Environmental innovations and firm's boundaries: evidence from two ecological industries in North–East Italy

Abstract

The paper investigates the eco–innovation (EI) impact of firms' outsourcing in ecological industries. Differently from "dirty industries", where outsourcing is typically driven by the search of cost–savings and is not respectful of environmental issues (e.g. the search for "pollution heavens" in offshoring strategies), in ecological ones it could/should be functional to the sustainability mission of their firms. This argument is tested with respect to a sample of firms operating in two ecological sectors (sustainable building and photovoltaics) in North–East Italy. The results of the empirical investigation support an "EI–friendly" use of outsourcing by ecological industries only limitedly. Externalising high value–added activities significantly decreases the firm's EIs, while a positive effect emerges only from outsourcing of ancillary activities. Agglomeration economies, which could potentially attenuate transaction costs, have only a limited role. An impact on firm's EIs appears also from its knowledge relationships with research organisations as well as from the production relationships with business partners that do not originate from an outsourcing decision. All this points to the role of the firm's capabilities for the sake of EIs and to the transactional problems that their externalisation could pose to the firm's environmental sustainability.

Keywords: environmental innovations; outsourcing; agglomeration.

JEL codes: Q55, 032, L23, L24.

1 Introduction

The interplay of globalisation and ICT advancements has made outsourcing a pervasive business strategy in the current economic scenario. "The procurement of products or services from sources that are external to the organisation" (Lankford and Parsa, 1999, p.310) is driven by several motivations, among which the search of cost–savings is dominant (Abraham and Taylor, 1996). Its impact is also manifold. Outsourcing can increase the firm's productivity and profitability, although its positive effect is conditional on an wide set of elements (e.g. firm's size internationalisation, own sector and that of the provider) (Olsen, 2006). The switch from "make" to "buy", and the ensuing decrease of the firm's vertical integration, also affects its innovativeness, through a combination of positive and negative effects (e.g. competence upgrading vs. knowledge leakages) that have attracted a lot of attention in economic and management studies. Overall, from different theoretical perspectives, the expected impact is negative, but the actual one is still dependent on the relevant context (e.g. on the kind of outsourced activity) (Mazzanti et al., 2007).

In this stream of research, the relationships between the firm's boundaries and its environmental performances have received rather little attention. An important exception is represented by the so called "pollution–heaven hypothesis" (PHH) (Mani and Wheeler, 1998): firms in "dirty industries" use international outsourcing (i.e. offshoring) to exploit cross–region/country asymmetries in environmental regulations and turn around the costs of a sustainable performance.

No evidence can instead be found on whether outsourcing affects the firm's capacity of introducing/adopting new environmental solutions in ecological industries (like, for example, sustainable building and photovoltaics), where the search for pollution heavens, or more in general of environmental cop outs, is not an issue. This is to us quite surprising, given the important role of "interactive drivers" in stimulating the firm's environmental innovations (EIs). Innovation co–operation with business partners and research organisations emerged as a significant driver (De Marchi, 2012; Cainelli et al., 2012). More in general, significant traces of an "open innovation" mode (Chesbrough, 2003) have been found, as the firm's knowledge sourcing and absorptive capacity seem to impact on EIs, although with important specifications (Ghisetti et al., 2013). These interactive drivers are strictly related with the firm's boundaries and with its organisation, as evolutionary and resource/competence based views of the firm have widely shown (Mahnke, 2001). Accordingly, outsourcing is a sensitive issue for the analysis of EI, and its neglect is thus quite unfortunate.

In this paper we try to fill this gap, by investigating the outsourcing decisions of firms in ecological industries and their impact on EI. In doing that, we test whether these firms make an "EI–friendly" use of their externalisation strategies, or whether the obstacles stressed by outsourcing theories bind their activities.

The test is performed on an original sample of 140 surveyed firms operating in two ecological sectors (sustainable building and photovoltaics) in 4 North–East Italy regions (Emilia Romagna, Friuli Venezia Giulia, Trentino Alto Adige and Veneto). This empirical setting, characterised by some of the most notable local production systems (i.e. industrial districts) of Italy, enables us to consider the role of agglomeration economies that regional and urban studies have found in investigating the drivers and the impact of outsourcing at the local level (Taymaz and Kiliçaslan, 2005).

The rest of the paper is organised as follows. In Section 2 we review the literature on outsourcing and innovation and try to extend its results to the case of EI, by putting forward our research hypotheses. In Section 3 we present the characteristics of our sample, the empirical application and the econometric strategy. Section 4 illustrates the results. Section 5 concludes with some comments on the relevance and on the possible future extension of our results.

2 Theoretical background

To the best of our knowledge, the only case of an environmental impact of outsourcing that received attention is represented by the PHH. In brief, through outsourcing, firms in "dirty industries" (e.g. with intense waste production) relocate production and/or trade of pollution–intensive goods from their "home" country to relatively less regulated ones (Jeppesen et al., 2002).[1] However, at a closer scrutiny, the PHH is not about the impact of outsourcing as such. But rather of the so–called "regulatory–drivers" of environmental performances and innovations (e.g. Horbach et al., 2012), and of their asymmetries across geographical zones with different levels of development (Dasgupta et al., 2000; Mani and Wheeler, 1998).

When outsourcing (and offhsoring, in particular) is more directly addressed, its role in transmitting environmental practices and green–knowledge spillovers (from the global to the local level, in particular) also emerges and tends to turn the PHH argument upside down (Christmann and Taylor, 2001). This is particularly so in "non–dirty" industries and in ecological (or "green") ones, whose technologies and production processes are inspired by the "decoupling" of the economic performance of their activities from their environmental impact (UNIDO, 2013).[2] In these cases, the PHH does not provide sensible insights about the role of outsourcing for the firms' objective of creating new ways of improving their environmental performance, in particular through their EIs. Other approaches need to be considered, which the extant literature of ecological and environmental (management) economics however does not directly provide.

At first sight, the nature of EIs themselves would seem to suggest that outsourcing is indeed an issue for their adoption. EIs are systemic innovations, not confined to the technological sphere, but also encompassing organisational

[1] In spite of the consistent debate it is attracting at the policy–level, the hypothesis has not found consistent empirical support yet (Brunnermeier and Levinson, 2004; Levinson and Taylor, 2008; Wagner and Timmins, 2009).

[2] Although this ecological/green character could in principle be pursued by any industry, nowadays the circle of those which accomplish with it encompasses, among the others, green building materials, water resources conservation, photovoltaics, and geothermal energy, just to mention the most relevant.

and service–based aspects.[3] The multi–faceted nature of EIs and the limited array of competencies firms have to deal with them, make external interactions particularly important for their introduction. In particular, innovative oriented industrial linkages and inter–firm networking can be as important drivers of EIs as of other innovations (e.g. technological and organisational).

However, the research on the "interactive drivers" of EIs is still scanty and mainly focused on research co–operation and knowledge sourcing, whose positive impact generally emerges in spite of some important qualifications and exceptions.[4] A specific analysis of the impact of outsourcing is instead missing, and calls for an eclectic review of the literature on outsourcing and technological innovations.

The standard paradigm in investigating this relationship points to contractual incompleteness (Grossman and Helpman, 2002), ownership allocation and efficient investments (Grossman and Hart, 1986), formal versus real authority (Aghion and Tirole, 1997) and, in general, the incentive conflicts entailed by contractual relationships (Foss, 2000). The most popular of these approaches is represented by transaction costs economics (TCE) (Williamson, 1975), according to which vertically integrated firms are generally superior to disintegrated ones in dealing with innovation (Robertson and Langlois, 1995). In brief, technological change usually relies on highly specific assets and is very uncertain. In the presence of opportunistic contractual relationships (e.g. outsourcing), it thus stimulates rent–seeking behaviours that hamper the efficiency level of the necessary investments. Furthermore, vertically integrated firms are also better equipped in managing the complementary assets and in coordinating the new and unrelated information entailed by innovation (Teece, 1986, 1980).[5]

In principle, nothing would prevent that TCE holds true also with respect to EIs, as outsourcing might be an obstacle for EIs. Investments with an environmental aim are very often location–specific (such as in the case of energy and raw materials reducing EIs) and can even be "dedicated" (in the TCE sense) to specific clients, who enter in the design of the new product and/or process with an environmental impact. In this way, EIs generate "quasi–rents" that even sustainable firms could be tempted to appropriate. However, in green sectors, business partners are generally committed towards environmental sustainability and, accordingly, often adopt voluntary and systemic corporate social responsibility practices (Cetindamar, 2007). This could somehow attenuate oppor-

[3]This appears evident from the most standard definition of EI as "the production, assimilation or exploitation of a product, production process, service or management or business methods that is novel to the firm [or organisation] and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives" (Kemp and Pontoglio, 2007, p.10).

[4]Among the few contributions, see Mazzanti and Zoboli (2009); De Marchi and Grandinetti (2013); De Marchi (2012); Cainelli et al. (2012); Ghisetti et al. (2013). More abundant is instead the literature on such standard drivers of EIs as "market–pull", "technology–push" and, above all, "regulation" effects (e.g. Horbach, 2008; Rehfeld et al., 2007; Rennings et al., 2006).

[5]To be sure, a positive correlation between innovativeness and outsourcing can be put forward by incorporating "governance inseparability" into TCE, in the way suggested by Argyres and Liebeskind (1999). On this issue, see Mazzanti et al. (2007).

tunistic behaviours by the firms and make outsourcing less exposed to hold–up problems. Further obstacles to the extension of TCE to EIs emerge by looking at the technological regimes of the green sectors, as represented by their conditions of innovation opportunities, appropriability, learning cumulativeness and nature of the relevant knowledge base (Malerba and Orsenigo, 1993). In a number of cases, these sectors actually operate in a Schumpeterian "Mark I" regime of creative destruction, in which knowledge and capabilities upgrading, also through outsourcing, become crucial, even at the risk of a certain knowledge leakage (Mahnke, 2001). Overall, even by sticking to the TCE logic, an "EI–friendly" use of outsourcing cannot be ruled out in ecological sectors.

In this last respect, more supportive insights come from a different theoretical perspective, represented by those resource–based and evolutionary approaches addressing the implications of outsourcing for the firms' capabilities and competences (Mahnke, 2001) and set the contractual analysis in 'real time' (Argyres and Liebeskind, 1999; Langlois, 1992). In this research stream, outsourcing is retained also as a channel through which firms can try to solve the trade–off between the "exploration" of new capabilities and the "exploitation" of their present ones (Leonard-Barton, 1992). By contracting out some of its economic activities, the firm can increase the number of its knowledge interfaces, thus increasing the opportunities of learning–by–interacting. In turn, this can have a positive impact on the solution of the "competence traps" that the path–dependence of its economic activities entails (Levinthal and March, 1993).

As we anticipated above, in the case of EIs, this cognitive role of outsourcing is possibly even more important.[6] The introduction of an EI requires the firm to deal with different techno–economic problems, whose solution is often contracted out to a different and/or more competent external provider.[7] In this last respect, the production relationships that firms establish with their business suppliers, especially in ecological industries organised into clusters (e.g. industrial districts), is as important as those of innovation co–operation they establish with research organisations (De Marchi, 2012; Cainelli et al., 2012).

According to a resource/competence–based view, environmental innovators thus seem to have margins for making an "EI–friendly" use of outsourcing. However, this is not guaranteed either. Also EIs, like standard technological innovations, can in fact be hampered if the outsourcer looses the capacity to manage the relationships between internal and external activities (Windrum et al., 2009). Along the same line, the outsourcer could be unable to undertake internal activities complementary to the outsourced ones, which are necessary for their innovative exploitation (McIvor, 2005).[8]

[6]The resource–based view of the firm has also been extended to the analysis of the firm's environmental performance — the so–called "natural resource–based view" (e.g. Hart, 1995; Russo and Fouts, 1997). However, the cognitive role of outsourcing to which we refer here has been hardly addressed within it.

[7]Carrillo-Hermosilla et al. (2010), for example, argue that EIs require knowledge pertaining to the "design", the "users' involvement", the "product–service", and the "governance" dimensions, that the firm rarely posses in a full–package.

[8]The former case often occurs in the case of long–term contracts of "total outsourcing", in which the control of the outsourced activities is entirely passed over to the provider.The

Although with these caveats, the research hypotheses that we put forward is that outsourcing has a positive impact on EIs in ecological sectors. However, a number of factors could affect it (e.g. specific sector of externalised and of actual EI activity) and need to be controlled for in the empirical analysis. First of all, as said above, this is the case of the explicit transfer of green–knowledge that occurs through the relationships that the focal firm entertains with research organisations producing basic and applied knowledge in the field, like universities and research institutes (De Marchi, 2012). Extremely important are also the interactions that the firm establishes with other business partners (Cainelli et al., 2012). Indeed, irrespective of an eventual shift from "make" (in–house) to "buy" (externally) — like the one captured by outsourcing — the firm can actually have relationships with other business players based on the division of labour in production — e.g. subcontracting — or based on co–operation agreements in specific phases of the production process. Also in these cases, EI–functional knowledge, embodied in the underlying production exchanges, can reach the focal firm. Furthermore, as the resource–based view of the firm has shown, knowledge exchange differs, whether firms are part of the same business group or not, as ownership ties can make the knowledge transmission more effective.

The geographical context in which the firms operate is also very important, because of agglomeration economies. As far as outsourcing is concerned, the presence of Marshallian externalities (Beaudry and Schiffauerova, 2009), has been found to positively moderate its economic impact in two ways. On the one hand, the manifold proximity — e.g. geographical and cognitive (Boschma, 2005) — implied by local specialisation economies reduces transportation costs, while the price of the externalised activities is lowered by local competition (Holl, 2008). On the other hand, the problems of opportunistic behaviours that prevent outsourcing from yielding its expected results in atomistic relationships can be attenuated, as Marshallian economies also entail a social proximity that induces trust among the business partners (Becattini, 1990). Also the role of Jacobs externalities, based on variety, has been found crucial (Beaudry and Schiffauerova, 2009). In particular, the presence of agglomerated firms that are active in different sectors has been found to increase their innovativeness — possibly more than Marshallian ones (Duranton and Puga, 2001) — as it allows for the cross–fertilisation of ideas and favours the recombination of existing knowledge (Frenken et al., 2007a).

While these ideas have been largely investigated in the case of technological innovations, their analysis in the case of EIs is nearly absent, and represents a further element of originality of the paper.

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latter instead is relevant in the opposite case of "partial outsourcing", when the control of the outsourced activity remains with the outsourcer. Both of them, have been found responsible of the so–called "productivity paradox" of outsourcing, in which its short–term advantages translate into disadvantages in the long run.

3 Empirical application

In order to investigate the relationship between outsourcing and EI we build upon a unique database comprising information for companies located in a limited area and being part of two ecological industries.

As for the geographical area, we focus on four administrative regions (NUTS 2) of the North–East of Italy: Emilia Romagna, Friuli Venezia Giulia, Trentino Alto Adige and Veneto. These regions constitute one of the most dynamic areas in the country, with levels and rates of growth of GDP above the national average, where agglomeration economies in the form of industrial districts have flourished since the period immediately after the Second World War (Brusco, 1982; Becattini, 2002). The focus on this group of regions is suitable to test our research hypotheses for three reasons. First, the area is characterized by a flexible specialisation system with a widespread presence of SMEs, where outsourcing of production stages is the norm (Brusco, 1982). Second, the area is characterized by the active integration of communities of people and populations of industrial firms, that make of social capital an important deterrent to opportunistic behaviours (Putnam et al., 1994). Third, the environmental performances of the North–East of Italy, although with some exceptions, are among the highest in the country.

In these 4 regions, we concentrate on sustainable building and photovoltaic industries: two ecological/green sectors that are also suitable for testing our research hypothesis (see Section 2). Sustainable building (also known as green construction) expands and complements the classical concerns of construction industry relative to economy, utility, durability, and comfort of buildings. In particular, sustainable building concentrates on structures and processes that are environmentally responsible and resource–efficient throughout the building's life–cycle: siting, design, construction, maintenance, renovation, and demolition (Anink et al., 1996). The photovoltaic industry instead belongs to the second–generation technologies of the renewable energy industry. It mainly consists of the production of solar cells that convert light into electricity. Photovoltaics industry in Italy has undergone through an impressive process of growth. Solar photovoltaic installations and capacity grew respectively of an impressive 123% and 185% in the 2007-2012 period (GSE, 2012).

3.1 Data

The sample used in this paper was extracted from an original database developed in 2011 by the joint effort of the Departments of Economics of the Universities of Bologna and Trento (Italy) within the OPENLOC research project (`http://www.openloc.eu/`). A survey was launched to collect information on the regional industries described in Section 3, by administering a structured questionnaire to the owners–managers of the relative firms. The questions concerned information on firms' structural characteristics — like sales and employees — on a number of dimensions of both their production and innovation processes (technological and non–technological), and on the relative outcomes.

In particular, a focus was placed on their interactions, by distinguishing their different typologies — e.g. production vs. knowledge exchanges — and their different partners — e.g. business players and research organisations.

Given the absence of a clear-cut definition industrial classification for sustainable building and photovoltaic industries, the firms' population has been identified by using different sources, in particular: (i) the registers of Italian chambers of commerce (CCIAA): (ii) the online Bureau Van Djik AIDA database: (iii) lists of participants to professional "green" exhibitions (Legno e Edilizia in Verona (17-20 March 2011), Ecocasa Expo in Reggio Emilia (3-6 March 2011), Impianti solari Expo in Parma (25-27 March 2011)) and (iv) a list of firms registered in industrial "green" associations (GIFI, ISES, APER, Habitech and GBC).

The resulting population included 931 companies. From it, a subset of 213 target firms was extracted. This subset was stratified according to the administrative region (the second level in the Nomenclature of Territorial Units for Statistics codes) of firm location and industry segment (mainly 16 and 27 NACE rev. 2 codes). The relative importance of these two industries from an ecological point of view can be gauged by the share of employment pertaining to "green" occupations within them. Although not available for the Statistical classification of economic activities in the European Community (NACE), the Bureau of Labor and Statistics provides the green goods and services private sector employment for the corresponding classes in the 2012 North American Classification System (NAICS).[9] We build a cross-walk between the two industrial classifications (from the four digit NAICS 2012 to the two digit NACE rev. 2 industrial classifications) and compute the share of total employment due to "green" occupations for the two relevant classes and compare it to the average share of employment for the overall manufacturing industry. While the overall manufacturing sector is characterised by a share of employment "green" in the order of 4.3%, biomaterials and photovoltaics have a share of 9% and 7.9% respectively.[10] Between October and December 2010, the owner–managers of the 213 target firms were contacted and were available for a telephone interview based on the questionnaire described earlier.

Full information was finally obtained for 140 out of these 213 firms. This final sample is representative of the overall population of the 931 companies by region and industry segment ($\chi^2[3] = 0.21$ and $\chi^2[1] = 2.6$, respectively). With respect to them, three sets of information are available for the period 2006-2010. First, information on their performance in terms of EIs, with a disaggregation of their typologies (e.g. pollution reducing vs. energy saving). Second, and crucially to our study, information on specific aspects of vertical organisation of firms' production — namely, their outsourcing decisions in the different activities of their value chain (e.g. cleaning services vs. human resource management). Finally, the database includes further useful information to control for the firms' availability of both direct (e.g. technology transfer) and indirect (e.g. co–

[9] Available at `http://www.bls.gov/green/`.

[10] Further details on the analyiss carried out to gauge the "green" weight of the two industries are available from the authors upon request.

operation in production) knowledge sources, for the agglomeration economies that can accrue from their geographical concentration and from the industry–variety of their local environment, as well as for their structural characteristics (e.g. size, age, etc.).

3.2 Econometric model and dependent variables

The dependent variable of our empirical exercise is the introduction of new (or significantly improved) environmental innovations (EIs). With respect to them the respondents of the OPENLOC survey were asked CIS–like (Community Innovation Survey) questions, addressing a set of different environmental benefits coming from product, process, service, organisational and marketing innovations.[11] More precisely, following the CIS 2006-2008, which for the first time comprehends a special environmental session, firms were asked about their EIs according to a definition consistent with that provided in Section 2 (footnote 3) and encompassing as many as 9 typologies of them, that is: (i) reduced material use per unit of output; (ii) reduced energy use per unit of output; (iii) reduced CO2 'footprint' (total CO2 production); (iv) replaced materials with less polluting or hazardous substitutes; (v) reduced soil, water, noise, or air pollution; (vi) recycled waste, water, or materials; (vii) reduced energy use; (viii) reduced air, water, soil or noise pollution; (ix) improved recycling of product after use.

We define *EcoInn*, as a dummy variable equal to 1 if the focal firm introduced any of these 9 types of EIs during the 2006-2010 period, and to 0 otherwise. Following the extant literature, we also distinguish among the 9 typologies those that can be treated as product rather than process EIs. With the dummy *EcoInn_Prod*, we identify whether the firm has obtained environmental benefits that can be referred to the after–sales use of its goods or services, that is EIs from (vii) to (ix). On the same token, we create the variable *EcoInn_Proc*, which takes value 1 if the firm has introduced environmental benefits during the production of goods or services, that is EIs from (i) to (vi), and takes value 0 otherwise.

The relationship between outsourcing and EIs is investigated by plugging the former among the factors that influence the probability of obtaining the latter, through the estimation of the following logit models:

$$P(Y_i = 1|X_i, Z_i) = \Lambda(X_i'\beta + Z_i'\delta)$$

where $\Lambda(z) = e^z/(1 + e^z)$ is the logistic function. Y_i is one of the three measures of innovation performance presented above (i.e., *EcoInn*, *EcoInn_Prod* and *EcoInn_Proc*), X_i is a vector of variables including measures of outsourcing activities carried out by firm i in the 2006-2010 period (see Section 3.3); Z_i indicates a series of firm–specific control variables.

As a robustness check, since product and process environmental innovations are not likely to be independent of each other, we conducted a bivariate probit

[11] For a review on innovation surveys, see Mairesse and Mohnen (2010)

analysis to capture the possible interdependence between these two outputs.

3.3 Independent and control variables

Our main independent variables are the firm's outsourcing decisions with respect to the 17 different activities that the OPENLOC survey distinguishes. Following previous work on outsourcing at the local level (Mazzanti et al., 2009), we build up three measures of outsourcing by grouping these 17 activities into 3 classes: (i) ancillary; (ii) production; and (iii) production supporting activities. The first one, *Out_Anc*, is a dummy variable taking value 1 if the firm outsourced any of the following "ancillary activities", which are accessory to the actual production process: inventories management, internal logistics, distribution logistics, cleaning services, plants maintenance, machinery maintenance, and data processing. The second outsourcing variable, *Out_OutProd*, measures (still with a dummy) the outsourcing decision of any of the retained "production activities", encompassing the supply of intermediate products, production stages, products & trademarks and other production activities. Finally, the dummy *Out_SupProd* refers to the externalisation decision of "production supporting activities", which are not primarily productive, but that contribute more directly to the production process than the former: marketing, engineering, research & development, labour consultancy, human resource management, and quality control.

As can be immediately appreciated, these 3 groups of activities have a different contribution to the firm's value added and their externalisation can thus be expected to have a different impact on its capabilities of innovating, and of eco–innovating in particular.

A set of other co–variates refers to the nature of the knowledge and production relationships that the firms in our sample establish with external agents. As we said, these have been recently found important in accounting for an open mode of eco–innovation. At first, we retain their explicit Knowledge Technology Transfers, by distinguishing with two dummies whether they benefited from them with respect to public organisations (like, universities and research institutes), $KTTPub$, and private business partners (suppliers, customers, and competitors), $KTTBus$, respectively. Secondly, we consider whether the firms in the sample established other production relationships than "pure outsourcing" — such as co–operation agreements on certain production stages, or subcontracting contracts with their providers — either with other independent market players, $ProdMkt$, or with players linked with them by some property relationship, *ProdPropr*, or with a mix of the two, $ProdMixed$. We then further segment the previous five types of relationships by assessing whether firms maintained them with only one external agent (unilateral relationship) or with two or more (multilateral relationship). Accordingly, we have created the following 9 dummies: unilateral public knowledge relationship ($KTTPub\_Uni$), multilateral public knowledge relationship ($KTTPub\_Multi$), unilateral business knowledge relationship ($KTTBus\_Uni$), multilateral business knowledge relationship ($KTTBus\_Multi$), unilateral market production relationship ($ProdMkt\_Uni$), multilateral market production relationship ($ProdMkt\_Multi$), unilateral proprietary production relationship ($ProdPropr\_Uni$),[12] unilateral mixed production relationship ($ProdMixed\_Uni$) and multilateral mixed production relationship ($ProdMixed\_Multi$). This last distinction is an important one, given the higher opportunities of rent–seeking behaviours that the presence of few partners naturally induces.

While the difference between the Out variables and the KTT ones appears evident, that between the former and the variables about the production relationships of the firms ($Prod$) deserves some comments. While the kind of knowledge transfer that occurs in the two cases can be substantially similar — and to a large extent related, if not even embodied, in the underlying production exchange — the production relationships of the second group do not involve any change in the firm's vertical scope and in its boundaries with respect to the market. In this last respect, the firm's outsourcing can be taken to be both more enabling — allowing the firm to substitute internal assets with more viable/efficient external ones — and more problematic — involving a loss of control on previously owned activities. On this basis, their distinction appears an important one to retain. Moreover, by including these variables we try to control for a potential problem of omitted variable bias, as the relationship between outsourcing and eco-innovation is likely to be influenced by production and knowledge relationships.

In order to consider the role of agglomeration economies, we have built up two sets of proxies. First of all, we included a set of variables ($Num2km$, $Num2\_15km$ and $Num15\_22km$), which refer to the natural logarithm (plus one) of the number of sample firms that are located within a certain distance from firm i (within 2 km, in-between 2 and 15 km, and in-between 15 and 22 km, respectively).[13] Given the pervasive presence of industrial districts in the North–East of Italy, we take this geographical proximity as sufficient evidence of the Marshallian economies that characterise them. As for the presence of Jacobs externalities, instead, and of their eventual role in spurring EIs through the firm's variety, we have extended Frenken et al. (2007b) approach and, for each industry–province, is, we calculated the entropy of the workers shares held by the j sectors of the same province (s) other than i. $Entropy_{is}$ is defined as $-\sum_{j \neq i} p_{js} log_2(p_{js})$ where p_{js} is the share of employment in industry $j \neq i$ and province s. In both cases, should the relative agglomerations economies be significant in favouring the firm's EIs, their role in attenuating the transactional problems that outsourcing is expected to have in atomistic business environments, and their moderation of the EI impact of outsourcing should be controlled.

In addition to our key explanatory variables, we have included a number of controls on firms' characteristics. First, we inserted a variable measuring the

[12]As no firm entertains a multilateral proprietary production relationship, the relative variable is not present.

[13]These distances have been selected by crossing previous studies on the same geographical area (Cainelli and Iacobucci, 2010), with the direct observation of its specific firm density. Robustness checks on alternative distances are available from the authors at request.

R&D intensity of the firm, which is defined as the logarithm of R&D share of sales (plus one) in the 2006-2010 period ($ShareRD\_Exp$). Second, a variable related to firm size measured as the natural logarithm of the total turnover (plus one) in the 2006-2010 period ($LTurnover$) is inserted. We also included a variable representing the international orientation of the firm ($LSalesShareExp$), defined as the logarithm of the shares of exports in sales (plus one) in the 2006-2010 period. $LAge$ represents the logarithm of firm age (plus one) in 2010. Finally, as we hypothesise that the resource endowment of a firm would be important in determining the firm's ability to eco–innovate, we also controlled for the enterprise physical capital. We thus define $LGrossInvExpXEmpl$ as the logarithm of gross investment expenditure per employee (plus one) in the 2006-2010 period.

Finally, a set of variables to control for the effect of industrial and geographical specificities has been included. The sectoral dummy $Sector$ takes value 1 when firm i belongs to sustainable building industry and 0 when it belongs to photovoltaic industry. The geographical dummies have been defined taking into account the location of companies in the four regions: Emilia Romagna ($Geo1$), Friuli Venezia Giulia ($Geo2$), Trentino Alto Adige ($Geo3$) and Veneto ($Geo4$).

Table 1 provides the descriptive statistics of the variables defined above. Table 2 reports the correlation matrix for the independent regressors, from which it can be inferred, since the correlation across the independent variables is low, the absence of any relevant problems of multi–collinearity.

4 Results

Table 3 contains the results on the firm's propensity of eco-innovating in general terms (specificatin [1]), product eco-innovation (specification [2]) and process eco-innovation (specification [3]). Overall, our research hypothesis about an "EI–friendly" use of outsourcing does not seem to be confirmed. On the contrary, the externalisation of the activities with the highest value–added for the firm, that is $Out\_SupProd$, has a significant negative impact on its EIs in all the model specifications. Taking the decision to externalise "production supporting activities" brings a reduction of 36.8% in the likelihood of carrying out eco-innovation (29.3% and 34.5% for product and process EIs respectively). This suggests that, even in ecological industries, the outsourcing of the relative assets could be exposed to problems of hold–up (following the TCE logic) and/or, following a competence perspective, that their externalisation could entail a loss of control on resources that are pivotal for the firm's EI. The only traces of a positive impact emerges, though weakly, from the outsourcing of ancillary activities (Out_Anc) and in the case of product eco-innovation (specification [2]). With respect to these, firms could benefit from an internal re–skilling of their workforce on more EI sensitive tasks, being their externalisation less exposed to opportunistic behaviours, given their generic nature. All in all, the strategic recommendation for increasing the firm's eco–innovative profile in (these two) green sectors is to stay vertically integrated.

The only relevant differences among the three specifications of Table 3 seem to refer to the role of different outsourcing activities on product EIs. Indeed, not only is the externalisation of production supporting activities ($Out\_SupProd$) problematic for their adoption, as in the general case, but this is also true for the outsourcing of production activities as such, although less significantly ($Out\_OutProd$). In other words, when the firm aims at introducing an EI whose impact can be deemed more tangible in the market, its degree of vertical integration appears even more binding. The loss of control on production stages (such as the supply of intermediary goods) could also entail a loss of competencies that are crucial for the implementation of a new green–product. From a different perspective, the accomplishment of such a product could increase the degree of specificity of the relative investments along its whole value–chain.

The analysis of the other production–based relationships reveals that the shift from "make" to "buy" is actually what makes their EI impact problematic. Indeed, when the firm interacts with other business players by keeping its vertical scope unaltered, adding new production–embodied/linked knowledge to its existing one, rather than substituting between the two, its EI capacity significantly increases. In other words, entering into the value–chain of the local system, by keeping the coherence of the internal value–chain, is a plus in terms of EIs. To be sure, this is so when the production relationships occur unilaterally with an independent market player ($ProdMkt\_Uni$), while multilateral ones do not have a significant impact, possibly because of the firm's incapacity of making an effective use of the too diverse production experiences of its partners. Still, when they occur with a unique firm, which is linked to the focal one by ownership ties ($ProdPror\_Uni$), and thus part of the same business group, these production relationships can even create redundant information signals, whose EI impact, also in the presence of higher administration costs, turns out to be negative. In brief, the network of production relationships in which firms are typically embedded in the investigated regions acts as vehicle of learning–by–interacting in the green realm. However, that occurs providing these production relationships do not substitute the ones the firm manages internally and providing they are maintained with individual (possibly dedicated) partners, whose ownership independence generates actual sources of brand–new knowledge.

The relevance of univocal, and thus possibly dedicated, relationships emerges also with respect to the standard forms of knowledge transfer that the firms receive from public research organisations ($KTTPub\_Uni$). With this specification, the evidence recently obtained at the European level (mainly from CIS data) about the positive EI impact of research co–operation gets confirmed in the present context too. Conversely, explicit knowledge transfer from business partners do not impact on the receiving firm's EIs ($KTTBus$), suggesting that an underlying production relationship is necessary for green knowledge to be effectively transferred in the business realm.

Coming to the role of agglomeration economies, quite surprisingly, when we think of the case of technological innovations, the variety of the industrial context in which the firms operate does not help *per se* in eco–innovating. Jacobs externalities are (weakly) negative in the two sectors at stake (*Entropy*), suggesting that a green–related kind of variety could be necessary for the cross–fertilisation of knowledge among sectors not to be an obstacle for eco–innovating: variety, in general, is not a green asset. Marshallian externalities also emerge like diseconomies, when firms are agglomerated in the immediate neighbours of the focal one ($Num2km$) and quite apart from it ($Num15\_22km$): in the former case, a congestion on the local factors of production/innovation can be the explanation, while in the latter the advantages of proximity could fade away and be more than compensated by a competition effect. In between these two extremes, however, co–location makes the firm in the sample more eco–innovative, providing a qualified kind of support to the case of the green clusters.

It is also interesting to notice that the more eco–innovative firms are the younger of the sample ($LAge$ significantly negative), but also the larger ($LTurnover$ significantly positive). In (these two) ecological sectors, the so–called "liability of newness" does not appear to be an obstacle to EI, while there are traces of a "liability of smallness" in the same respect. With respect to firms in the photovoltaic industries, those in sustainable building ($Sector1$) seem to have a disadvantage in EI. On the contrary, the firms located in Veneto ($Geo4$) show an advantage when Emilia Romagna ($Geo1$) is considered a benchmark.

Tables 4, 5 and 6 report the results containing the interaction effects between $Out_SupProd$ and our measures of diversity (*Entropy*) and agglomeration ($Num2km$, $Num2\_15km$ and $Num15\_22$). It is extremely interesting to notice that, with the exception of one of the 3 distances, the physical proximity to other firms seems to bring in other forms of proximities (in particular, social and institutional), which remedy the problems of outsourcing production supporting activities ($Out\_SupProd$). It seems that, even when the problems of too little ($Num15\_22km$) and too much ($Num2km$) proximity can be ruled out, the co–location with other firms neither helps nor damages the introduction of new green–products.[14] In this latter case, the relevant knowledge might be of more codified nature and thus be conveyed to the firm by more explicit forms of knowledge transfer. Indeed, this is also confirmed by the replication of the results we have obtained from the general impact of the green–knowledge produced by public research organisations ($KTTPub\_Uni$).

As the interpretation of interaction effects in non-linear models can be problematic, we follow previous studies (Ai and Norton, 2003; Buis, 2010) and compute the interaction effects for each observation in our sample. Figures 1 and 2 show the statistical significance of the interaction effects by plotting the z-statistic for each observation against the predicted value (according to specification [2] and [4] in table 4). Graphs show that the portion of observations with a fitted probability of carrying out eco-innovation ranging between 0.4 to 0.8 present statistically significant interaction terms.[15] We interpret this as a confirmation of the results presented in the above paragraph.

[14] This result requires us to be cautious in retaining the significant impact of their interaction with $Out\_SupProd$.

[15] Similar results are obtained of product and process EIs. These are available from the authors upon request.

As we said in Section 3.2, as a robustness exercise we have also used a bivariate probit procedure, in order to capture the possible interdependence between product and process EIs, as they are not likely to be independent of each other.[16]

The bivariate probit estimation (Table A1 in the appendix) confirms the overall results of our previous regressions, with a particular emphasis on the negative effects of outsourcing, that is now confirmed for both product and process EIs wit respect to production supporting activities ($Out\_SupProd$), while that of production activities as such (Out_Prod) appears only in the case of product ones. Interesting confirmations emerge also for the knowledge exchanges with public organisations, for the role of (non externalised) production relationships, and for the characteristics of the eco–innovative firms (young and big). Less significant, but still consistent in sign, appear the results regarding agglomeration externalities.

5 Concluding remarks

Even when PHH is not taken into account, and only eco–sustainable sectors are considered, outsourcing does not appear to have a fully supportive role in spurring environmental innovation. On the contrary, the externalisation of activities that can be deemed core for the adoption of EIs — such as R&D, training and human resource management — even decrease the firm's propensity of eco–innovating, and the same occurs for that of production activities in the case of product EIs. Finally, even the effects of a possible EI re–skilling of the firm's workforce in consequence of the outsourcing of ancillary activities appear scanty, and disappear in the case of process EIs.

It appears that firms in ecological sectors are not able to make an EI–friendly use of their outsourcing practices, unless these are carried out in the presence of a qualified form of agglomeration economies (i.e., of Marshallian economies with a certain degree of co–location). This latter consideration suggests that, out of the two possible explanations of the result, rooted in TCE and in the resource–based view of the firm, respectively, the former could have a higher explicative role. While outsourcing could break up the complementarity between the firm's competencies, the risks of opportunistic behaviours induced by specific green–assets could have an even greater damping effect on the firm's EI.

Indeed, deverticalisation appears in our case problematic, as production relationships between business partners have a positive impact, providing they do not change the firm's vertical scope. As we pointed out, in order to benefit from the division of labour prevailing within these particular local labour systems, firms need to stay vertically integrated. This last insight is particularly important when we think of the advantages that larger firms have shown in the adoption of EIs.

[16] This lack of independence is confirmed statistically by the extemely high value of the correlation coefficient between the error terms in the two equations ($rho = 0.92$).

Another key element to stress is related to the fact that in these local contexts, knowledge transfer with public research organisations emerges as important for EIs as elsewhere, providing it is not bothered by an excessive number of external sources. This is also the case of production–based relationships that spur EIs as long as they are univocal and between independent business units. The need of dedicated knowledge exchanges thus seems to emerge as another general result of our empirical application.

A last conclusive remark is due for the role of agglomeration economies with respect to EIs. Quite surprisingly, variety by itself does not represent a plus for eco–innovation, but rather turns out to be a possible source of redundancy in information flows. Similarly, the co–location (and possible co–specialisation) of the firms in a limited portion of the territory does not help them in eco–innovating, unless the problems of a too little and too much proximity are ruled out.

Table 1: Descriptive statistics

Variable	Mean	SD	Min	Max
EcoInn	0.36	0.48	0	1
EcoInn_Prod	0.32	0.47	0	1
EcoInn_Proc	0.34	0.48	0	1
Out_Anc	0.04	0.20	0	1
Out_Prod	0.12	0.33	0	1
Out_SupProd	0.06	0.23	0	1
KTTBus_Uni	0.13	0.34	0	1
KTTBus_Multi	0.11	0.32	0	1
KTTPub_Uni	0.15	0.36	0	1
KTTPub_Multi	0.05	0.22	0	1
ProdMkt_Uni	0.04	0.19	0	1
ProdMkt_Multi	0.06	0.23	0	1
ProdPropr_Uni	0.03	0.17	0	1
ProdMixed_Uni	0.02	0.15	0	1
ProdMixed_Multi	0.05	0.22	0	1
ShareRD_Exp	0.25	1.02	0	8.58
LAge	2.69	0.76	0.69	4.80
LGrossInvExpXEmpl	3.88	1.44	0	9.09
LTurnover	14.49	1.17	11.51	18.15
LSalesShareExp	0.93	1.46	0	4.56
Entropy	4.99	0.12	4.50	5.13
Num2km	0.93	0.38	0.69	2.08
Num2_15km	0.68	0.64	0	2.08
Num15_22km	2.16	0.86	0	3.43
Sector1	0.91	0.28	0	1
Geo1	0.24	0.43	0	1
Geo2	0.14	0.34	0	1
Geo3	0.19	0.39	0	1
Geo4	0.44	0.50	0	1

Table 2: Correlational table

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
(1)	Out_Anc	1																									
(2)	Out_Prod	0.25	1																								
(3)	Out_SupProd	0.40	0.38	1																							
(4)	KTTBus_Uni	0.02	0.25	0.18	1																						
(5)	KTTBus_Multi	-0.08	-0.06	0.01	-0.14	1																					
(6)	KTTPub_Uni	0.11	0.15	0.24	0.14	0.10	1																				
(7)	KTTPub_Multi	-0.05	0.22	-0.06	0.11	0.23	-0.10	1																			
(8)	ProdMkt_Uni	0.15	0.05	0.28	-0.07	-0.07	-0.08	-0.04	1																		
(9)	ProdMkt_Multi	-0.05	0.10	-0.06	-0.09	0.20	0.07	0.08	-0.05	1																	
(10)	ProdPropr_Uni	-0.04	0.07	0.14	0.06	-0.06	0.17	-0.04	0.43	0.14	1																
(11)	ProdMixed_Uni	0.46	0.10	0.18	0.09	-0.05	0.21	-0.03	-0.03	-0.04	-0.03	1															
(12)	ProdMixed_Multi	-0.05	0.22	0.08	-0.09	0.12	0.09	0.10	-0.04	0.51	0.16	-0.03	1														
(13)	ShareRD_Exp	-0.02	-0.06	-0.03	0.00	-0.03	0.24	0.01	-0.05	-0.06	-0.04	0.01	-0.05	1													
(14)	LAge	-0.01	0.15	-0.11	-0.12	-0.05	0.05	0.02	-0.13	0.09	-0.19	-0.04	0.00	-0.13	1												
(15)	LGrossInvExpxEmpl	-0.05	-0.04	0.05	-0.12	0.09	0.13	0.07	0.01	0.07	0.01	0.00	-0.02	0.03	0.12	1											
(16)	LTurnover	0.10	0.20	0.08	-0.13	-0.07	0.15	0.09	0.06	0.16	0.10	-0.02	0.07	-0.14	0.34	0.12	1										
(17)	LSalesShareExp	-0.05	-0.14	-0.05	-0.08	0.07	0.01	-0.02	0.03	0.10	-0.04	0.00	0.08	0.27	-0.02	0.07	0.22	1									
(18)	Entropy	-0.03	0.21	0.05	0.22	-0.08	-0.12	0.04	-0.04	-0.14	-0.11	0.06	-0.07	-0.19	-0.05	-0.01	-0.19	-0.08	1								
(19)	Num2km	0.06	0.06	-0.07	-0.12	-0.06	-0.07	0.00	-0.12	0.10	-0.11	0.17	-0.02	-0.01	-0.02	0.00	-0.11	0.05	0.22	1							
(20)	Num15km	-0.01	0.03	0.10	-0.01	-0.13	-0.07	-0.03	0.14	0.04	0.02	-0.02	0.04	0.02	0.10	-0.05	0.07	0.03	0.12	-0.15	1						
(21)	Num22km	-0.07	-0.06	0.00	-0.12	-0.17	-0.29	-0.11	0.04	-0.03	-0.12	0.00	0.03	-0.01	0.00	-0.04	-0.17	-0.02	0.24	0.35	0.41	1					
(22)	Sector1	-0.06	0.04	-0.14	-0.11	-0.13	-0.16	-0.16	-0.22	0.08	-0.25	0.05	0.07	-0.08	0.33	-0.12	0.03	-0.09	-0.10	0.01	0.05	0.12	1				
(23)	Sector2	0.06	-0.04	0.14	0.11	0.13	0.16	0.16	0.22	-0.08	0.25	-0.05	-0.07	0.08	-0.33	0.12	-0.03	0.09	0.10	-0.01	-0.05	-0.12	-1	1			
(24)	Geo1	-0.03	0.00	0.08	0.04	0.07	0.10	0.10	0.17	0.01	0.11	0.03	0.10	0.08	-0.12	-0.07	0.02	-0.01	-0.06	-0.28	-0.22	-0.35	-0.19	0.19	1		
(25)	Geo2	-0.08	-0.08	-0.10	-0.03	-0.01	-0.17	0.10	-0.08	-0.10	-0.07	-0.06	-0.09	-0.03	-0.04	-0.01	-0.02	0.20	-0.12	0.08	0.10	0.07	-0.03	0.03	-0.22	1	
(26)	Geo3	-0.01	-0.12	-0.12	-0.13	0.23	0.21	-0.11	-0.09	0.12	0.03	-0.07	-0.03	0.07	0.03	0.24	0.09	0.01	-0.38	-0.10	-0.10	-0.36	0.02	-0.02	-0.27	-0.19	1
(27)	Geo4	0.10	0.15	0.09	0.09	-0.23	-0.13	-0.07	-0.02	-0.03	-0.07	0.07	-0.01	-0.10	0.11	-0.13	-0.07	-0.14	0.43	0.26	0.20	0.54	0.17	-0.17	-0.50	-0.35	-0.43

Table 3: Probability of introducing an eco-innovation

	(1)	(2)	(3)
	EcoInn	EcoInn_Prod	EcoInn_Proc
Out_Acc	1.747	2.061*	1.877
	[1.254]	[1.242]	[1.253]
Out_OutProd	-0.503	-1.884*	-1.121
	[0.726]	[0.972]	[0.755]
Out_SupProd	-6.269***	-5.974***	-6.295***
	[1.638]	[1.803]	[1.637]
KTTBus_Uni	0.947	0.718	0.537
	[0.665]	[0.680]	[0.658]
KTTBus_Multi	0.206	-0.526	0.235
	[0.819]	[0.952]	[0.860]
KTTPub_Uni	3.043***	3.166***	3.234***
	[0.860]	[0.973]	[0.848]
KTTPub_Multi	0.153	-0.216	-0.932
	[0.888]	[1.087]	[0.996]
ProdMkt_Uni	5.549***	6.641***	6.134***
	[1.797]	[2.009]	[1.833]
ProdMkt_Multi	0.760	1.166	0.822
	[0.930]	[0.957]	[0.919]
ProdPropr_Uni	-5.723***	-6.505***	-6.034***
	[1.546]	[1.848]	[1.592]
ProdMixed_Uni	1.182	1.554	1.431
	[1.473]	[1.616]	[1.540]
ProdMixed_Multi	1.000	2.036*	1.627
	[0.966]	[1.077]	[1.012]
ShareRD_Exp	0.276	0.084	0.093
	[0.283]	[0.205]	[0.192]
LAge	-1.389***	-1.413***	-1.305***
	[0.453]	[0.483]	[0.435]
LGrossInvExpXEmpl	0.175	0.372*	0.232
	[0.182]	[0.190]	[0.195]
LTurnover	0.784***	0.823***	0.885***
	[0.240]	[0.261]	[0.266]
LSalesShareExp	0.105	0.034	0.001
	[0.181]	[0.184]	[0.179]
Entropy	-4.936**	-4.105*	-4.004*
	[2.234]	[2.266]	[2.194]
Num2km	-1.660**	-1.601*	-1.666*
	[0.837]	[0.933]	[0.884]
Num2_15km	0.944**	0.627	0.741*
	[0.451]	[0.397]	[0.426]
Num15_22km	-1.070**	-0.763*	-0.849*
	[0.505]	[0.431]	[0.484]
DSector1	-3.179***	-3.962***	-3.594***
	[0.950]	[1.111]	[0.968]
DGeo2	-0.630	-1.128	-0.261
	[1.467]	[1.670]	[1.417]
DGeo3	-1.108	-0.660	-1.033
	[0.815]	[0.875]	[0.826]
DGeo4	2.065***	2.274***	2.085***
	[0.793]	[0.857]	[0.803]
Constant	18.712	13.852	12.600
	[11.700]	[11.589]	[11.582]
χ^2[25]	39.616**	38.851**	42.400**
Log-likelihood	-56.972	-52.520	-55.759
Mc Fadden's R^2	0.376	0.403	0.381
Observations	140	140	140

Robust standard errors and degrees of freedom are in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: *Probability of introducing an eco-innovation (in general terms): Interaction effects*

	(1)	(2)	(3)	(4)
Out_Acc	1.205	1.847	2.139*	2.288**
	[1.534]	[1.159]	[1.232]	[1.151]
Out_OutProd	-0.481	-0.774	-0.689	-0.689
	[0.785]	[0.797]	[0.798]	[0.761]
Out_SupProd	-149.438	-13.947***	-7.699***	-9.097***
	[152.223]	[3.554]	[2.379]	[2.605]
KTTBus_Uni	0.912	1.088*	1.006	1.024
	[0.676]	[0.662]	[0.660]	[0.660]
KTTBus_Multi	0.220	0.134	0.164	0.129
	[0.823]	[0.836]	[0.840]	[0.830]
KTTPub_Uni	2.926***	3.017***	3.159***	3.121***
	[0.881]	[0.866]	[0.917]	[0.885]
KTTPub_Multi	0.115	0.098	0.183	0.144
	[0.874]	[0.894]	[0.905]	[0.902]
ProdMkt_Uni	6.572***	6.449***	5.469***	5.730***
	[1.988]	[1.830]	[1.794]	[1.759]
ProdMkt_Multi	0.743	0.763	0.751	0.805
	[0.951]	[0.929]	[0.932]	[0.893]
ProdPropr_Uni	-5.904***	-6.002***	-5.867***	-5.867***
	[1.610]	[1.532]	[1.570]	[1.534]
ProdMixed_Uni	1.753	-0.280	0.360	-0.124
	[1.840]	[1.296]	[1.559]	[1.377]
ProdMixed_Multi	1.076	1.215	1.103	1.067
	[0.997]	[0.976]	[0.989]	[0.924]
ShareRD_Exp	0.303	0.227	0.237	0.231
	[0.294]	[0.273]	[0.276]	[0.275]
LAge	-1.334***	-1.300***	-1.382***	-1.360***
	[0.466]	[0.445]	[0.453]	[0.439]
LGrossInvExpXEmpl	0.154	0.200	0.199	0.204
	[0.187]	[0.189]	[0.192]	[0.189]
LTurnover	0.786***	0.763***	0.775***	0.771***
	[0.241]	[0.240]	[0.240]	[0.240]
LSalesShareExp	0.086	0.104	0.117	0.113
	[0.184]	[0.181]	[0.184]	[0.181]
Entropy	-5.172**	-4.904**	-4.773**	-4.743**
	[2.281]	[2.233]	[2.219]	[2.227]
Num2km	-1.646**	-1.592*	-1.623*	-1.628*
	[0.835]	[0.847]	[0.856]	[0.844]
Num2_15km	0.931**	0.884**	0.911**	0.902**
	[0.447]	[0.448]	[0.456]	[0.446]
Num15_22km	-1.056**	-1.103**	-1.076**	-1.103**
	[0.500]	[0.497]	[0.508]	[0.502]
Out_SupProd*Entropy	28.389			
	[30.152]			
Out_SupProd*Num2km		9.405***		
		[3.128]		
Out_SupProd*Num2_15km			0.949	
			[0.971]	
Out_SupProd*Num15_22km				2.515*
				[1.341]
Industry dummy	Inc.	Inc.	Inc.	Inc.
Geographical dummies	Inc.	Inc.	Inc.	Inc.
Constant	19.852*	18.898	17.950	17.969
	[11.921]	[11.727]	[11.648]	[11.701]
χ^2[26]	41.238**	45.019**	42.450**	43.381**
Log-likelihood	-56.723	-55.985	-56.766	-56.390
Mc Fadden's R^2	0.378	0.386	0.378	0.382
Observations	140	140	140	140

Robust standard errors and degrees of freedom are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: *Probability of introducing a product eco-innovation: Interaction Effects*

	(1)	(2)	(3)	(4)
Out_Acc	1.274	1.954	2.677**	2.366*
	[1.451]	[1.241]	[1.239]	[1.238]
Out_OutProd	-2.190*	-2.428**	-2.402*	-2.261**
	[1.209]	[1.239]	[1.235]	[1.090]
Out_SupProd	-167.840	-18.870***	-10.184***	-12.364***
	[107.516]	[4.588]	[3.619]	[3.823]
KTTBus_Uni	0.821	0.958	0.891	0.899
	[0.706]	[0.678]	[0.692]	[0.676]
KTTBus_Multi	-0.562	-0.638	-0.622	-0.695
	[0.982]	[0.981]	[0.988]	[0.971]
KTTPub_Uni	3.156***	3.160***	3.388***	3.247***
	[1.002]	[0.974]	[1.035]	[0.981]
KTTPub_Multi	-0.255	-0.343	-0.124	-0.288
	[1.067]	[1.115]	[1.119]	[1.127]
ProdMkt_Uni	8.323***	8.615***	6.912***	7.645***
	[2.294]	[2.182]	[2.139]	[2.120]
ProdMkt_Multi	1.127	1.157	1.152	1.280
	[0.992]	[0.989]	[0.990]	[0.939]
ProdPropr_Uni	-7.294***	-7.256***	-7.005***	-7.069***
	[2.076]	[1.925]	[2.009]	[1.953]
ProdMixed_Uni	2.110	-0.131	0.170	0.100
	[1.843]	[1.390]	[1.522]	[1.365]
ProdMixed_Multi	2.432**	2.587**	2.393**	2.268**
	[1.218]	[1.191]	[1.194]	[1.052]
ShareRD_Exp	0.078	0.027	0.022	0.033
	[0.209]	[0.195]	[0.203]	[0.201]
LAge	-1.351***	-1.270***	-1.395***	-1.375***
	[0.496]	[0.455]	[0.476]	[0.455]
LGrossInvExpXEmpl	0.362*	0.404**	0.413**	0.423**
	[0.197]	[0.191]	[0.201]	[0.195]
LTurnover	0.827***	0.802***	0.811***	0.816***
	[0.262]	[0.264]	[0.262]	[0.266]
LSalesShareExp	0.008	0.024	0.054	0.026
	[0.189]	[0.190]	[0.191]	[0.186]
Entropy	-4.434*	-4.187*	-3.910*	-4.116*
	[2.337]	[2.339]	[2.322]	[2.363]
Num2km	-1.579*	-1.552	-1.571	-1.595*
	[0.949]	[0.977]	[0.981]	[0.966]
Num2_15km	0.626	0.555	0.573	0.589
	[0.398]	[0.405]	[0.410]	[0.398]
Num15_22km	-0.755*	-0.828*	-0.786*	-0.834*
	[0.430]	[0.424]	[0.434]	[0.430]
Industry dummy	Inc.	Inc.	Inc.	Inc.
Geographical dummies	Inc.	Inc.	Inc.	Inc.
Out_SupProd*Entropy	32.243			
	[21.373]			
Out_SupProd*Num2km		14.835***		
		[4.093]		
Out_SupProd*Num2_15km			2.365	
			[1.581]	
Out_SupProd*Num15_22km				4.754**
				[2.085]
Constant	15.471	14.711	13.033	14.294
	[11.882]	[12.015]	[11.873]	[12.122]
χ^2[26]	38.653**	40.143**	38.107**	39.216**
Log-likelihood	-52.041	-50.615	-51.816	-51.286
McFadden's R^2	0.408	0.424	0.411	0.417
Observations	140	140	140	140

Robust standard errors and degrees of freedom are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: *Probability of introducing a process eco-innovation: Interaction Effects*

	(1)	(2)	(3)	(4)
Out_Acc	1.288	1.901	2.417**	2.417**
	[1.487]	[1.175]	[1.217]	[1.180]
Out_OutProd	-1.202	-1.497*	-1.425	-1.344*
	[0.838]	[0.866]	[0.869]	[0.798]
Out_SupProd	-150.175	-15.833***	-8.333***	-9.932***
	[131.855]	[3.733]	[2.466]	[3.000]
KTTBus_Uni	0.557	0.737	0.643	0.665
	[0.665]	[0.647]	[0.650]	[0.652]
KTTBus_Multi	0.245	0.152	0.189	0.126
	[0.871]	[0.890]	[0.894]	[0.879]
KTTPub_Uni	3.138***	3.219***	3.389***	3.309***
	[0.867]	[0.860]	[0.912]	[0.874]
KTTPub_Multi	-0.969	-1.039	-0.880	-0.977
	[0.970]	[1.011]	[1.009]	[1.016]
ProdMkt_Uni	7.427***	7.326***	6.047***	6.462***
	[2.067]	[1.894]	[1.874]	[1.842]
ProdMkt_Multi	0.788	0.811	0.799	0.915
	[0.952]	[0.939]	[0.941]	[0.884]
ProdPropr_Uni	-6.446***	-6.455***	-6.232***	-6.250***
	[1.679]	[1.610]	[1.636]	[1.617]
ProdMixed_Uni	1.954	-0.135	0.321	0.031
	[1.825]	[1.315]	[1.539]	[1.361]
ProdMixed_Multi	1.824*	1.975*	1.814*	1.690*
	[1.066]	[1.048]	[1.060]	[0.969]
ShareRD_Exp	0.106	0.049	0.055	0.057
	[0.198]	[0.188]	[0.194]	[0.190]
LAge	-1.238***	-1.192***	-1.288***	-1.272***
	[0.453]	[0.426]	[0.435]	[0.418]
LGrossInvExpXEmpl	0.209	0.261	0.260	0.268
	[0.204]	[0.203]	[0.205]	[0.204]
LTurnover	0.884***	0.861***	0.873***	0.872***
	[0.267]	[0.267]	[0.265]	[0.266]
LSalesShareExp	-0.019	-0.002	0.019	0.003
	[0.183]	[0.181]	[0.183]	[0.177]
Entropy	-4.263*	-4.037*	-3.769*	-3.846*
	[2.230]	[2.214]	[2.193]	[2.213]
Num2km	-1.639*	-1.601*	-1.628*	-1.649*
	[0.884]	[0.910]	[0.915]	[0.902]
Num2_15km	0.732*	0.670	0.693	0.700*
	[0.423]	[0.424]	[0.433]	[0.421]
Num15_22km	-0.834*	-0.894*	-0.857*	-0.899*
	[0.480]	[0.476]	[0.489]	[0.482]
Industry dummy	Inc.	Inc.	Inc.	Inc.
Geographical dummies	Inc.	Inc.	Inc.	Inc.
Out_SupProd*Entropy	28.582			
	[26.136]			
Out_SupProd*Num2km		11.631***		
		[3.282]		
Out_SupProd*Num2_10km			1.348	
			[1.052]	
Out_SupProd*Num10_30km				3.056*
				[1.628]
Constant	13.852	13.152	11.502	12.098
	[11.740]	[11.680]	[11.594]	[11.686]
χ^2[26]	44.548**	46.138***	43.947**	43.543**
Log-likelihood	-55.422	-54.411	-55.379	-54.972
McFadden's R^2	0.384	0.395	0.385	0.389
Observations	140	140	140	140

Robust standard errors and degrees of freedom are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1: Statistical significance of interaction effects: outsourcing times Num2km

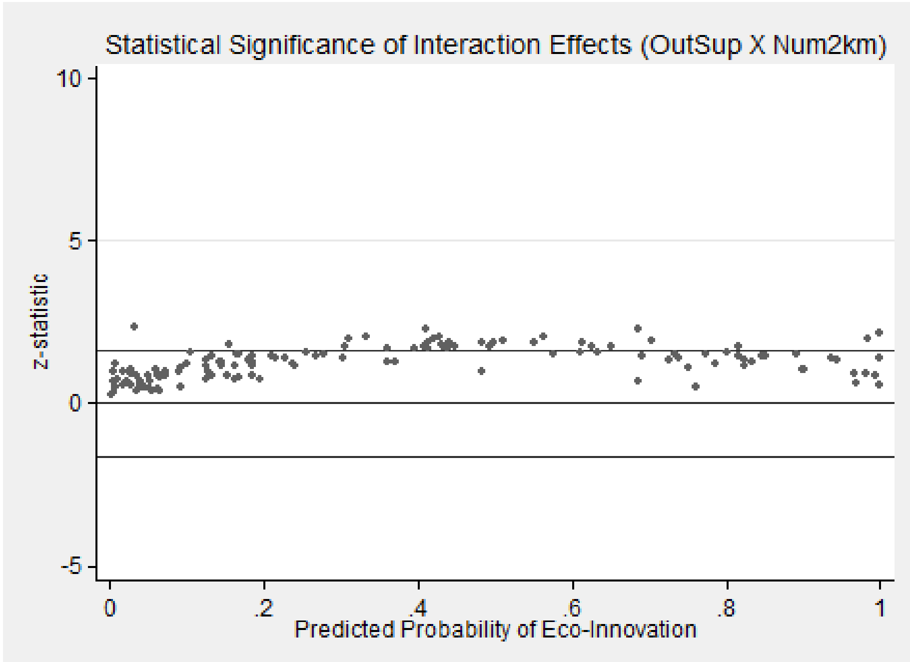

Figure 2: Statistical significance of interaction effects: outsourcing times Num15_22km

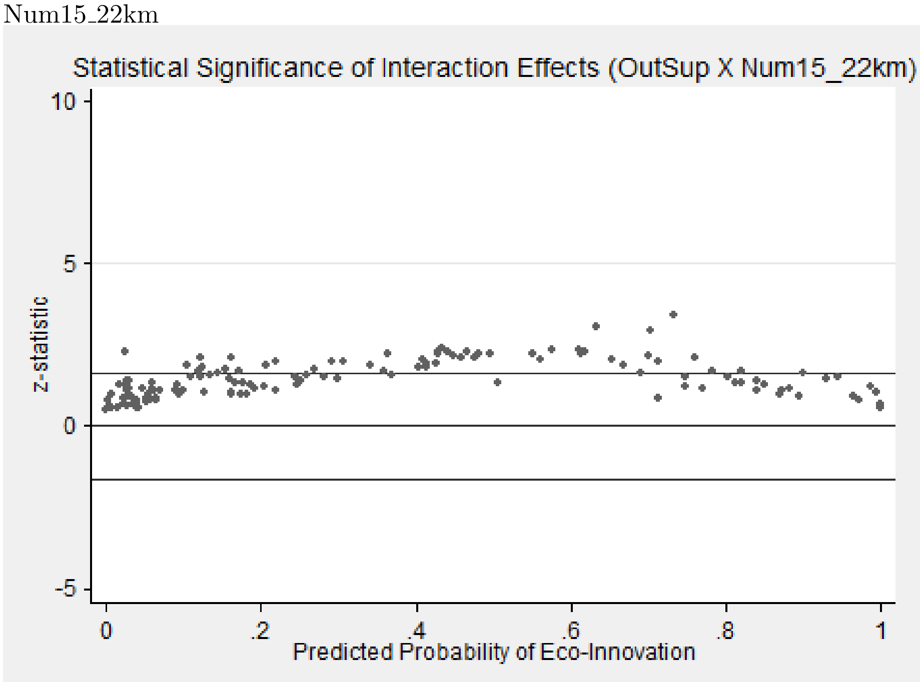

Table A1: Bivariate probit estimation

	EcoInn_Prod	EcoInn_Proc
Out_Anc	1.184	1.177
	[1.51]	[1.50]
Out_Prod	-1.216**	-0.765
	[-2.06]	[-1.62]
Out_SupProd	-3.171***	-3.635***
	[-3.37]	[-3.92]
KTTBus_Uni	0.340	0.327
	[0.85]	[0.81]
KTTBus_Multi	-0.151	0.205
	[-0.31]	[0.44]
KTTPub_Uni	1.793***	1.838***
	[3.92]	[3.91]
KTTPub_Multi	-0.198	-0.582
	[-0.29]	[-0.84]
ProdMkt_Uni	3.444***	3.172***
	[2.98]	[2.70]
ProdMkt_Multi	0.606	0.515
	[0.85]	[0.93]
ProdPropr_Uni	-3.506***	-3.224***
	[-3.70]	[-3.42]
ProdMixed_Uni	0.938	0.919
	[1.04]	[1.02]
ProdMixed_Multi	1.001*	0.998*
	[1.66]	[1.66]
ShareRD_Exp	0.070	0.061
	[0.61]	[0.53]
LAge	-0.713***	-0.706***
	[-3.29]	[-3.22]
LGrossInvExpXEmpl	0.138	0.121
	[1.43]	[1.15]
LTurnover	0.466***	0.467***
	[3.41]	[3.42]
LSalesShareExp	0.009	0.008
	[0.08]	[0.08]
Entropy	-2.347*	-2.436*
	[-1.72]	[-1.73]
Num2km	-1.030**	-1.021**
	[-2.19]	[-2.17]
Num2_15km	0.400*	0.404*
	[1.80]	[1.82]
Num15_22km	-0.476*	-0.474*
	[-1.86]	[-1.86]
Sectoral dummies	Incl.	Incl.
Geographical dummies	Incl.	Incl.
Cons	8.214	8.505
	[1.17]	[1.15]
ρ	0.92	
Wald test of $\rho = 0$	$\chi^2[1]$=102.385***	
Observations	140	

Robust standard errors and degrees of freedom are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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