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Insights from renewable energy

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Published in:
Journal of Cleaner Production

DOI (link to publication from Publisher):
10.1016/j.jclepro.2021.127381

Publication date:
2021

Document Version
Early version, also known as pre-print

Amendolagine, Vito, Lema, Rasmus, & Rabellotti, Roberta. (2021). Green foreign direct investments and the deepening of capabilities for sustainable innovation in multinationals: Insights from renewable energy. *Journal of Cleaner Production*, *310*, 127381. https://doi.org/10.1016/j.jclepro.2021.127381

Green foreign direct investments and the deepening of capabilities for sustainable innovation in multinationals

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Abstract

There is mounting agreement that the global economy is at the nascent stage of a green transformation involving multinational enterprises (MNEs) trying to enhance their capabilities for sustainable innovation and beginning to globalise their green efforts. But to what extent and how (if at all) do green Foreign Direct Investments (FDIs) contribute to the deepening of sustainability capabilities? To address this question, we employ a novel dataset of 1,217 green FDI in renewable energy sectors worldwide, during the period 1997 to 2015. A propensity score matching and difference-in-difference econometric strategy provides three main results. First, green FDIs enhance the overall orientation to sustainability of MNEs. They have both a greening effect on the firms' overall technology bases and increases specialisation in specific green technologies. Second, green FDIs have a significant positive impact on the degree and quality of MNEs innovative capacity in sustainable technologies. In other words, the MNEs extend their innovative capabilities towards more sustainability-oriented direction and strengthen their innovation activities related to green technologies. Third, we find that the globalisation process mode matters: in the long run, green FDIs result in newly-established subsidiaries contributing more to innovativeness and greening than acquisition of foreign firms. These findings have important implications for policies designed to increase the sustainability transition.

Keywords: Foreign Direct Investments, Global Connectedness, Green Innovation, Multinational Enterprises, Renewable Energy, Sustainability Transition

1 Introduction

Multinational enterprises (MNEs) play a multifaceted role in green transformation and one that can have both positive and negative effects (Kolk et al., 2017; Kolk and van Tulder, 2010). The large size of MNEs can make it more difficult to change entrenched routines, resulting in their becoming stuck in resource intensive and high-polluting production and operating modes (Kolk and Pinkse, 2008; Smink et al., 2015). On the other hand, their international reach enables access to relevant green knowledge in the global economy, which gives MNEs advantages related to in sustainability-oriented innovation (Maksimov et al., 2019). The present article tests this latter argument and investigates whether and how Green Foreign Direct Investments (GFDIs) affect MNEs' sustainability-oriented innovative capacity.

Our empirical focus is on investments in renewable energy technologies, which, given their well-established contribution to sustainable development and urgency related to the grand challenge of climate change, represent a crucial subset of total investment in sustainability-relevant technologies (Güney, 2019). In this paper, we define GFDIs as outward FDIs, aimed at establishing or acquiring subsidiaries related to the production or distribution of green technology, specifically renewable energy technology.

In this empirical context, our main research question is: *To what extent and how (if at all) do GFDIs contribute to deepening of sustainability-oriented innovation capacity in MNEs?* Our use of the word 'deepening' is deliberate and indicates a focus on firms with some previous experience in green innovation activity. Our research question is relevant for policy and practice because sustainability-oriented MNEs – both environmental pure-players (e.g., specialised renewable energy lead firms) and multi-technology conglomerates (Granstrand, 2004) with green business lines – may respond in different ways to achieving a greener economy (Ansah and Sorooshian, 2019; Hart, 2013).

We conduct a cross-country empirical analysis to answer the following subsidiary questions:

- *Greening and specialisation effects:* To what extent and how do GFDIs affect the sustainability-orientation of MNEs' knowledge bases? Do they expand the variety of green technologies or drive specialisation in distinct sustainability-related technology domains?
- *Green innovativeness*: How do GFDIs influence MNEs' sustainability-oriented innovation capability? What does this mean for the quantity and quality of green innovations?
- *FDI entry mode:* Does it matter whether GFDIs take the form of a newly established subsidiary or enable acquisition of an existing firm in the host economy? Is a more effective route to MNE greening achieved via acquisitions of existing green firms or greenfield investments?

We find that, in the first five years after the investment, GFDIs generate a greening effect (i.e., an increase of the share of green patents in the investors' patent portfolios) and have a positive impact on innovation (measured by patenting activity). Also, the effects of greenfield GFDIs increase annually, whereas cross-border acquisitions have only short-term effects on MNE innovativeness. Our findings contribute to the nascent literature on MNEs and green innovation (Aguilera-Caracuel et al., 2012; Doruk, 2016; Maksimov et al., 2019) and provide robust new empirical evidence for a sample of firms, which includes both MNEs focused on specific environmental technologies and large multi-technology corporations such as Siemens, General Electric and Samsung. Our evidence is of particular relevance in terms of the potential contributions of these types of multinationals to the sustainability transition.

The paper is structured as follows. Section 2 reviews the relevant literature on how investment-driven globalisation processes influence the innovative capacity of green lead firms. The existing knowledge on this issue is scant; we derive insights from (a) the literature on sustainability transition, specifically the strand of work on the role of MNEs, (b) the international business literature examining the contributions of MNEs to sustainable development and (c) the literature on GFDIs. We identify relevant gaps in the knowledge.

Section 3 describes the data sources and analytical methods. In the absence of an established framework and methodology to examine the effect of GFDIs on innovation, we describe our research steps in detail. We use data on FDIs and patents, for 1997 to 2015 and study the statistical differential effect on innovation among firms involved in GFDIs compared to similar other non-investing firms. To address our questions on the greening effect, we investigate the specialisation in the green patents filed after GFDI. To study green innovativeness, we examine the quantity and quality of the green patents filed following GFDI. We conduct separate tests for the different impact of greenfield investments and cross-border acquisitions. Section 4 presents our findings and Section 5 concludes by outlining the contributions to the literature, discussing some policy implications and suggesting areas for further research.

2 The literature

The growing pressure on businesses to operate sustainably has resulted in an increased focus in the international business literature on the environmental impacts of MNEs (see, e.g., Ashraf et al., 2020; Bocken et al., 2015; Kolk et al., 2017; Pisani et al., 2019). In the present paper, we aim to contribute to this literature by investigating, in detail, whether and how GFDIs affect the deepening of MNEs green innovative capabilities.[1] Work on (green) FDI and innovation identifies certain gaps in the research in both the international business literature (Kolk et al., 2017) and work on climate and sustainability, and the role of private sector innovation (Dechezleprêtre et al., 2011).

2.1 Global connectedness and dynamic green capabilities

Our starting point is the global connectedness hypothesis proposed by Maksimov et al. (2019). Their main proposition is that 'global connectedness' (Turkina and Van Assche, 2018) helps MNEs to cultivate the dynamic capabilities (Teece, 2014) required to increase environmental sustainability. According to Maksimov et al. (2019), MNEs accumulate 'dynamic green capabilities' via their connectedness, which provides direct access to relevant pools of green knowledge in the global economy strengthens their routines for integrating new green knowledge in the firm. Compared to non-globalised firms, 'MNEs are in a better position to be proactive rather than cautious in environmental sustainability and should be able to make the transition from ''avoiding harm'' to ''doing good'' more easily than other firms' (Maksimov et al., 2019, no page). In this paper, we explore the notion that MNEs are better placed than other firms to go green, based on their development of sustainable technologies.

Aguilera-Caracuel et al. (2012) advance a similar argument. They exploit the knowledge-based approach to explain how international experience (i.e., exports) and organizational learning capability, promote proactive environmental strategies. They show that, on its own, exporting activity does not increase the firm's green profile, but that more focused international environmental diversification is related positively to a proactive environmental strategy. Similar to the later work by Maksimov et al. (2019), they found that the positive relationship between international environmental diversification and environmental proactivity is moderated by organizational learning capabilities. Chiarvesio et al. (2015) show that exporting does not support green innovation, but that being a foreign subsidiary or undertaking FDIs have positive effects. In other words, the knowledge acquired by firms that are part of (a diversified) international group, augments their environmental orientation and, particularly, in the presence of strong organizational capabilities.

[1] We do not include knowledge diffusion from the home economy and MNE headquarters to the host economies and MNE subsidiaries. It has been shown that MNEs transfer technologies and knowledge from their headquarters to their foreign affiliates, with potential benefits for local innovation (Dunning, 2001; Rugman and Verbeke, 2001; Doruk, 2016). There is a large body of work showing that, depending on conditions, such as policies and domestic absorptive capacity, host economies may benefit from significant knowledge spillovers from FDIs (Blomstrom and Kokko, 1998). This has been shown to apply to green sectors, resulting in MNEs contributing to the sustainability transition as sustainability-relevant knowledge is transferred internationally through FDIs (Glachant and Dechezleprêtre, 2017; Golub et al., 2011; Sarkodie and Strezov, 2019).

In this context, the MNE's sustainability profile is important and is shaped significantly by the extent of environmental innovation. Firms differ in their *green intensity* or relative 'degree' of greenness. We consider the strength of their sustainability focus is representative of the firms' green innovation efforts in renewable energies compared to its overall innovation activities.

Our empirical analysis investigates two types of green multinationals which are distributed along an analytical continuum. At one extreme are multi-technology corporations, whose main innovation (and commercial) focus is not exclusively on green technologies, but which engage in some sustainability-oriented innovation activity. In terms of their contribution to the green transformation and given their significant overall innovation capacity,[2] what matters for these multi-technology corporations is more likely to be the degree to their FDIs allows them to move along the greenness dimension and improve their sustainability profile ('go greener'). These multi-technology corporations (Granstrand et al., 1997; Patel and Pavitt, 1997) may be able to integrate and leverage different knowledge domains from distinct application areas (Lema, 2010; Teece, 2014), in order to increase their green innovation. For example, they may exploit cross-subsidiary linkages in order to enrich sustainability-oriented technologies (Maksimov et al., 2019).

At the other end of the continuum are green pure players, which are firms that are specialized in green technologies (Santaló and Becerra, 2006). For pure players, given their dominant green profile, the key issue is whether their innovation capacity increases with an increase in their global connectedness: they may choose to diversify their efforts across several green technologies or focus on a specific technology, that is, they may differ in terms of their green specialization. Their degree of greenness can range from highly specialized to highly diversified and can be defined based on the green technologies enabled by their innovation activities. Connectedness can be achieved by locating affiliates abroad, often in specialized clusters with accumulated stocks of knowledge. Their subsidiaries and acquisitions may be aimed at entry to the green ecosystem, and connections with important local sustainability-relevant firms and other stakeholders (Kolk et al., 2017; Turkina and Van Assche, 2018).

Later in the paper, we test the effect of GFDIs on green intensity, green specialization and green innovativeness. First, we derive insights from the literature on the possible effects of FDIs on these greening effects. We go beyond the specific and quite limited work on green MNEs and include the general international business literature.

[2] Based on the EU Industrial R&D Investment Scoreboard, the multi-technology corporations in our sample include several R&D global spenders, such as Siemens, General Electric, Panasonic and LG (accessed 26 March 2021)

2.2 FDI and the firm's knowledge base: a greening effect?

To our knowledge, there are no studies that specifically examine whether and how FDIs affect the sustainability-orientation of the MNEs' knowledge base. Maksimov et al. (2019) examine how global connectedness can help MNEs become more environmentally sustainable, focusing on the international spread of their sales (including sales from overseas subsidiaries); however, but do not examine FDIs.

Our examination of the possible greening effect of FDIs is informed by the MNE literature, which discusses how FDIs affect the firm's knowledge base and, particularly, with respect to technological specialization versus diversification. The main insight is that FDIs are positively associated to increased diversification of the MNE knowledge base. For example, in a longitudinal study, Cantwell and Piscitello (2000) found that FDIs and technological diversification were significantly correlated and that the positive effect on diversification increases over time. They attribute this to the access via foreign R&D subsidiaries to knowledge that is new to the firm, and to the fact, also, that undertaking R&D abroad may free up domestic resources and allow engagement in new research areas. In line with the connectedness hypothesis, they argue that diversification depends on the formation of internationally integrated networks operating within MNEs, and competitiveness based on asset creation and acquisitions in specialized locations. This is consistent with the idea that MNEs build dynamic green capabilities by tapping into clusters specialized in environmental technologies. The study by Blomkvist et al. (2014) confirms these findings and suggests that internationalization based on FDIs increases knowledge base diversification via acquisition of foreign firms. They show that newly established subsidiaries do not have the same effect. In our empirical analysis, we investigate whether these findings hold in the specific context of GFDIs and their impact on green innovation capabilities.

Overall, we expect GFDIs will increase the greening of the overall MNEs profile, enhance the propensity to engage in new and emerging, environmentally friendly technologies and induce a larger proportion of green knowledge in the firm's knowledge base . We expect this to be based on the current global economic 'green race' which is affecting countries and sectors and which implies that green competitiveness will be key to international market success (Fankhauser et al., 2013). The literature suggests that GFDIs promote diversification of green knowledge. In other words, we expect GFDIs to increase the propensity to engage in a larger range of green technologies. MNEs tend to be more involved in international co-innovation than domestic firms, and may be better able to diversify their green knowledge than firms that do not engage in FDI. This notion is supported by Zhou et al. (2016), who found that the knowledge bases of green pure players (in the wind energy sector) are more diverse if their innovation process is based strongly on international networks. This applies to the cases of European and some Indian MNEs compared to Chinese firms which are less embedded in international networks.

2.3 Green innovativeness

The international business literature shows that firm internationalization is associated positively to greater innovativeness (Cassiman and Golovko, 2018; Castellani and Zanfei, 2007; Siedschlag and Zhang, 2015). Maksimov et al. (2019) extend the connectedness thesis to green innovativeness, measured as whether or not the firm has strong emissions reduction, natural resources saving and environmental product innovation policies. We extend the connectedness thesis even further to include the quantity and quality of MNE green patenting. We draw on work on the relationship between FDI mode(s) of internationalization and innovativeness (Cantwell, 2017). This stream of work shows that the innovativeness effect is mediated by the type of international investments, in particular, whether the investments are focused on overseas production or on R&D (Penner-Hahn and Shaver, 2005). In a study of the energy industry, including both 'black' and 'green' energy, Hurtado-Torres et al. (2018) show that overseas R&D investments increase MNEs' innovation output and, especially, if these investments are geographically distributed. This finding is in line with the connectedness thesis and suggests that overseas R&D investments enhance the MNE's capacity for technological learning and the benefit derived from R&D externalities.

There may be similar patterns related to the specific case of green innovation. For example, Noailly and Ryfisch (2015) build on the connectedness hypothesis and show that a large share of green patents worldwide is based on MNEs' cross-border R&D activities, which allow them to exploit both demand advantages originating from stricter environmental regulation in lead-markets, and acquisition of specific foreign capabilities in green technologies. Several studies indicate that internationalization increases the firm's propensity to introduce products or processes that reduce environmental impact. This is confirmed by Chiarvesio et al.'s (2015) study of Italian firms specialized in medium- and low-tech industries. These authors find that subsidiaries of multinational enterprises are more likely to implement green innovations because of their ability to tap into global knowledge.

Aguilera Caracuel et al. (2016) suggest that Small and Medium-sized Enterprises (SMEs) with higher levels of internationalization are better able to accumulate innovative capabilities and pay special attention to the development of a proactive environmental strategy. Similarly, Melane-Lavado et al. (2018) compare SMEs with and without FDIs and find that, overall, the former are more innovative, but are focused more strongly on innovation that increases sustainability.

In our study, we add to the existing literature by examining whether this applies also to the case of GFDIs. We expect that GFDIs will increase green innovation (Chiarvesio et al., 2015; Melane-Lavado et al., 2018; Noailly and Ryfisch, 2015), measured by both the numbers of green patents and their technological value, proxied by forward citations (Perri and Andersson, 2014; Phene and Almeida, 2008; Stiebale, 2016)

2.4 FDI entry mode

Research based on the global connectedness thesis mainly examines exporting as the mode of entry into foreign markets (Aguilera-Caracuel et al., 2012; Maksimov et al., 2019) and mostly ignores FDI as an expansion strategy for multinationals and its relation to innovativeness and greening (Chiarvesio et al., 2015). There is a long tradition of international business research that tries to explain the effectiveness of FDI as an entry mode and distinguishes between acquisition of foreign firms and establishment of greenfield foreign subsidiaries (Buckley and Casson, 2009; Meyer, 2001). There is a subset of this work which examines the relationship between FDI entry mode and MNE innovativeness (Blomkvist et al., 2014; Stiebale, 2013; Zander, 1999).

This strand of work provides two main conclusions. First, it shows that the overall impact of innovativeness on internationalization is augmented if it is based on acquisitions (Blomkvist et al., 2014). Foreign subsidiaries account for a large share of the new technologies introduced by MNEs, particularly if they are related to cross-border acquisitions (Zander, 1999). The effects hold for both the output variables (patents and product innovations) and input variables (measurable innovation efforts) and are stronger for high-tech industries (Stiebale, 2013).

Second, the international business literature highlights that foreign subsidiaries, both greenfield investments and acquisitions, contribute to overall innovativeness in MNE networks. However, there is a gap in our understanding of whether, over the longer term, subsidiaries are able to contribute to MNE strategic renewal. In this context and in the case of greenfield establishments, Blomkvist et al. (2010) highlight the importance of 'superstar subsidiaries', which stand out in the network and provide long term contributions to innovativeness. Similarly, Hansen et al. (2020) show that in the case of greenfield subsidiaries, technological capabilities generally increase over time, but that strategic renewal - the development of sustained competitiveness in new technology fields - is confined to selected subsidiaries.

Both findings suggest that acquisitions of existing foreign firms and their integration in the MNE network, will be effective in the short run and will enable rapid diversification in new green technology fields, compared to new foreign venture creation. Depending on the level of absorptive capacity (Amendolagine et al. 2018; Cohen & Levinthal, 1990), integration with centers of excellences in environmental technologies, can provide a fast-track green innovation collaborations enabling acquisition of new green technology expertise and synergies with existing technologies to allow strategic renewal in the green economy. Greenfield investments may be more beneficial for green innovativeness over the longer term, but the real impact on greening trajectories may be confined to a few green subsidiaries. Testing these expectations empirically sheds new light on the global connectedness thesis by verifying which particular modes of investments may be more effective for MNE green deepening and specialization.

3 Data and methodology

To understand whether GFDIs contribute to intensification of sustainability-oriented innovative capacity in MNEs, we focus on renewable energy, which is an exemplary case of a sustainability-focused industry (Mills et al., 2010). As argued in Golub et al. (2011), there is a general consensus that the production and distribution of renewable energy combined with the production of environmental services, such as waste management and recycling, captures a large part of GFDIs.

Our empirical analysis looks at the production and distribution of energy from renewable sources, such as hydro, biofuels, waste, solar PV, solar thermal, wind, geothermal and tides (IEA, 2019). Energy production account for 72% of all greenhouse gas emissions (WRI, 2020) and increasing innovation to make renewable energy technologies more efficient and affordable, and bringing a broader range of new technologies and solutions to market as soon as possible, are priorities for public and private actors involved in the green transformation (Markard, 2018; Stern, 2007).

3.1 The dataset

Identifying GFDIs in renewable energies is not straightforward because they can occur in production and electricity sectors, not normally identified as related to renewable energy. Green activities are often related to technologies applied in other than green sectors, and "*sectors and industries that are not environmental by nature but where the potential for pollution abatement is important*" (Golub et al., 2011: 16).

To overcome these issues, we follow the four step approach proposed by Glachant and Dechezleprêtre (2017), who identify the amount of climate-change related FDIs, based on foreign subsidiary holdings of companies with at least one climate change-related technology patent. We describe our methodology in more detail below.

In the first step, we match Orbis and PATSTAT data to identify firms with at least one patent in a sub-set of the technological category denominated Technologies or applications for mitigation or adaptation against climate change, according to the European Patent Office (EPO) classification.[3] We focus on the Y02E subgroup, which includes Climate change mitigation technologies in energy generation, transmission and distribution in the areas of: energy generation through renewable energy sources and Technologies for the production of fuel of non-fossil origin.[4]

Second, among the firms identified as having at least one patent in a renewable energy technology based on PATSTAT data, we identify companies with at least one foreign subsidiary according to ORBIS data.

The third step consists of a textual search[5] on subsidiary business activity, provided by Orbis, including only those firms in our sample working on the production and/or distribution of renewable energy.

The fourth step uses information from ZEPHYR, a companion database of ORBIS, to identify cross-border acquisitions[6] among foreign subsidiaries, allowing the others to be classified as greenfield investments (Stiebale, 2013).

After cleaning the data of investments in tax havens,[7] which are less likely to be related to technology innovations, we obtained a sample of 1,217 GFDIs in biofuel, geothermal, hydro, marine, solar, waste and wind. Figure 1 depicts GFDI trends between 1997 and 2015 and shows a peak in 2011 followed by a decreasing trend. It should be noted, also, that acquisitions increased all along the period and, in 2014, overtook greenfield investments. Appendix Tables A.1 and A.2 present evidence on the home (Germany: 18% of the total, USA: 14%, Japan: 10% and Denmark: 10%) and host countries (UK: 175 investments, China and Germany: 101 and USA: 87).

[3] To avoid possible double counting, we use the DOCDB simple patent families, which collect patent applications covering a single invention. DOCDB is the EPO master documentation database and has worldwide coverage (more than 100 patent offices). We consider patents filed after 1970 since we include investments since 1997.

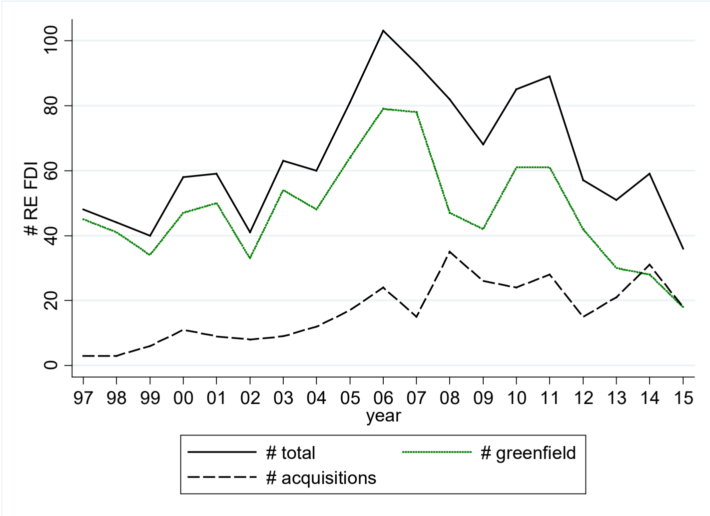
[4] The Y02E code refers to alternative sources of energy to fossil fuels. It includes technologies allowing sustainable energy generation using fossil fuels and more efficient transmission and distribution technologies, and enabling technologies for alternative energy sources. There are 7 main technical areas, split across over 200 sub-categories. We consider two of these areas and include the following CPC (Cooperative Patent Classification) codes: geothermal energy (Y02E10/1), hydro energy (Y02E10/2), marine energy (Y02E10/3), solar thermal energy (Y02E10/4), solar photovoltaic energy (Y02E10/5), solar thermal-PV hybrid (Y02E10/6), wind energy (Y02E10/7), biofuels (Y02E50/1), fuel from waste (Y02E50/3). More information is available in EPO (2021).

[5] The key words are: wind, solar, PV, photovoltaic, biofuel, waste, marine energy, marine power, hydro energy, hydro power, geothermal, renewable, non-fossil, biodiesel, biogas, biomass.

[6] As line with the literature, our sample includes only investments with at least 50% ownership (Guadalupe et al., 2012; Stiebale, 2016, 2013).

[7] Based on the OECD list of tax havens (OECD, 2021).

Figure 2. GFDIs (1997-2015)



Authors' elaborations

Table 1 provides information about investors' green intensity, measured as share of green patents in their patent portfolios, which allows us to distinguish between:

- multi-technology corporations with 50% or fewer green patents in their portfolio, which accounts for the majority of investors and investments;
- pure green players with more than 50% of their patents in renewable energies (Y02E subgroup), which accounts for around 25% of total investments.

Table 1 – Investors' green intensity (# and%)

	Firms	GFDI	Greenfield Investments	Acquisitions
Multi-technology corporations	375 (78)	923 (76)	683 (76)	240 (76)
Green pure players	103 (22)	294 (24)	219 (24)	75 (24)
Total	478 (100)	1217 (100)	902 (100)	315 (100)

Authors' elaborations

Table 2 presents investors' main technological specialization, defined as the largest number of patents in a particular green technology. It shows that the largest share of investment is in wind (33%), solar photovoltaic technologies (31%) and solar thermal technologies (16%). Among acquisitions, solar photovoltaic (30%) exceed wind technology (28%) investments.

Table 2. Distribution of GFDI based on investors' technological specialization (# and%)

Main technological specialization	GFDI	Greenfield Investments	Acquisitions
Wind	400 (32.9)	313 (34.7)	87 (27.6)
Solar photovoltaic	379 (31.1)	285 (31.6)	94 (29.8)
Solar thermal	195 (16.0)	138 (15.3)	57 (18.1)
Biofuel	95 (7.8)	60 (6.7)	35 (11.1)
Hydro	75 (6.2)	55 (6.1)	20 (6.3)
Waste	63 (5.2)	44 (4.9)	19 (6.0)
Geothermal	8 (0.7)	5 (0.6)	3 (1.0)
Marine	1 (0.1)	1 (0.1)	0 (0.0)
Solar hybrid	1 (0.1)	1 (10.1)	0 (0.0)
Total	1217 (100)	902 (100)	315 (100)

Authors' elaborations

3.2 Methodology

To investigate the causal effects of GFDI on investors' innovative performance, we consider four outputs calculated over the five years following the investment, at time t:

$$\ln(1+Y_{t+s})-\ln(1+Y_{t-1}), \text{ where } s=0,1,2,3,4,5.$$

The greening effect is measured as:

- green intensity, calculated as the share of renewable energy patents in the investor's total patents in a given year;
- green specialization is estimated using the Herfindahl index and is equal to 1 if the firm has applied for a green patent in only one technology and is zero if the firm has applied for patents in many different renewable energy technologies (Quintana-García and Benavides-Velasco, 2008).

Green innovativeness is estimated as:

- green patents, calculated as the investor's number of renewable energy patent applications in a given year (Amendolagine et al., 2018; Stiebale, 2016);
- forward citations, which is an indicator of patent value, measured as the average number of forward citations to the green patents applied for by an investor in a given year (Perri and Andersson, 2014; Phene and Almeida, 2008).

Estimation of the impact of FDIs on investors can be subject to endogeneity and reverse causality issues. Self- -selection is also a problem since larger, more efficient and more innovative firms are more likely to undertake FDIs (Helpman et al., 2004; Navaretti et al., 2010). In other words, the green patenting activity of MNEs with respect to firms without foreign investments might be independent of their decision to undertake such investments and might depend, instead, on the MNE's intrinsic characteristics (e.g., greater propensity for green patenting compared to other firms).

To address this potential selection bias, we test for FDI causal effects using propensity score matching combined with difference in differences estimators (Cozza et al., 2015; Debaere et al., 2010; Stiebale, 2016, 2013; Stiebale and Trax, 2011). Propensity score matching is used to build a counterfactual sample of companies without foreign investments but with similar *ex-ante* probabilities of engaging in FDI. To reset the conditions to random selection, these companies are representative of investors had they not engaged in GFDI activity (Navaretti et al., 2010).

The probability of FDI is estimated using a logit model, which yields the propensity scores used to match investors and non-investors, based on several firm characteristics, including controls for innovation activity before the investment. The results of the logit model (see Appendix B) confirm that companies undertaking GFDI have different *ex ante* characteristics with respect to other companies. They generally apply for more patents (and, especially, more green patents) and work on a range of green technologies, have greater international experience, are larger sized and, on average, are younger. We include in our counter sample only those non-investors that are similar to investors, that is, have similar probability of engaging in GFDI.[8]

Using a sample that includes both investors and non-investors, selected by propensity score matching, we estimate the causal impact of GFDI on investor patenting activity; we distinguish between cross-border acquisitions and greenfield investments. The equation is written as:

$$\Delta y_{i,j,x,t+s} = \alpha + \beta \, GFDI_{i,j,x,t} + \gamma_j + \delta_x + \vartheta_t + \varepsilon_{i,t},$$

where δ_x, ϑ_t, $\varepsilon_{i,t}$, and are fixed effects for investor industry, home country and year of investment.

4 Green foreign direct investment, greening effect and green innovativeness

The empirical analysis addresses three sets of research questions: first we investigate whether and how overseas green investment influences specialization and the variety of green patents; second, we examine the number and quality of the green patents filed by MNEs follow GFDI; third, we test for the different impact of greenfield investment and cross-border acquisitions.

[8] The effectiveness of the matching is shown by the results of covariate balance tests reported in Appendix B.

Table 3 presents the propensity score matching difference-in-difference results and allows comparison of the changes in average outcomes for the two groups of firms – investors and non-investors - during the period from year of investment (t = 0) to five years after investment (t = 1, 2,…,5). It presents the effects of investments on the greening effect, measured by green intensity and green specialization, and on green innovativeness, measured by green patents and forward citations. With exception of forward citations, all outputs have a significant positive coefficient, meaning that GFDI increases the likelihood of both the greening effect and green innovativeness, as discussed below.

Table 3. Propensity score matching difference-in-difference estimators

	t=0	t=1	t=2	t=3	t=4	t=5	#Obs.
Greening effect							
Green Intensity	0.0215	0.0522***	0.0517***	0.0366**	0.0234	0.0457***	5589
	(0.0138)	(0.0129)	(0.0146)	(0.0158)	(0.0174)	(0.0155)	
Green Specialization	0.0195	0.0549***	0.0575**	0.0552**	0.0328	0.0666***	5589
	(0.0206)	(0.0205)	(0.0237)	(0.0251)	(0.0257)	(0.0246)	
Green innovativeness							
Green Patents	0.1340***	0.2028***	0.2707***	0.3014***	0.3085***	0.3431***	5589
	(0.0411)	(0.0466)	(0.0582)	(0.0616)	(0.068)	(0.067)	
Forward Citations	0.0242	0.1134	0.1007	0.0483	0.0413	0.0681	5589
	(0.067)	(0.0730)	(0.0826)	(0.0830)	(0.0834)	(0.0755)	

Matching by kernel algorithm with common support.
Outputs equal to $\ln(1+Y_{t+s})-\ln(1+Y_{t-1})$, where s=0,1,2,3,4,5.
All regressions include fixed effects for investors country, investor NACE 2-digit sector and year of investment.
Standard errors are clustered at investor level and reported in parentheses.
* p-value< 0.10, ** p-value< 0.05, *** p-value 0.010.

4.1 Greening effect

Table 3 rows 1 and 2 present the outputs used to measure the greening effect - green intensity and green specialization - and the columns indicate how the impact of FDI on these two indicators changes over time from t=0 to t=5.

We find that GFDIs have a positive (and significant in year t= 1,2,3 and 5) impact on green intensity, which means that it increases the share of green patents in the investors' patent portfolio, that is, it increases green innovation activity in MNEs. This is a major contribution to the literature on global connectedness because it suggests that GFDI increases the greenness of MNE innovation activity and speeds the change to sustainable technologies.

This result is especially relevant in the context of the prevalence of multi-technology corporations in our sample (Aguilera-Caracuel et al., 2012; Rezende et al., 2019). Table 1 shows that almost 80% of investors do not focus exclusively on green technologies and, therefore, our finding indicates that

GFDIs enhance their green innovation capacity and their sustainability profile. This suggests that companies, such as Siemens, General Electric, Panasonic, Samsung and LG among others, that engage in GFDIs, engage also in more intensive green innovation activity. Maksimov et al. (2019), that what triggers MNEs' 'going green' and 'doing good' (investing in environmental innovation) profiles may differ. It should be noted that firms already engaged in green innovation (i.e., pure green players) increase their green innovation capability through overseas engagement. Multi-technology corporations' engagement in GFDI activities increases their green profile and accelerates the sustainability transition.

The results for green specialization show that GFDIs drive a focus on innovation in specific technological areas as opposed to expanding the range of their green technological efforts. That is, they deepen the MNE's competence in specific green technologies. This rejects our expectations, based on the evidence in the international business literature, and suggests that GFDIs help MNEs to deepen their innovation capabilities in the (few) technologies that are more likely to grow rapidly, such as solar or wind, in which they already have the majority of their green patents (see Appendix Table A.3). Previous empirical work on green innovation emphasizes that a major motivation for innovation is the need to adapt existing knowledge to consumers' needs and foreign markets' regulations (Chiarvesio et al., 2015; Noailly and Ryfisch, 2015). Therefore, our finding of increased specialization following GFDIs, suggest that innovation activity is driven by opportunities to exploit existing comparative advantages in knowledge and experience, aimed at expanding into new markets (Hanni et al., 2011).

4.2 Green innovativeness

Table 3 rows 3 and 4 show a positive and significant impact of GFDI on the number of green patents and a positive, but non-significant impact on the quality of the innovative activity (forward citations). We focus on the first output, which shows that the number of green patents applied for by investors increases significantly from the year of investment to five years after the investment (Chiarvesio et al., 2015; Melane-Lavado et al., 2018; Noailly and Ryfisch, 2015). This is an important finding considering that our sample includes firms with a green profile, so called pure green players, and, also, multi-technology corporations.

The learning process proposed in Hansen et al. (2020) provides qualitative support for these dynamics. In the case of a Danish company producing wind blades in India, they find that, initially, knowledge flowed exclusively from headquarters to subsidiary, but that, after some time, based on complementarities, the headquarters received knowledge from the subsidiary and knowledge flows became bi-directional. This qualitative evidence might explain the finding from econometric analyses, that it takes time for the headquarters to absorb and assimilate the knowledge acquired through investment activity.

4.3 FDI mode of entry

Table 4 presents modes of entry and shows that in the case of greenfield investments, the findings are similar to those for the full sample. We observe, also, that greenfield investments have a positive and significant impact on the value of investor patents, measured by average number of forward citations to patents produced four and five years after the investment. This suggests that GFDIs are motivated by a genuine intent to innovate rather than by a strategy aimed only at acquiring intellectual property rights (Stiebale, 2016).

These results do not hold for acquisitions; the coefficients are significant only for one output: green patents, which is significant only up to the first year after the investment. This implies that the impact of green acquisitions on the number of green patents has a very short-term effect, which is in line with our expectation that acquisition of existing firms is effective in the short run and can be an efficient means to enter a new green technology field. In particular, for multi-technology corporations, acquisitions of existing firms can provide a fast-track to embeddedness in clusters of excellence in environmental technologies and enable rapid access to relevant green innovation knowledge. This finding suggests that acquisitions are aimed, mainly, at acquiring technological assets with an immediate impact on the MNE's innovation capacity, but have limited impact on their longer-term innovation activity (Nocke and Yeaple, 2008).

Therefore, while greenfield investments seem to drive the general result about the dynamic effects discussed in Section 4.2 (see the case of the Danish wind company producing blades in a greenfield-type subsidiary in India), acquisitions offer quick wins, but provide fewer opportunities for knowledge access in the long run.

Table 4. Propensity score matching difference-in-difference estimators: Greenfield Investments and Acquisitions

		t=0	t=1	t=2	t=3	t=4	t=5	#Obs.
Greening effect								
Green Intensity	Greenfield Investments	0.0312	0.0440**	0.0599***	0.0562***	0.0563***	0.0632***	4232
		(0.0200)	(0.0190)	(0.0200)	(0.0191)	(0.0198)	(0.0182)	
	Acquisitions	0.0118	-0.0037	-0.0123	-0.0046	-0.0301	-0.0322	4211
		(0.0263)	(0.0249)	(0.0303)	(0.0281)	(0.0366)	(0.0329)	
Green Specialization	Greenfield Investments	0.0651**	0.0616**	0.0710**	0.1040***	0.0969***	0.1244***	4232
		(0.0264)	(0.0293)	(0.0303)	(0.0312)	(0.0316)	(0.0302)	
	Acquisitions	0.0049	0.0630	0.0082	0.0495	-0.0323	-0.0178	4211
		(0.0402)	(0.0427)	(0.0423)	(0.0457)	(0.0499)	(0.0528)	
Green innovativeness								
Green Patents	Greenfield Investments	0.1120**	0.1989***	0.2454***	0.3544***	0.3759***	0.4245***	4232
		(0.0464)	(0.0627)	(0.0719)	(0.0801)	(0.0894)	(0.0889)	
	Acquisitions	0.1459*	0.1895**	0.1220	0.1509	0.1102	0.0488	4211
		(0.0788)	(0.0862)	(0.0958)	(0.1014)	(0.1126)	(0.1146)	
Forward Citations	Greenfield Investments	0.0800	0.0238	0.1321	0.1405	0.1983**	0.2323***	4232
		(0.0840)	(0.1003)	(0.1022)	(0.0900)	(0.0950)	(0.0881)	
	Acquisitions	-0.0891	-0.0031	-0.2135	-0.2155	-0.3498*	-0.3535*	4211
		(0.1544)	(0.1788)	(0.1418)	(0.1780)	(0.1850)	(0.1967)	

Matching by kernel algorithm with common support.
The outputs are equal to $\ln(1+Y_{t+s})-\ln(1+Y_{t-1})$, where s=0,1,2,3,4,5.
All regressions include fixed effects for investor country, investor NACE 2-digit sector and year of investment.
Standard errors are clustered at investor level and reported in parentheses.
* p-value< 0.10, ** p-value< 0.05, *** p-value 0.010

5 Concluding discussion

MNEs are often associated with corporate environmental wrongdoing (Fiaschi et al., 2020; Giuliani, 2018) and often organize globally to avoid environmental regulations and use accumulated corporate power to sustain outdated technologies and slow the green transformation (Kolk and Pinkse, 2008; Smink et al., 2015). The influence of multinationals on green transformation is certainly complex and multifaceted and highlights the importance of our contribution on the role of GFDIs to the debate on whether and how multinational firms can reduce 'environmental harm' and increase 'environmental help' by more intensive sustainability-oriented innovation capabilities.

Our main findings are as follows. First, GFDIs enhance the 'greening' of the MNE’s overall technology base and increases specialization in specific green technologies. Second, GFDIs have a significant positive effect on the level of MNE innovation capacity in sustainability-oriented technology fields. Third, the internationalization mode matters: in the long run, newly established subsidiaries contribute more to innovativeness and greening than acquisitions of foreign firms.

Our results are generally positive and support our expectations about the beneficial relationship between internationalization and greening. These expectations were informed by the nascent academic literature which has recently begun to focus on MNE internationalization and greening (Aguilera-Caracuel et al., 2012; Maksimov et al., 2019), but not specifically on FDI. We contribute to this work by showing that foreign investments deepen sustainability-oriented innovation capabilities in MNEs and have a similar effect to other forms of internationalization. such as exporting and foreign licensing. These insights are relevant, also, for international organizations interested in GFDI, that have had to rely, so far, mainly on descriptive statistics (Golub et al., 2011; UNCTAD, 2016; UNEP, 2017).

It is not surprising that GFDIs increase the sustainability-orientation of pure green players, that is MNEs focused specifically on environmental technologies. It confirms the idea that any type of FDI supports MNE innovativeness (Amendolagine et al., 2018). Since the pure players in our sample are focused on green innovation, this effect is expected. However, our finding that GFDIs increase the overall sustainability focus in multi-technology corporations, which constitute the bulk of our sample, is novel. In particular, we show that GFDIs increase green specialization in these firms. Given that the world’s largest and most influential manufacturers are multi-technology firms, this insight is not trivial and is good news from a green transformation perspective. If large MNEs are increasingly focusing their innovation activities on making green technologies more efficient, affordable and accessible, their contribution to the green transformation will be remarkable.

Our study shows, also, that incremental internationalization is related to superior (more and better quality) green innovation compared to rapid internationalization. Firms that engage in GFDIs in the form of greenfield investments, file more green patents (and these patents are cited more) than firms whose GFDIs take the form of acquisitions of foreign green innovators. In other words, there may be few shortcuts to corporate greening efforts based on internationalization. Rather, corporate greening is more sustainable if built incrementally in foreign subsidiaries.

The impact of outward GFDIs on sustainability-oriented innovation has so far been overlooked by both policy makes and international business scholars, as a mechanism to support the green transformation. In the policy case, our findings suggest that governments should encourage and sustain internationalization in environmentally friendly domains to encourage the green transformation, and support decarbonization of energy systems in the specific domain of renewable energies. The potential impact on green innovation should be taken into account when implementing investment frameworks which have increased in recent years.

Future research could further investigate the differences between green pure players and multi technology corporations. In our analysis this is only a control dimension; further research should examine in more detail whether multi-technology MNEs behave significantly differently to green pure players and whether they have specific advantages in globally orientated green innovation. More research should be focused on the extent to which our results are dependent on the starting point of green specialization, and under what conditions is 'greening' of MNEs more effective.

It would be interesting, also, to analyze the reverse causality involved in home-host capabilities transfer in MNEs in more depth. Knowing more about the conditions under which subsidiaries are able to absorb investors' knowledge and develop their own innovative capabilities could help policy makers to maximize the gains from inward GFDIs. Adding key firm-level characteristics, such as absorptive capacity and green R&D intensity in foreign subsidiaries, would allow a better understanding of the micro-level mechanisms involved in knowledge transfer within MNEs and the spillover effects accruing to host countries and regions.

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Appendix A

Table A.1. GFDIs: home countries (# and %)

Country	GFDIs	Greenfield Investments	Acquisitions
Low/middle income country	69 (5.7)	44 (4.9)	25 (7.9)
High income country	1148 (94.3)	858 (95.1)	290 (92.1)
Germany	222 (18.2)	178 (19.7)	44 (14.0)
USA	170 (14)	104 (11.5)	66 (21.0)
Japan	126 (10.3)	105 (11.6)	21 (6.7)
Denmark	120 (9.9)	97 (10.7)	23 (7.3)
France	109 (9.0)	85 (9.4)	24 (7.6)
Spain	62 (5.1)	48 (5.3)	14 (4.4)
Italy	45 (3.7)	36 (4.0)	9 (2.9)
Taiwan	40 (3.3)	36 (4.0)	5 (1.3)
China	36 (3.0)	29 (3.2)	7 (2.2)
Others	287 (23.5)	184 (20.41)	102 (32.7)
Total	1217 (100)	902 (100)	315(100)

Authors' elaborations.

Table A.2. GFDIs destination (# and %)

	GFDIs	Greenfield Investments	Acquisitions
Low/middle income	341 (28.0)	294 (32.6)	47 (14.9)
High income	876 (72.0)	608 (67.4)	268 (85.1)
Europe and Central Asia	697 (57.3)	493 (54.7)	204 (64.8)
East Asia and Pacific	249 (20.5)	228 (25.3)	21 (6.7)
South Asia	80 (6.6)	74 (8.2)	6 (1.9)
Latin America and Caribbean	71 (5.8)	40 (4.3)	31 (9.8)
North America	97 (8.0)	48 (5.3)	49 (15.6)
MENA	13 (1.1)	10 (1.1)	3 (0.9)
SSA	10 (0.8)	9 (1)	1 (0.3)
UK	174 (14.3)	131 (14.5)	43 (13.6)
China	101 (8.3)	95 (10.5)	6 (1.9)
Germany	101 (8.3)	64 (7.1)	37 (11.8)
USA	87 (7.2)	43 (4.8)	44 (14.0)
India	80 (6.6)	74 (8.2)	6 (1.9)
Italy	44 (3.6)	25 (2.8)	19 (6.0)
Netherlands	44 (3.6)	37 (4.1)	7 (2.2)
Spain	41 (3.4)	31(3.4)	10 (3.2)
Australia	40 (3.3)	34 (3.8)	6 (1.9)
France	39 (3.2)	28 (3.1)	11(3.5)
Other countries	466 (38.3)	340 (37.7)	126 (40.0)
Total	1217 (100)	902 (100)	315 (100)

Authors' elaborations.

Table A.3. Applicants of green patents (# and %) (1970-2018)

First applicant	**Firms**	**MNEs**	**MNEs % of total**	**MNEs % of firms**	**Individuals**	**Universities**	**Others**	**Total**
Biofuel	12468 (50.1)	629	2.5	5.0	6440 (25.9)	3293 (13.2)	2690 (10.8)	24891 (7)
Geothermal	2642 (52.1)	105	2.1	4.0	1813 (35.8)	271 (5.3)	344 (6.8)	5070 (1)
Hydro	16225 (42.2)	5347	13.9	33.0	16603 (43.1)	1717 (4.5)	3932 (10.2)	38477 (11)
Marine	2240 (24.2)	1	0.0	0.0	4686 (50.6)	1401 (15.1)	935 (10.1)	9262 (3)
Solar hybrid	480 (42.8)	2	0.2	0.4	339 (30.2)	173 (15.4)	129 (11.5)	1121 (0)
Solar PV	78133 (72.6)	20942	19.5	26.8	12055 (11.2)	10242 (9.5)	7143 (6.6)	107573 (31)
Solar thermal	33699 (45.2)	898	1.2	2.7	30659 (41.1)	4318 (5.8)	5878 (7.9)	74554 (22)
Waste fuel	11790 (53.4)	1933	8.7	16.4	5976 (27.0)	2118 (9.6)	2211 (10.0)	22095 (6)
Wind	27221 (46.1)	9094	15.4	33.4	23413 (39.7)	4326 (7.3)	4055 (6.9)	59015 (17)
Total	184898 (54.0)	38951	11.4	21.1	101984 (29.8)	27859 (8.1)	27317 (8.0)	342058 (100)

Authors' elaborations

Appendix B

Logit analysis for the counterfactual sample

Table B.1 presents the variables included in the logit analysis to calculate propensity scores. The first set of regressors controls for firms innovation activity before the investment, and includes the following variables: a) log of total number of patents applied for by the investor between 1970 and one year before the investment (*Patent stock t-1*); b) log of number of green patents applied for one year before the investment (*Green patents t-1*); c) share of green patents in investor's patent portfolio, calculated as investor's total patent portfolio one year before the investment (*Green intensity stock t-1*); and d) technological concentration of green patents calculated as investor's total patent portfolio one year before the investment (*Green specialization stock t-1*).

We add other characteristics that might affect the choice to invest abroad, such as size[9] (*D middle size, D large size, D very large size*), investor age at investment year (*Age*), legal form (*D PLC*), past experience of FDIs (*FDI experience*), distinguishing between greenfield investments (*Greenfield investments experience*) and cross-border acquisitions (*Acquisitions experience*). Finally, to control for unobserved firm-level fixed effects (Blundell et al., 2002), we include firm innovation activity before 1997, which is the first year considered in our sample of investments (*Pre-sample patents* and D *pre-sample patents*).

Since our sample includes FDIs in different years, in order to assign counterfactual treatment dates to the firms included in the control group, we follow the procedure described in Chari et al. (2012) and adopt a proportional random investment time assignment approach to ensure that the counterfactual sample has the same time distribution as the investments in the treated group.

Table B.2 reports the results of the logit regressions to calculate the *ex-ante* probability to undertake FDI (*Model 1*), GFDI (*Model 2)* and green acquisitions (*Model 3*). The results show that the size of the patent portfolio and the number of green patents before investing increase the likelihood of GFDIs. The coefficient of technological concentration in green patents is negative and statistically significant, implying that more diversification across different green technologies boosts the probability of GFDIs. This might be explained by the exploratory nature of investments that are more likely to be undertaken by companies with more technologically diversified patent portfolios

[9] Following Orbis, very large companies are those that meet at least one of the following criteria: a) operating revenue larger than/equal to €100 m; b) total assets larger than/equal to €200 m; c) number of employees larger than/equal to 1000; d) listed company. Large companies are those that meet one of the following criteria: a) operating revenue larger than/equal to €10 m; b) total assets larger than/equal to €20 m; c) number of employees larger than/equal to 150. Medium companies are those that meet one of the following criteria: a) operating revenue larger than/equal to €1 m; b) total assets larger than/equal to €2 m; c) number of employees larger than/equal to 15.

(Quintana-García and Benavides-Velasco, 2008). The remaining results generally confirm the existing evidence and show that larger and younger firms, public limited companies and investors with previous experience are more likely to undertake GFDIs (Cozza et al., 2015; Stiebale, 2016; Stiebale and Trax, 2011).

The results of the logit models allow us to calculate propensity scores to match investors with non-investors with similar characteristics, through the kernel matching estimator with common support (Cozza et al., 2015).[10] To test whether the matching is successful, we ran t-tests on the differences in the mean values of the covariates between investors and non-investors, before and after the matching. We found that, after the matching, the differences in the covariate mean values became mostly non-significant. Tables B.3 and B.4 present the results of the t-tests.

[10] The matching uses the algorithm by Leuven and Sianesi (2003).

Table B.1. - The variables

Variable	Description	Mean	Standard Deviation	Min	Max
Patent stock t-1	Log of the # of patents between 1970 and 1 year before the investment	2.016	2.415	0	13194
Green patents t-1	Log of the # of green patents between 1970 and 1 year before the investment	0.220	0.676	0	6378
Green intensity stock t-1	Share of green patents in investors' total patent portfolio between 1970 and 1 year before the investment	0.240	0.369	0	1
Green specialization stock t-1	Herfindahl index measuring technological concentration of all green patents after 1970 and up to 1 year before the investment	0.468	0.474	0	1
D middle size	=1 if firm is middle size	0.245	0.430	0	1
D large size	=1 if firm is large size	0.182	0.386	0	1
D very large size	=1 if firm is very large size	0.293	0.455	0	1
Age	Difference between the year of the investment and the year of incorporation	2. 595	1. 203	0	5. 843
D PLC	=1 if the firm is a PLC	0.290	0.454	0	1
FDI Experience	Log of the # of foreign subsidiaries	0.566	1.817	0	10851
Greenfield investments experience	Log of the # of greenfield investments	0.427	1.283	0	7.113
Acquisitions experience	Log of the # of cross-border acquisitions	0.158	0.593	0	3.761
Pre-sample patents	Average # of patents applied before 1997	53.564	597.721	0	12024.81
D pre-sample patent	=1 if pre-sample patents >0	0.341	0.4742	0	1

Table B.2. - Logit models

	GFDIs (1)	Greenfield Investments (2)	Acquisitions (3)
Patent stock, t-1	0.1978***	0.1913***	0.1604**
	(0.0487)	(0.0544)	(0.0724)
Green patents, t-1	0.5633***	0.4877***	0.7573***
	(0.1281)	(0.1345)	(0.1711)
Green intensity stock, t-1	0.4614	0.4482	0.6185
	(0.2978)	(0.3448)	(0.4893)
Green specialization stock, t-1	-0.5658***	-0.6790***	-0.4436
	(0.2113)	(0.2377)	(0.3179)
D middle size	-0.0788	0.3167	-1.2224
	(0.6112)	(0.8433)	(1.1722)
D large size	1.8690***	1.9163**	1.9578***
	(0.5585)	(0.8294)	(0.6184)
D very large size	4.2920***	4.4347***	4.4049***
	(0.5447)	(0.7983)	(0.6270)
Age	-0.1818***	-0.2022***	-0.0932
	(0.0698)	(0.0764)	(0.1064)
D PLC	0.9745***	1.1310***	0.7159***
	(0.1791)	(0.2034)	(0.2396)
FDI experience	0.4267***		
	(0.0470)		
Greenfield FDIs experience		0.6054***	
		(0.0726)	
Acquisitions experience			1.3534***
			(0.2004)
Pre-sample patents	0.0006	0.0007	0.0004
	(0.0006)	(0.0006)	(0.0004)
D Pre-sample patents	-0.7567***	-0.6805***	-0.7345**
	(0.2276)	(0.2445)	(0.3346)
Constant	-2.1534*	-1.3496	-15.6909***
	(1.2812)	(1.4773)	(1.5753)
Observations	6833	6318	5698
ll	-1.1e+03	-8.8e+02	-4.1e+02

Output variables are dichotomous variables taking on values 1 in case of GFDI (model 1), greenfield investments (model 2) and acquisitions (model 3), and 0 otherwise.
All regressions include fixed effects for investor's country, investor's NACE 2-digit sector and year of investment.
Standard errors are clustered at investor level and reported in parentheses. * p-value< 0.10, ** p-value< 0.05, *** p-value 0.010.

Tab. B.3. Covariate balance test: GFDI

Variable		Mean		t-test	
		Treated	**Control**	**p>t**	**p>|t|**
Patent stock, t-1 (in abs.value)	U	4422	15955	37.88	0
	M	36083	37737	-0.86	0.392
Green patents, t-1	U	0.78012	0.12156	30.55	0
	M	0.38876	0.39044	-0.03	0.974
Green specialization stock, t-1	U	0.12565	0.25975	-10.78	0
	M	0.12083	0.10586	0.94	0.348
Green intensity stock, t-1	U	0.52515	0.46622	1.96	0.05
	M	0.51444	0.48234	0.76	0.451
D small size	U	0.01082	0.32634	-21.37	0
	M	0.02124	0.0272	-0.62	0.533
D middle size	U	0.01573	0.57428	-19.62	0
	M	0.03089	0.04336	-0.74	0.457
D large size	U	0.0413	0.20684	-12.77	0
	M	0.07143	0.07237	-0.06	0.953
D very large size	U	0.94002	0.17968	61.14	0
	M	0.89189	0.87874	0.66	0.507
Age	U	3228	2485	18.63	0
	M	30466	30877	-0.54	0.587
D PLC	U	0.79548	0.20186	43.47	0
	M	0.68919	0.72053	-1.11	0.269
FDI experience	U	27969	0.17645	49.42	0
	M	18302	19362	-0.59	0.556
Pre-sample patents	U	341.35	32413	16.99	0
	M	35338	32194	0.35	0.726
D Pre-sample patents	U	0.58899	0.29814	18.49	0
	M	0.51544	0.49702	0.59	0.554

U: Unmatched sample; M: Matched sample

Tab. B.4. Covariate balance test: Greenfield FDI and Acquisitions

Variable		Greenfield				Acquisitions			
		Mean		T-Test		Mean		T-Test	
		Treated	Control	p>t	p>|t|	Treated	Control	p>t	p>|t|
Patent stock, t-1 (in abs. value)	U	4.4629	1.6112	34.22	0	4.303	1.5777	22.41	0
	M	3.4482	3.4994	-0.19	0.851	3.4192	2.8701	1.30	0.196
Green patents, t-1	U	0.77585	0.12246	28.03	0	0.79257	0.12306	22.32	0
	M	0.35981	0.45478	-1.22	0.223	0.3725	0.30104	0.68	0.499
Green specialization stock, t-1	U	0.11529	0.2588	-10.08	0	0.15583	0.26218	-4.44	0
	M	0.11909	0.14355	-0.98	0.327	0.19749	0.17285	0.48	0.634
Green intensity stock, t-1	U	0.43816	0.46763	-1.6	0.11	0.52515	0.4701	1.81	0.071
	M	0.40033	0.41868	-0.47	0.641	0.56065	0.44871	1.57	0.119
D small size	U	0.00793	0.3253	-18.59	0	0.01923	0.3253	-10.51	0
	M	0.02362	0.03179	-0.56	0.576	0.06024	0.11629	-1.27	0.205
D middle size	U	0.01849	0.5758	-16.88	0	0.00769	0.5822	-10.19	0
	M	0.05512	0.06814	-0.42	0.672	0.0241	0.04434	-0.5	0.618
D large size	U	0.03699	0.20734	-11.39	0	0.05385	0.21037	-6.15	0
	M	0.10236	0.09834	0.15	0.88	0.10843	0.13175	-0.46	0.646
D very large size	U	0.94584	0.17946	53.68	0	0.92308	0.17323	31.57	0
	M	0.84646	0.83581	0.33	0.743	0.81928	0.72979	1.38	0.17
Age	U	3.2094	2.4886	15.85	0	3.2823	2.479	10.92	0
	M	3.0021	3.1492	-1.4	0.162	2.8736	2.8263	0.23	0.818
D PLC	U	0.8111	0.20176	39.3	0	0.75	0.19787	21.74	0
	M	0.66535	0.63429	0.73	0.464	0.56627	0.62817	-0.81	0.419
Greenfield experience	U	1.916	0.14581	45.06	0				
	M	11.644	13.201	-0.91	0.365				
Acquisitions experience	U					0.89995	0.02814	40.95	0
	M					0.28471	0.28186	0.03	0.979
Pre-sample patents	U	376.53	3.3676	17.45	0	238.9	3.1934	13.6	0
	M	32.274	29.642	0.2	0.844	14.101	17.585	-0.18	0.859
D Pre-sample patents	U	0.6037	0.29851	17.07	0	0.54615	0.2957	8.61	0
	M	0.5	0.46907	0.7	0.487	0.45783	0.39475	0.82	0.414

U: Unmatched sample; M: Matched sample