + \gamma_i + \delta_j + \theta_t + \epsilon_{i,t,j}$$

Dependent Variable: # of forward citations in country j (where the first investor resides) to all green patents of the investor i (cumulated up to year t)

Main independent variables:

- **# of green FDIs** by investor i in country j at year t (**intensive margin**)
- **Dummy variable:** 1 in country j where the investor i has at least one investment (year of the first investment), 0 otherwise (**extensive margin**)

Controls

- **Cumulative Green Patents** $_{i,j,t}$ cumulative # of green patents owned by investors i up to year t ;
- **Green Patents Age** $_{i,j,t}$ share of the cumulative # of green patents with an age between 4 to 6 years, owned by investor i up to year t

Negative binomial estimation with investor, host country & year FE and errors clustered at the investor level

$s=0,1,2,3$

Table 1 Green Knowledge Spillovers: the intensive Margin

#Forward Citations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Cumulative Green Patents	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Green Patents Age	1.279*** (0.097)	1.281*** (0.098)	1.274*** (0.098)	1.257*** (0.097)	1.279*** (0.097)	1.282*** (0.098)	1.275*** (0.098)	1.258*** (0.097)	1.279*** (0.097)	1.281*** (0.098)	1.274*** (0.098)	1.257*** (0.097)
# FDI	0.134** (0.054)											
# FDI (t-1)		0.121** (0.055)										
# FDI (t-2)			0.123*** (0.046)									
# FDI (t-3)				0.128*** (0.050)								
# Greenfield FDI					0.074 (0.071)							
# Greenfield FDI (t-1)						0.094 (0.073)						
# Greenfield FDI (t-2)							0.098* (0.058)					
# Greenfield FDI (t-3)								0.108* (0.062)				
# M&As									0.225*** (0.080)			
# M&As (t-1)										0.167** (0.079)		
# M&As (t-2)											0.168** (0.072)	
# M&As (t-3)												0.166** (0.072)
F.E. (target country, investor, year)	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Obs.	81240	77855	74470	71085	81240	77855	74470	71085	81240	77855	74470	71085

Table 2. Green Knowledge Spillovers: the extensive margin

# Forward Citations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Cumulative Green Patents	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Green Patents Age	1.281*** (0.097)	1.283*** (0.098)	1.276*** (0.097)	1.259*** (0.096)	1.280*** (0.097)	1.283*** (0.098)	1.276*** (0.097)	1.259*** (0.096)	1.280*** (0.097)	1.282*** (0.098)	1.275*** (0.098)	1.258*** (0.096)
FDIs Dummy	0.122* (0.068)											
FDIs Dummy (t-1)		0.083 (0.064)										
FDIs Dummy (t-2)			0.110** (0.055)									
FDIs Dummy (t-3)				0.122** (0.051)								
Greenfield FDIs Dummy					0.047 (0.086)							
Greenfield FDIs Dummy (t-1)						0.059 (0.082)						
Greenfield FDIs Dummy (t-2)							0.106 (0.072)					
Greenfield FDIs Dummy (t-3)								0.117* (0.067)				
M&As Dummy									0.219** (0.093)			
M&As Dummy (t-1)										0.136 (0.087)		
M&As Dummy (t-2)											0.142* (0.078)	
M&As Dummy (t-3)												0.147** (0.074)
F.E. (target country, investor, year)	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Obs.	80856	77487	74118	70749	80856	77487	74118	70749	80856	77487	74118	70749

- Green FDI enhance green technological spillovers both at the intensive and extensive margin;
- The effect is stronger for acquisitions than greenfield investments;
- Introducing macro mediating factors, forward technological spillovers are stronger in countries
 - with stricter environmental policy
 - with lower GDP per capita. This finding is coherent with Amendolagine et al (2023) showing that relative to domestic companies the MNE subsidiaries do more green innovations in countries where the GDP per capita is lower

In less developed countries MNEs can really make a difference in terms of green innovation!

Wind and Solar Technologies

- In wind technologies the effect is significant for greenfield investments and acquisitions;
- In solar technologies, the effect is weaker and limited to acquisitions. This finding is coherent with Amendolagine et al (2023) showing that the subsidiaries' advantage in terms of patent quality is larger in wind than in solar PV.



**Knowledge is more tacit in wind
and more codified in solar!**

Robustness checks

- Controls for time-variant MNE-specific internal R&D intensity (measured by the stock of intangible assets) and host-country knowledge base (measured by the number of patents per capita);
- **Placebo test:** non green FDI (at the extensive margin) from investor i in country j does not significantly increase the number of forward citations to investor i 's green patents.



Only green FDI have a positive and significant impact on green technological spillovers

Preliminary conclusions

- Green FDIs (and only green FDIs) are important drivers of innovation in green renewable energies;
- Their impact is not limited to MNEs' boundaries (Amendolagine et al., 2021) and their subsidiaries (Amendolagine et al., 2023) but they also increase green technological spillovers in the host countries, enhancing domestic green innovative activities;
- Their impact is stronger in case of acquisitions rather than in greenfield investments and in the wind industry with respect to solar.
- Their impact is stronger in developing economies and in countries with stricter environmental policy.

Policy implications

- **Attracting green FDI**, countries can enhance their green innovative capacity.
- Policies attracting green FDI should go hand in hand with measures **encouraging knowledge spillovers from MNE subsidiaries to domestic companies**, such as policies including local content requirements and training of the local workforce.
- Green technology transfer should take a more central role in the WTO and TRIMS agreements, accounting for the **public goods nature of green technologies** and supporting their global diffusion through FDI.
- International organizations, such as the UNFCCC, should direct **more attention to FDI as a key channel for green technology transfer**.



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