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Green Innovation Strategies, Innovation Success, and Firm Performance—Evidence from a Panel of Spanish Firms

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Abstract: This paper examines the effects of adopting types of green innovation strategies on a firm's innovation success and performance. The empirical analysis applies propensity score and kernel matching to a Spanish firm panel during 2008–2016. The results provide robust evidence that the pursuit of green innovation strategies increases a firm's innovation success in the form of higher turnover due to new-to-market, or radical product innovation compared with innovating firms that do not adopt green innovation strategies. However, despite this positive effect on the competitiveness of firms that adopt green innovation strategies, they are generally little able to benefit in terms of their performance. While the results suggest improvements in the labour productivity of firms that adopt general green innovation strategies, no effects are experienced by firms that adopt green product innovation strategies. Moreover, the results suggest the absence of any firm performance benefits in terms of turnover or employment growth. These findings indicate that markets do not provide 'win-win' situations, and policy intervention is critical to support green innovation strategies.

Keywords: green innovation; firm performance; innovation success; propensity score matching; Spain

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1. Introduction

In light of the importance of environmental degradation and climate change, firms and policymakers are increasingly aware of the importance of green innovation. The concept of green innovation refers to innovations in products, processes, or organisations with reduced environmental impact. The crucial contribution of green innovation to green growth [1,2] and the realisation of a sustainable economy is now well accepted [3]. However, while the economics of innovation and the environmental economics literatures find that regulation, technology push, and market pull drive green innovation, its effects on firm performance remain debated. This lack of consensus in the literature constitutes an important gap in knowledge: the higher complexity, uncertainty and costs of green innovation compared with other innovations, demanding a shift in organisational goals, practices and routines [4], may discourage investments in green innovation if these do not increase and possibly weaken the firm's performance in terms of growth, employment and productivity. This would necessitate policy intervention in order to counteract such missing or adverse market incentives.

Moreover, we know little about the effects of the adoption of green innovation strategies on the innovation success of firms that adopt green innovation strategies compared to firms that do not adopt green innovation strategies. This matters because if firms that adopt green innovation strategies were more successful in innovation than non-adopting innovators, due to the build-up of sustainability-oriented innovation capabilities [5], and nonetheless failed to realise better firm performance, this would be puzzling and warrant further policy stimuli.

Theoretically, the link between green innovation and firm performance in terms of turnover growth, employment growth, or labour productivity remains undetermined and is therefore an empirical question. For instance, positive growth returns from green innovation are linked to improvements in markets' evaluation of the firm, access to new markets, and cost reductions through increased resource efficiency (e.g., see the survey in [6]; see also [7,8]). In the short term, however, green innovation may lead to higher costs and hence lower growth returns (see also [9]). A U-shaped effect on firm performance has been found [10]. The link to employment may, for example, be negative if labour productivity increases, or positive if green innovation activities require additional investment or more specialized or better-qualified employees (e.g., [11,12]).

Although the recent literature review concludes that, overall, there is a positive empirical relationship between green innovation and economic performance, whereby analyzed measures of the latter include revenue growth, the review points out that green innovation shapes economic performance only moderately. Moreover, the association between green innovation and economic performance is weaker than that between green innovation and environmental, operational, or social performance [13]. The study also points to recent contradictory evidence of the association between green innovation and economic performance. Recent studies on the effects of green innovation on turnover growth, for instance, suggest that these effects may be positive [12] or negative [14]. Positive effects are observed with circular economy innovations, defined as those innovations that help to realize the objectives of sustainable development by targeting environmental economic, and social dimensions of sustainability [12]. The study applies quantile regressions to two waves, 2014 and 2016, of the German part of the Community Innovation Survey. Negative effects are found in a study on the influence of eco-innovation strategies, one of these being defined as 'develop services with lower environmental impact/output' [14]. The study employs the Heckman two-step estimation procedure and is based on a sample of Italian service sector firms, thus being one of the few studies that investigate the service sector. When differentiating between high-growth firms and non-high-growth firms, a more recent study reports that green innovation is positively associated with the sales growth rates only of high-growth firms [15]. A study using data on European small- and medium-sized enterprises (SMEs) observes a U-shaped relationship between eco-strategies and firms' sales growth, indicating that a greater breadth of eco-strategies is associated with better firm performance [16]. More specifically, using an ordered logit model, the analysis finds that there is a positive association between the eco-strategies of renewable energies, recycling or designing products that are easier to maintain, repair or reuse, and sales growth, whereas there is a negative association between the eco-strategies to reduce water or energy pollution and sales growth. Scarce evidence to date distinguishes between the effects of green product innovation and green process innovation on revenue growth, finding positive effects from the former and either positive or insignificant effects from the latter [17]. The study's results are based on a 2016 cross-section of European SMEs. Four types of eco-process innovation are used, replanning of water usage to minimize use and maximize reuse; using renewable energy; replanning energy usage to minimize use; and minimizing waste by recycling, reusing, or selling to another company. Eco-product innovation is measured by eco-innovations with a focus on redesigning products and services to minimize the use of materials or use recycled materials.

Similarly to the effects of green innovation on turnover growth, positive effects of green innovation on the employment level and employment growth are reported ([18], [12], respectively), whereas negative effects on employment growth [7] and insignificant effects of green process innovation on the employment level [18] are also found. Differentiating between 'clean' and 'dirty' industries, one study finds that the positive association between green innovation and employment is stronger for firms in dirty than in clean industries, based on data from the Spanish Technological Innovation Panel (PITEC) during 2007–2011 [18]. The study adopts a cross-sectional methodology with lagged values from earlier waves.

The evidence for labour productivity effects is similarly diverse. Some studies obtain a statistically insignificant effect on the growth of labour productivity measured as turnover per employee [4], while others obtain either insignificant or negative effects [14]. A positive effect on labour productivity is also found, for instance for two out of nine types of green innovation in a study using a cross-section of firms from the Irish part of the Community Innovation Survey [19]. The results are based on ordinary least squares estimation, taking account of endogeneity through an instrumental variables approach. The findings further suggest that one type of eco-innovation is negatively associated with labour productivity, whereas the remaining six types display no relationship with labour productivity. Thus, the study reflects the diverse evidence obtained in the current literature on the effects of eco-innovation on labour productivity.

This study contributes to this literature by examining the following research questions:

- Do firms that adopt green innovation strategies perform better or worse than firms that do not adopt green innovation strategies in terms of their innovation success and their turnover growth, employment growth, and labour productivity?
- Does the evidence differ between general green innovation strategies and green product innovation strategies?

In order to answer these questions, nonparametric propensity score and kernel matching estimators are employed, which have rarely been used in this literature to date, in order to control for endogeneity bias due to self-selection. These methods are applied to a panel of Spanish manufacturing and service sector firms for the period 2008–2016, whereby the sample period has been dictated by data availability. Innovation success is measured as the percentage of turnover due to, respectively, new-to-market and new-to-firm product innovation. The firm performance indicators used are turnover growth, employment growth, and labour productivity measured as turnover per employee.

This study relies on data from the PITEC survey. Spain is an interesting context within which to investigate the research questions at hand due to the increasing relevance of environmental issues for the Spanish economy and the uniqueness of the Spanish innovation structure [4,18]. Private-sector efforts and increasing policy pressures have been realised in order to promote sustainable development [18]. Moreover, the data available in the PITEC survey allow for a comparison of firms that adopt green innovation strategies versus firms that do not adopt green innovation strategies.

The results provide robust evidence that the pursuit of green innovation strategies increases the firm's innovation success in the form of higher turnover due to new-to-market, or radical, product innovation compared with innovators that do not pursue green innovation strategies. However, despite this positive effect on firms' competitiveness, they are generally little able to benefit in terms of their performance. While improvements in the labour productivity of firms that adopt general green innovation strategies are observed, no effects are experienced by firms that adopt green product innovation strategies. Moreover, the results suggest the absence of any firm performance benefits in terms of turnover or employment growth. These findings indicate that markets do not provide 'win-win' situations, and policy intervention is critical to support green innovation strategies.

2. Materials and Methods

2.1. Materials

The empirical analysis is based on data from the Spanish Panel of Technological Innovation (PITEC). The PITEC comprises data collected annually by the Innovation-in-Companies Survey and is Spain's input to the EU Community Innovation Survey. The PITEC is based on four samples targeting different firms' populations: a sample of larger firms listed on the Spanish Central Company Directory (DIRCE), firms with intramural R&D drawing on the Research Business Directory (DIRID), and two samples of smaller firms (with less than 200 employees) that report external R&D, but no intramural R&D expenditures, and that report no innovation expenditure. The PITEC dataset covers more than 12,000 firms. The analysis covers the period 2008–2016, reflecting the availability of our key variables. (The 2016 wave is the last wave of data that has been published by the National Statistics Institute, INE, for use by researchers.) Each of the nine waves covers a three-year period. The sample includes manufacturing as well as services innovators due to the importance of the services sector for green innovation [20].

Following a recent contribution to the green innovation literature [21], the key green innovation strategy variables are built by considering firms' innovation objectives that, on the basis of an ex post assessment (i.e., at the end of each three-year period) can be deemed green. Specifically, two categories of green innovation strategies are defined by linking firms' green innovation objectives to other manufacturing technologies [10]. First, a binary variable is created that takes on the value 1 if the firm has attributed high importance to the innovation objective of *reducing* its *environmental impact*. (The only difference to the variable definitions in [21] is that in the current analysis, a firm is categorised as having adopted an innovation objective if it attributed 'high' importance to the innovation objective rather than 'high or medium' importance as in the earlier study.) This variable constitutes the general green innovation strategy. Second, green process innovation strategies are removed from this variable to create the auxiliary variable *Other*, and then this latter variable is interacted with the innovation objectives of increasing market share and of entering new markets in order to create the variable *green product innovation–develop new products*. This variable constitutes the green product innovation strategy.

Finally, the PITEC also provides information on the outcome variables. Innovation success is measured as the percentage of turnover due to, respectively, new-to-market and new-to-firm product innovation. The firm performance indicators are turnover growth, employment growth, and labour productivity measured as turnover per employee. (The resource-based view of the firm [22–24] suggests specific competitive advantages, and thus, innovation success may also be viewed as a type of performance. I thank a referee for suggesting this point.) Table 1 provides the summary statistics for all variables.

2.2. Methods

In order to estimate the effect of a firm's pursuit of green innovation strategies on innovation success (*new-to-market* and *new-to-firm turnover*, respectively), and firm performance (*turnover growth*, *employment growth*, and *labour productivity*), a propensity score matching technique is employed [25]. This way, endogeneity bias due to self-selection into the treatment, i.e., the adoption of a green innovation strategy, is controlled for, based on observable covariates by comparing 'treated' firms (those firms that adopt a green innovation strategy) with similar 'untreated' firms (those firms that do not adopt a green innovation strategy) [26].

Since each wave of the data covers a three-year period, t, $t-1$ and $t-2$, the outcome variables—innovation success and firm performance—are measured at year $t + 3$ after the treatment, i.e., the pursuit of a green innovation strategy in order to avoid spurious correlations. Hence the average treatment effect on the treated (τ_{ATT}) may be expressed in terms of the innovation success or performance of firms that adopt a green innovation strategy at $t + 3$, $E\left(y^1_{t+3}\middle|\, S_t = 1\right)$, and the counterfactual of innovation success or performance for the same group of firms if they did not adopt a green innovation strategy, $E\left(y^0_{t+3}\middle|\, S_t = 1\right)$:

$$\tau_{ATT} = E\left(y^1_{t+3} - y^0_{t+3}\middle|\, S_t = 1\right) = E\left(y^1_{t+3}\middle|\, S_t = 1\right) - E\left(y^0_{t+3}\middle|\, S_t = 1\right) \quad (1)$$

where $S = 1$ (0) denotes the treated (untreated) group, and y denotes the outcome variable. The fundamental identification problem is that only one of the two possible cases is observed for each firm, i.e., whether the firm does—$E\left(y^1_{t+3}\middle|\, S_t = 1\right)$—or does not—$E\left(y^0_{t+3}\middle|\, S_t = 0\right)$—adopt a green innovation strategy. Hence a suitable control group of untreated firms is created, which is as similar as possible to the group of treated firms, based on the likelihood of receiving the treatment, i.e., the likelihood that a firm adopts a green innovation strategy [27].

Table 1. Summary statistics.

Variables	Definition	Obs	Mean	Std. Dev.
Reduce environmental impact	Innovation objective (IO), high importance (HI): Reduce environmental impact: yes = 1, no = 0	56,084	0.236	0.425
Other	*Reduce environmental impact* without green process innovators (i.e., interacted with medium, low or no importance IO: r Reduce energy or materials per unit of output produced)	56,084	0.125	0.331
Develop new green products	*Other* interacted with IO, HI: Increase market share or Enter new markets	56,084	0.106	0.307
New-to-market turnover	Percent turnover due to new-to-market product innovation	56,084	11.049	23.837
New-to-firm turnover	Percent turnover due to new-to-firm product innovation	56,084	15.362	28.534
Turnover growth	Annual growth in turnover	47,166	0.381	31.357
Employment growth	Annual growth in *Employment*	47,198	0.009	1.054
Labour productivity	Turnover divided by *Employment* (natural logarithm)	56,084	270900.8	1484883
Regulation	IO, high or medium importance (HMI): Comply with environmental or health and safety regulation	29,121	0.550	0.498
Funding	Binary indicator (BI): Firm received public innovation funding from regional, national or EU sources: yes = 1, no = 0	31,688	0.424	0.494
Exporter	BI: Firm is an exporter	31,688	0.723	0.448
Employment	Number of firm employees (natural logarithm)	31,688	4.343	1.614
Internal_R&D	BI: Firm invested in internal R&D	31,688	0.705	0.456
External_R&D	BI: Firm acquired external R&D	31,688	0.345	0.476
Existing_knowledge	BI: Firm acquired existing knowledge, e.g., from patents	31,688	0.027	0.161
Machinery	BI: Firm acquired machinery or equipment	31,688	0.202	0.402
Training	BI: Firm invested in training for innovative activities	31,688	0.167	0.373
Market_research	BI: Firm introduced innovations to market, including market research	31,688	0.260	0.438
Design	BI: Firm engaged in design activities	31,688	0.086	0.280
Cooperator	BI: Firm cooperated on innovation	29,121	0.438	0.496
Increase_range	IO, HMI: Increase product range	29,121	0.757	0.429
Increase_mkt_share	IO, HMI: Increase market share	29,121	0.715	0.451
Enter_new_mkt	IO, HMI: Enter new markets	29,121	0.693	0.461
Group	BI: Firm belongs to a group	31,688	0.471	0.499
Domestic	BI: Firm is a domestic enterprise	15,147	0.701	0.458

In creating the control group, a propensity score matching technique is used in order to select suitable controls from the group of untreated firms, whereby observed characteristics are matched as closely as possible to those of the treated firms before the treatment [25,26]. Using probit models, the propensity score, i.e., the probability that a firm adopts a green innovation strategy, is estimated based on a set of relevant observable characteristics identified in the green innovation literature (e.g., [4] and Table 2). The treated and untreated observations are then matched according to their estimated propensity score. A common support condition is imposed, dropping the treated and untreated observations whose propensity scores are larger or smaller than the maximum or minimum of the other category. Then the nearest-neighbour matching technique is applied with a strict caliper bandwidth, matching each treated observation only with the closest untreated observation within a 0.05 range in the propensity score. Table 2 reports the results of the balancing tests, verifying the consistency of the construction of the control group and the overall quality of the matching procedure for the sample of firms that pursue the general green innovation strategy of reducing their environmental impact. (The results for the green product innovation strategy are similar and available upon request.) The results from using kernel matching as an alternative matching estimator corroborate the robustness of the findings (Table A1).

Table 2. Propensity score estimation and matching average balancing test.

	Propensity Score		**Mean**		**Bias**	***t*-Test**	
	Coefficient	**(s.e.)**	**Treated**	**Control**	**%**	***t*-Value**	***p*-Value**
Regulation	0.568 ***	(0.040)	0.767	0.766	0.3	0.11	0.909
Funding	0.075 *	(0.041)	0.555	0.544	2.1	0.65	0.516
Exporter	0.064	(0.051)	0.817	0.819	−0.6	−0.21	0.834
Employment	0.084 ***	(0.014)	5.443	5.443	0.2	0.05	0.958
Internal_R&D	0.160 ***	(0.051)	0.833	0.833	2.0	0.69	0.493
External_R&D	0.034	(0.039)	0.516	0.516	0.3	0.10	0.923
External_knowledge	0.240 ***	(0.091)	0.057	0.057	−0.6	−0.17	0.862
Machinery	0.140 ***	(0.042)	0.298	0.230	−4.9	−1.45	0.147
Training	−0.005	(0.048)	0.217	0.212	1.3	0.37	0.709
Market_research	−0.003	(0.041)	0.347	0.348	−0.1	−0.03	0.973
Design	0.122 **	(0.060)	0.130	0.125	1.5	0.44	0.663
Cooperator	0.073 *	(0.038)	0.556	0.544	2.4	0.73	0.465
Increase_range	0.029	(0.050)	0.795	0.797	−0.4	−0.14	0.888
Increase_mkt_share	−0.073	(0.053)	0.763	0.761	0.6	0.21	0.835
Enter_new_mkt	0.122 ***	(0.051)	0.740	0.741	−0.2	−0.06	0.956
Group	0.330	(0.398)	0.998	0.998	1.2	0.38	0.705
Domestic	−0.083 **	(0.041)	0.678	0.679	−0.2	−0.07	0.945

R^2	*LR-chi^2*	*p>chi^2*	*MeanBias*	*MedBias*	*B*	*R*	*Obs Tr.*	*Obs Untr.*
0.004	21.36	1.000	1.5	1.1	14.9	1.18	1916	4529

Notes: Robust standard errors in parentheses [28]: *** $p < 1\%$; ** $p < 5\%$; * $p < 10\%$. The regressors are lagged by three years. *Mean*: mean value of each control variable for firms in the treated and control groups after matching. *Bias*: median standard bias across all covariates included in the probit estimation after matching. *T-test*: *t*-tests for the equality of mean values between treated and untreated firms in the matched sample. *Var. ratio*: variance ratio of residuals orthogonal to the linear index of the propensity score in the treated group. The bottom row presents summary statistics for the whole sample: pseudo-R-squared from the probit estimation, corresponding chi-squared statistic and *p*-value of likelihood-ratio test of joint significance of covariates; *mean bias* and *median bias* are summary indicators for the distribution of bias across the samples; *Rubin's B*: absolute standardized difference of means of a linear index for the propensity score in treated and matched non-treated groups. *Rubin's R*: ratio of treated to matched non-treated variances for the propensity score index.

It is also important to bear in mind the limitations of the methodology used. Although propensity score matching is widely used in innovation research due to its ability to deal with potential common support problems, it does not entirely reduce the concerns of unobservable factors explaining a firm's adoption of a green innovation strategy and the firm's performance. This methodology cannot establish the effect of the treatment beyond the eligible groups of the treated and untreated observations included in the analysis, which might potentially bias the estimation of the overall effect if these groups are not representative of the entire population.

3. Empirical Results

Table 2, column 2, shows the results from the propensity score estimation for the probability that a firm pursues the general green innovation strategy of reducing its environmental impact. The results are broadly in line with the literature. Public policy proxies of regulation and the receipt of public innovation funding have a significantly positive effect. Several technology-push variables also have positive effects, including internal R&D, external knowledge acquisition, acquisition of machinery and equipment, design innovation, and innovation cooperation. The objective to enter new markets exerts a positive market-pull effect. Finally, domestic firms are significantly less likely than foreign firms to pursue the strategy of reducing their environmental impact.

Table 3 presents the main results. First, the results provide robust evidence that the pursuit of a green innovation strategy increases a firm's innovation success compared with innovators that do not adopt a green innovation strategy. Both types of green innovation strategies are associated with 3.1–4.1% higher turnover due to new-to-market, or radical innovations than if no green innovation strategies were adopted. This outcome variable represents innovation commercialisation and is, therefore, arguably the most important measure of a firm's innovation success. It may also be considered one possible measure of innovation efficiency [29], which captures the potential innovation output and the transformational efficiency of innovation inputs [30,31]. Regarding turnover due to new-to-firm, or incremental innovations, this remains unaffected in the case of the general green innovation strategy, whereas it is significantly reduced in the case of the green product innovation strategy.

Table 3. Effect of green innovation strategies on firms' innovation success and firm performance compared with non-green innovators—nearest-neighbour matching results.

Innovation Success and Firm Performance Outcomes	**Green Innovation Strategies**	
	General Green Innovation: ***Reduce Environmental Impact***	**Green Product Innovation:** ***Develop New Products***
Innovation success:		
New-to-market turnover	0.041 ***	0.031 ***
	(0.008)	(0.012)
New-to-firm turnover	−0.004	−0.033 **
	(0.010)	(0.014)
Firm performance:		
Turnover growth	−0.027	−0.095
	(0.642)	(0.064)
Employment growth	−0.005	−0.001
	(0.008)	(0.011)
Labour productivity	0.067 *	−0.026
	(0.038)	(0.047)

Notes: Robust standard errors in parentheses [28]: *** $p<1\%$; ** $p < 5\%$; * $p < 10\%$. Number of observations: 3097–6445.

Second, firms that adopt the general green innovation strategy of reducing their environmental impact experience an increase in their labour productivity of 6.7% compared with firms that do not adopt a green innovation strategy, although this effect is statistically significant only at the 10% level. However, the pursuit of the green innovation strategy to develop new products is not associated with increased labour productivity. The disaggregation into two different types of green innovation strategies may, therefore, suggest one reason for the heterogeneity of results found in earlier studies that do not distinguish between different types of green innovation (e.g., [12,14]).

Third, the results suggest the absence of any firm performance benefits in terms of turnover growth or employment growth. This means that firms that adopt green innovation strategies do not benefit in terms of stronger, thus-measured business performance. These results compare with the either positive [12,14,18] or insignificant or negative [14,17,18] effects that have been found in previous research. Interestingly, this study's result of the insignificant effect of the pursuit of a green product innovation strategy contrasts with the disaggregated earlier result of positive effects of green product innovation in [17]. It is noteworthy here, however, that the present study focuses on innovation strategy rather than on innovation output as in the earlier study.

Fourth, in order to test whether the impact of the adoption of green innovation strategies on performance may run sequentially via the channel of innovation success, the individual treatment effects for the significant innovation success variable were calculated and parametric OLS regressions of the subsequent firm performance measures on the individual treatment effects were estimated. (Standard errors were clustered at the firm level. The results are available upon request). There were no statistically significant effects.

One possibility that might explain the puzzling result may be an inherent 'incompatibility' of manufacturing and service innovators. (I thank a referee for pointing this out.) Therefore, the analyses underlying Table 3 were repeated for the manufacturing and service subsamples separately, the industries of which are listed in Table 4. However, the results are generally consistent with the aggregate results presented in Table 3. (These results are available upon request).

Table 4. The manufacturing and services sectors included in the analysis.

Manufacturing sectors:
Petroleum products; food, beverages, and tobacco; textile; clothing; leather and footwear; wood and cork; pulp and paper; graphic arts and reproduction; chemicals; pharmaceuticals; rubber and plastic products; other non-metallic mineral products; metallurgy; metal; computers, electronic and optical products; electrical products; machinery and equipment not elsewhere classified; vehicles; shipbuilding; spaceship and aeroplanes; transport equipment not elsewhere classified; furniture; manufacturing not elsewhere classified; and machinery and repair.
Service sectors:
Agriculture, livestock and fishing; mining and quarrying; energy and water; waste management; construction; commerce; warehousing; accommodation; telecommunication; information technology; software development; finance and insurance; real estates; R&D; other activities; administrative services; education; social services; arts, recreation, and entertainment; and other services.

Hence overall, the analyses suggest that even though firms that adopt a green innovation strategy experience significant innovation success compared to innovators that do not adopt a green innovation strategy, there are few, if any, performance gains.

4. Conclusions

Recently, the concept of green growth [1,2] has taken centre stage in policy debates about sustainable economic development. The central tenet of this narrative is the economic opportunities arising from the pursuit of green growth. The World Bank's definition necessitates green innovation as the key enabler and driver of green growth [32]. However, in light of the complexities, uncertainties, and costs surrounding green innovation, what incentive do firms have to invest in it? One possibility, ceteris paribus, might be the potential for stronger competitiveness and firm performance as a result of the investment [7]. However, theory and empirical evidence remain inconclusive as to the effect of green innovation on firm performance. Therefore, this study, applying propensity score matching techniques, empirically tests whether firms that adopt green innovation strategies perform better or worse than innovators that do not adopt green innovation strategies in terms of their innovation success and their turnover growth, employment growth, and labour productivity. Furthermore, this study tests whether the evidence differs between general green innovation strategies and new-product-developing green innovation strategies.

Through the pursuit of green innovation strategies, firms build substantial 'green' capabilities [5]. Consistent with the dynamic capabilities literature which suggests that routines and accumulated knowledge in the form of environmental systems favour the adoption of more radical green innovation technologies, this study's results suggest that these green capabilities help firms that adopt a green innovation strategy to benefit from a higher turnover due to new-to-market, or radical innovation compared with innovators that do not adopt green innovation strategies. This implies the potential for disruptive innovations. The economic growth literature suggests that this entails the ability to spur economic growth and living standards beyond what we can expect from the pursuit of non-green innovation strategies alone.

However, it is puzzling that despite this positive effect on firms' competitiveness, they are overall little able to benefit in terms of their performance. Specifically, while the results suggest some improvements in the labour productivity of firms that adopt general green innovation strategies, no effects are experienced by firms that adopt green product innovation strategies. The absence of any positive turnover or employment growth effects suggests that current market incentives may not be sufficient to entice firms to adopt important green innovation strategies. That is, markets do not provide ‘win-win’ situations.

The results indicate that, on the one hand, environmental and innovation policy are critical for the design of policy measures to create the market incentives needed to encourage firms to invest in green innovation strategies. On the other hand, specific policies should offer direct stimulating support to enable successful green innovation. Newproductsdeveloping green product innovation strategies may, for instance, be supported by the procurement of new green products by governments to stimulate demand for new green products (cf. [33]).

Spain is ranked 12th in the world in terms of its capability to produce green products, and 3rd in terms of its future potential to do so [34]. Hence, there currently exists much untapped ‘green’ potential. Rather than expect that markets will provide ‘win-win’ situations, green industrial policy needs to shape markets and incentivize and support firms to increase their green production capabilities. This way, firms will be able to approach their full potential to capture green growth opportunities for the realisation of a sustainable economy.

It is also important to bear in mind the limitations of this study. First, the sample period ends in 2016 due to the lack of availability of more recent data. Therefore, the study cannot check whether the suggested puzzle remains standing more recently. Second, the study has been conducted using Spanish data. While it has been outlined why the Spanish case is a useful one to study, the results might not apply to other country settings, and this could be worthwhile testing in future research. In particular, Spain has seen private-sector efforts and increasing policy pressures to promote sustainable development. There may also be more recent data available for other countries. Third, for data availability reasons, this study examines the effect of green innovation strategies. Future research might explore innovation success and firm performance for green innovation input or output measures. Fourth, this study considers general green and green product innovation strategies. One interesting avenue for future research might be to disaggregate these further.

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Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Table A1. Effect of green innovation strategies on firms’ innovation success and firm performance compared with non-green innovators–kernel matching results.

Innovation Success and Firm Performance Outcomes	**Green Innovation Strategies**	
	General Green Innovation: ***Reduce Environmental Impact***	**Green Product Innovation:** ***Develop New Products***
Innovation success:		
New-to-market turnover	0.036 ***	0.040 ***
	(0.007)	(0.010)
New-to-firm turnover	−0.007	−0.019 *
	(0.009)	(0.011)

Table A1. *Cont.*

Innovation Success and Firm Performance Outcomes	Green Innovation Strategies	
	General Green Innovation: *Reduce Environmental Impact*	Green Product Innovation: *Develop New Products*
Firm performance:		
Turnover growth	−0.892	−0.637
	(1.789)	(1.877)
Employment growth	−0.010	−0.009
	(0.007)	(0.010)
Labour productivity	0.063 **	0.022
	(0.030)	(0.041)

Notes: *** $p < 1\%$; ** $p < 5\%$; * $p < 10\%$. Number of observations: 3097–6445.

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