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Are Regional Systems Greening the Economy? the Role of Environmental Innovations and Agglomeration Forces

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Summary

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Keywords: Environmental Innovations, Firm Economic Performances, Local Spillovers, Manufacturing, Agglomeration.

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ARE REGIONAL SYSTEMS GREENING THE ECONOMY? THE ROLE OF ENVIRONMENTAL INNOVATIONS AND AGGLOMERATION FORCES

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Abstract

The adoption and diffusion of environmental innovations (EIs) is crucial to greening the economy and achieving win-win environmental – economic gains. A large and increasing literature has focused on the levers underlying EIs that are external to the firm, such as stakeholders' pressure and policy pressure. Little attention, however, has been devoted so far to the possible role of local spatial spillovers which are one of the factors affecting sector/geographical specialisations. We analyse a rich dataset that covers the innovative activities and economic performances of firms in the Emilia-Romagna region in Italy, an area rich of manufacturing districts. We analyse EIs drivers and effects on firms' performances through a two-step procedure. First, we look at the relevance of spatial levers, namely whether the agglomeration of EIs induces EIs in a given firm. Second, we test whether EIs are significantly related to firms' economic performances. As to the importance of spatial levers, the role of agglomeration turns out to be fairly local in nature: we find that spillovers are significantly inducing innovation within municipal boundaries. Regarding economic performances, firms' productivity is positively related to EI adoption; in particular, firms that jointly adopt EIs and organisational changes show a better economic performance.

Keywords: environmental innovations, firm economic performances, local spillovers, manufacturing, agglomeration.

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1. Introduction

Environmental innovations (EIs) are receiving increasing attention as a key factor for the progress towards a greener and more competitive economy. As is well-known, innovation is a driver of productivity growth, and sustainable economic growth depends on investments in new ways of managing production, both from the technological and organisational viewpoint, that help preserving the environment. The notion of EI represents a broad concept that can encompass various dimensions (Kemp and Pontoglio, 2011). One of the most recent definitions of eco-innovation (used in this paper as synonymous of environmental innovation) describes it as the production, application or use of a product, service, production process or management system new to the firm adopting or developing it, and which implies a reduction in environmental impact and resource use (including energy) throughout its life-cycle (Kemp, 2010).

Given the potentially strategic role played by EIs for the sustainability of economic growth, many studies have examined the factors underlying them. In particular, as some authors have pointed out (Horbach, 2008; Horbach and Oltra, 2010), the drivers of EIs can be categorised both as internal (e.g. training) and external (e.g. cooperation with other agents) to the firm, including among the latter sector/structural features as well as policy levers (Borghesi et al., 2012; Veugelers, 2012). Moreover, Horbach et al. (2012) have recently framed the factors correlated to EIs around the dimensions of regulation, market push factors, technological factors and firms' specific features. Beyond these factors, also spatial and geographical drivers may play a relevant role. Despite very recent works (Cainelli et al., 2012; Horbach, 2013), however, the analysis of EIs in regional settings has been generally overlooked so far. As Truffer and Coenen state (2012, p.3): *'Much of the sustainability transitions literature can be criticized for being spatially blind and for (implicitly) overemphasizing the national level at the expense of other geographical levels. More specifically, the role of regions in sustainability transitions has received little attention in this literature'*[1].

To overcome this shortcoming of the existing literature, this paper aims at enriching the discussion over the relational/spatial factors that might be behind EIs adoption and diffusion[2] in economically agglomerated regional settings.

Spatial and spillover effects become crucially important under a perspective that defines 'regional competitive advantages' as a key factor to achieving sustainability and competitiveness aims. In this regard, it is noteworthy to observe that a sector-based and regional perspective is

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1 For a broad discussion on regional studies and sustainability transition issues we refer the interested reader also to Benneworth et al. (2012).

2 See Hall and Helmers (2013) for a discussion on inventions, innovation and diffusion concepts in the realm of green technologies.

coherent with new policy and growth approaches in the EU. Recently, in fact, a rebalanced emphasis that explicitly includes the role of geographical aspects as a driver of development and growth is apparent in the re-launching of the redefined Lisbon agenda. Thus, EU growth policy is moving toward a more balanced perspective that accounts for both joint regional-sector based 'smart' specialisation which explicitly accounts for climate change, and environmentally related issues in light of the EU 20-20-20 strategy on environmental and energy targets (Iammarino and McCann, 2006; Costantini and Mazzanti, 2013).

The analysis of the diffusion of EIs at spatial and sector level is particularly relevant in the EU since, as it is well-known, small-medium enterprises (SMEs) and district-based industries play a crucial role in many EU countries. While much emphasis has been placed on the behaviour of large firms (e.g. corporates), environmental and innovation economists should deepen the analysis of how EIs spread and are adopted in economic contexts that are rich in SMEs (Brioschi et al., 2002; Cainelli and Zoboli, 2004; Mazzanti and Zoboli, 2009). This would also allow a fruitful integration between environmental economics and regional studies.

In this work we attempt to originally extend the analysis of EI adoption and diffusion in two main ways.

In the first place, we aim at capturing the EIs levers that can be found in the firm's territorial institutional and economic features. This extends the set of factors that favour the adoption of EIs (Horbach et al., 2012) and strictly embeds EIs within a regional setting environment. We aim at studying which geographical factors are relevant in supporting EIs in regional systems characterized by a high density of firms agglomerated into districts. This has been a somewhat overlooked issue regarding EIs, but it is relevant given the complementarity of EIs with techno-organisational change in a broader meaning (Antonioli et al., 2013). EIs are not only a technical box, but rather an embedded factor within a firm's institutional features and the territory the firm belongs to. These local features then interplay and integrate with the global challenges firms face, namely exposure to international markets and, for the sake of this paper, the new challenges posed by climate change.

In the second place, we study the effects of EIs, possibly integrated with other firm strategies, on economic performances (see, among others, Horbach and Rennings, 2012; Cainelli et al., 2011; Jaffe et al., 1995; Ambec et al., 2010; Ambec and Barla, 2006; Ambec and Lanoie, 2008; De Marchi and Grandinetti, 2013; De Marchi et al., 2013) by adding the spatial component. In this regard, differently from most previous contributions, we place particular emphasis on SMEs, which represent the large majority of firms and the heart of industry in most EU countries. This focus is especially important in countries such as Italy where industry is historically structured on a web of SMEs, that are often 'organised' into districts and exploit networking and cooperation activities as resources that enhance competitiveness through knowledge transfer (Boschma and Lambooy, 2002; Beaudry and Breschi, 2003).

Summing up, the main aims of the empirical work are: (i) to assess whether regional systems rich with agglomeration economies are a pre-condition for EI diffusion, (ii) to investigate whether EIs are integrated with other techno-organisational strategies and finally (iii) to analyse whether EIs – taken alone or in integration with other innovations – impact on a firm's productivity performances.

We carry out our empirical analysis on the basis of an original survey that covers more than 500 firms in the Emilia-Romagna Region in the North-East of Italy. Such a survey allows us to have information on the firm's spatial location and balance sheets, which enables to get a deeper understanding of the 'firm's behaviour'. The survey is temporally comparable with the CIS 2006-2008. We deliberately introduced 'CIS-like' questions[3] on EI issues (see Borghesi et al., 2012; Cainelli et al., 2012 and Antonioli et al., 2013 for discussions on EU CIS issues). To study the EIs effects on economic performances we merge the innovation dataset with original balance account sheets at the firm level. To additionally control for environmental regional features, we also merge the innovation dataset with emission data.

The Emilia-Romagna Region is a case worth investigating under many respects. In the first place, it is a relevant industrial macro region of the EU that presents high innovation capacity (Brioschi et al., 2012; Putnam, 1993). It is thus worth assessing the extent to which EIs are a core firm strategy and whether the 'Emilian model' -founded on dense agglomeration economies and district-based competitive advantages (Cainelli, 2008; Antonietti et al., 2014)- is moving towards a greener economy. Though the region still remains relatively competitive, it harshly suffered during the 2009 crisis – due to a collapse in its exports – and is now moving towards a new industrial setting and new competitiveness sources. EIs might be a relevant part of this new development. In fact, EIs are strictly related to two market failures (under-provision of innovation and over-production of externalities) and might generate higher environmental and economic performances. The region, therefore, provides a good case study to analyse the evolution of an industrial context rich of SMEs towards a green economy path - a 'new' growth path that might potentially generate value to the Italian economic system that has suffered a 'productivity stagnation' over the past 10-13 years (Figure 1)[4].

Figure 1 around here

In the second place, though the region's innovative capacity is helping its environmental performances (Costantini et al., 2013), the heavy industrial structure penalises its overall performance, which does not particularly excel within the Italian scenario. The region, in fact, because of its industrial structure, ranks slightly above the national average (0 on the Y axis in fig.2 and 3) in terms of emissions per value added as it can be appreciated employing a shift share analysis on Italian emission data: values of emission per region above (below) 0 mean a

3 All questions are available upon request.

4 It is worth noting that this stagnation is somewhat correlated to laggardness in environmental performances (Marin and Mazzanti, 2013).

worse (better) performance than the national average.[5] One explanation is that the relatively high environmental production efficiency of Emilia Romagna is currently not sufficient to compensate for the scale effect and the composition effect deriving from the structure of its economy (Figures 2 and 3).

Figure 2 and 3 around here

Though the EI performance of the Emilia-Romagna region has been better than the average Italian performance in the last decade, this industrial macro region presents also some relevant critical aspects to be addressed in the future. In particular, it will be important to complement the competitive advantage of Emilia Romagna in some traditionally strong sectors (principally heavy manufacturing sectors, such as ceramics and machinery) with the development of new sectors and new strategies within the old sectors.

The paper is structured as follows: section 2 presents the main research hypotheses and data, section 3 outlines the empirical model and comments on the econometric evidence that emerges from the analysis, section 4 concludes.

2. The set of research hypotheses and the data

Though the role of factors external to the firm, such as cooperation with other firms, have long been studied in the innovation literature (see Cassiman and Veugelers, 2002 for a seminal work), their understanding in the “environmental innovation” literature is still relatively in its early phases. Some recent key studies find that the internal resources devoted to R&D are not among the drivers of environmental innovation adoption (Cainelli et al. 2012; Horbach and Oltra, 2010, Horbach, 2008; Borghesi et al., 2012) and that environmental innovative firms cooperate on innovation with external partners more than other innovative firms (De Marchi, 2012). This makes the analysis of spatial and sector spillovers (possibly driven by cognitive proximity, Costantini et al., 2013) as potential omitted covariates in innovation functions even more relevant.

Firms may in fact receive and exchange innovation inputs and knowledge at various geographical levels: regional, provincial, municipal, district. This favours ‘eco-innovation commons’, that is, royalty-free access to patented innovations or adoption of innovations new to firms and developed by (nearby) firms (Hall and Helmers, 2013), which can contribute to the diffusion of EIs within a territory. To get a deeper understanding on this issue, it is therefore important to assess at the empirical level the boundaries within which agglomeration economies may operate. The latter highly depend on the institutional and economic features of a region. In

5 See Costantini et al. (2012) for a detailed account of the shift share analysis from which the structural and efficiency component are derived.

this paper we exploit original information at our disposal on the firms' location to test whether 'within municipality' or 'outside municipality' spillovers occur in the adoption of innovation, taking into account the fact that in Italy 'district' agglomeration are often within a municipal boundary. Building on the aforementioned reasoning and on the relevant literature, we define our first research hypothesis (H1) as follows.

H1 – The degree of closeness to other firms that adopt EIs can influence the diffusion of innovation through knowledge transfer and the presence of homogeneous institutional conditions in a given territory.

The relationship between EIs and their eventual economic effects is an important part of the possibility to integrate sustainability and competitiveness (Costantini and Mazzanti, 2012 and 2013). On the one hand, environmental innovations are an important source of sustainability since they might reduce the environmental impact of firms; on the other hand, they can have a relevant economic impact, as it has been stressed since the early 90's by the literature on the Porter hypothesis (van Leuwenen and Mohnen, 2013). Some specific studies have examined the relation between economic, innovation and environmental performances in different countries (see Gilli et al., 2013 for a survey). In particular, Cainelli et al. (2011) have studied the productivity effects of firms' environmental strategies and green features in the case of the Italian manufacturing and service sectors; Earnhart and Lizal (2010) have investigated the environmental-economic performances of the Czech firms, while Oberndorfer et al. (2013) have examined the extent to which stock market value incorporates a green firm's features in the case of large stock market German firms. Building on and further extending the research direction developed by this literature, we will examine here the EI effects investigating the second and third research hypotheses (H2 and H3) specified below.

H2 – The adoption of product and process EIs by firms might enhance the competitiveness of productive organisations through value creation and efficiency achievements.

H3 - The integration of EIs with the other techno-organisational strategies of the firm positively affects the economic performance of the firm.

We test H2 and H3 for two years: 2010 and 2011, which represent the very first biennium after the deep recession of 2009 to understand whether EIs had impacts in two different years of the economic ‘crisis’[6]. Exploiting our data we use different indicators of firm’s productivity to enrich the evidence on the economic effects of environmental innovations and present some sensitivity tests.

We test the hypotheses by using an original dataset constructed out of a firm-level survey on manufacturing firms with more than 20 employees (Huselid and Becker, 1996; Huselid, 1995) in the Emilia-Romagna Region (hereinafter ER) that is located in the North-East of Italy (Cainelli et al., 2012). This dataset can offer valuable insights on the extent to which EIs are really integrated within a firm’s strategies and on their impact on the firms’ economic performances. The sample is stratified by size, sector and geographical location of the firms and it is representative of the firm’s ‘population’ (see tab. A1 in the Appendix). We focus on relatively larger firms given the complexity and richness of the data we aimed to gather (techno-organisational innovation, eco-innovations, international strategies, Human Resources Management). Interviews were carried out in 2009 by a professional company (SWG) specialised in polls and surveys. To allow for comparison with the EU CIS5, we covered 2006-2008. Eco-innovation questions specifically aim at replicating the CIS section on eco-innovation.[7]

Given the aim of this paper, we merge the Emilia-Romagna survey with balance account sheets that are available at the firm level for the period 2003-2011. The time span allows considerable flexibility in the use of account data. The latter are used both as EI covariate (using data before 2006), in the first stage of analysis, and as the main dependent variable, in the second stage of analysis, to test the impact of EIs on productivity in 2010 and 2011.

The rich set of information we have at our disposal allows us to use a relatively large block of controls in order to account for as much heterogeneity as possible in our estimation procedure. Indeed, firm level studies usually suffer from unobserved heterogeneity due to lack of data on managerial attitudes, which we are able to capture using variables that measure innovation in the technological, organisational and ICT spheres (see Tab.A2 and A3 in the Appendix for a full description of the covariate and descriptive statistics). As emerges from the correlations reported in Tab.A4 in the Appendix, the main non-dichotomous regressors included in our estimations and described in the next section, do not seem to present severe multicollinearity problems.

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6 In 2009 the GDP collapsed by about 6% in Italy, Germany and the region we analyse itself, which was largely dependent upon export performances. Though 2010 and 2011 were still years of economic crisis, the latter was less severe than in 2009. What is more, in 2010 the Italian economy experimented a brief recovery.

7 While replicating most of the CIS questions, we also introduced some additional ones, which allows to get new information and test more hypotheses on the integration between EIs and other firm strategies. The full 12-page questionnaire is available upon request.

3. The empirical evidence

We employ a two stage procedure, that partially follows Hall et al.'s (2012) recent analysis of Italian firms, to provide evidence regarding H1-H3 testable implications. In the first stage, we investigate the factors that are behind EIs through a full regional lens. The main addition we provide to the literature on the drivers of EIs is the inclusion of a 'spatially referred' term (Share_EI_Municipality) that absorbs omitted heterogeneity from a statistical point of view and gives information on the role of agglomeration as a force underlying the adoption of EIs in local industrial systems. In this first econometric stage, the factors behind EIs are studied both by taking innovations on a separate basis (probit models) and by verifying the relevance of correlation between various innovations (e.g. EIs and technological innovations) through the implementation of bivariate probits[8]. The first stage specification is as follows:

$$(1)\ EI_i = c + a1(CONT)_i + a2(Share\_EI\_Municipality)_i + e_i$$

where CONT is a set of covariates described in detail in sub-section 3.1 below, Share_EI_Municipality is the 'spatially referred' variable mentioned above, namely, the average adoption share of EI (bounded between 0 and 100) of firms located within the same municipality, and e is the error term.

The second part of our empirical exercise directly relies on the use in the second stage equation of the predicted values of the first stage regression, as well as on the use of accounting variables to construct dependents that proxy labour productivity. In this regard, we focus on several proxies of labour productivity: value added per employee (VAEMP), output per employee (OUTPUTEMP) and revenues per employee (REVEMP). All three productivity indicators are measured in 2010 and 2011. Since the covariates are measured on the time span 2006-2008, the diachronic nature of the second stage specification helps us mitigating potential endogeneity problems due to simultaneity (Michie and Sheehan, 2003). The second stage specification is as follows:

$$(2)\ PERF_{i,t} = c + b1(CONT)_{i,t-1} + b2(EI\_FITTED)_{i,t-1} + b3(INNO)_{i,t-1} + u_{i,t}$$

where PERF indicates each performance indicator, CONT is again a set of controls and INNO is here a full set of innovation indexes usually related in the empirical literature to the economic performance of the firm (e.g. Hall et al. 2012), EI_FITTED is the fitted value of the probability

8 We also applied a multivariate probit as a robustness check and we obtained the same results of the bivariate probits.

of introducing environmental innovation given by the first stage. Finally, u is the error term and the subscripts t and t-1 denote the time at which the variable is measured, showing the existence of a lag in the model between the covariates and the dependent variables.

3.1 The factors correlated to EI in a regional setting

Table 1 shows the results of the estimations performed at the first stage. Columns (2) to (5) report probit (column 1) and bi-probit (columns 2 to 5) estimations respectively[9]. As the table shows, the valued added per employee in the past (2003-2005) as well as the training of employees turn out to be statistically significant and positively correlated to EIs in all estimated regressions.

Tab.1 around here

These results, which are coherent with other findings in the literature (Cainelli et al., 2012), suggest that firms investing more in training activities and having more productive employees tend to be more prone to implement eco-innovation (whether alone or jointly with other forms of innovation). While the present estimations do not allow us to draw any conclusion on the direction of causality, it seems plausible to argue that training activities positively integrate with EIs and firms benefit from such integration. Indeed, better trained workers are likely to be more productive given the improvement in their capabilities and absorptive capacity, due to training, which can generate a virtuous circle among EIs and economic performance[10]. As far as the past economic performance is concerned it is reasonable to hypothesize that 'wealthier' firms are more likely to introduce innovation, both EIs and other types, given that they can invest more in R&D activities and they can also buy new technologies from external sources.

A particularly interesting result, which supports H1, is that the share of firms performing EIs within each municipality (Share_EI_Municipality) is always statistically significant and positively related to the probability of adopting EIs. This suggests the existence of a positive spillover effect of EIs within the municipalities in ER: being located in a municipality with a higher share of EIs enhances the probability for each firm of adopting EIs[11]. The existence of EI

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9 Size and sector dummies have been included in all estimations but turn out to be seldom significant. When sector dummies are significant (Food and Machinery) they have a negative sign, which suggests that they have a lower capacity to introduce EIs with respect to the benchmark sectors not included in the specification: Metallurgy, Textile, Shoes and Paper Printing (the latter three are not included in the specification because they predict failure perfectly in the probit model).

10 The same argument could be applied to ICT, given the positive correlation with EIs adoption. However, in this case the significance level in tab.1 is spurred by the correlation between ICT and Prod and Proc rather than between EIs and ICT.

11 The same does not apply to the share of firms adopting EIs across neighbouring municipalities that is not statistically significant in all estimated regressions. This seems to confirm that EI spillover effects in ER tend to

spillover effects at the municipal level can probably be explained by the particularly large size of ER municipalities, which are about twice as large as those in Veneto and 4 times larger than the municipalities of Lombardy and Piedmont (the other main industrial regions in northern Italy). The relevance of the municipal context for EIs, moreover, is consistent with the findings of the literature on the Italian industrial districts which generally shows a long-standing trend towards the agglomeration of firms and specialisation within single municipalities (Brioschi et al., 2002). It is also coherent with the role of 'social capital' and civicness that Putnam (1993) highlights in his well-known seminal contribution, in which the Emilia-Romagna region turned out to be at the top of the civicness (p.97) and institutional performance ranking (p.84). This social capital glue (Cainelli et al., 2007) also creates the pre-condition for firms to engage in solid networking. 'Space' is relevant in many dimensions, not only as a 'distance' concept (see for example Boschma, 2005): the proximity of firms and agents in a context that offers reliability in terms of socio-institutional performances goes beyond the mere physical space element. Moreover, the relevance of the municipal context that emerges in the present analysis recalls the important role historically played by municipalities in the development of Italian capitalism, at least in the North (Putnam, 1993).[12] The substantial role of municipality indirectly emerges also by other empirical tests, that were performed including among the covariates simple geographical distances among the firms and the share of eco-innovators in the neighbourhood of each firm (within 2km, between 2-10km, between 10-30km, more than 30km), disregarding the municipalities boundaries. The lack of evidence of such ‘geographical’ variables indirectly points to the specific role of municipality characteristics in influencing the firms propensity to eco innovate[13].

3.2 Environmental innovation and the economic performance of the firm

Tables 2a and 2b show the correlation of several covariates (including EIs) to three alternative performance indicators that refer to 2010 and 2011: (1) production volume, (2) valued added per

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occur within single municipalities rather than across them. The same results occurred when we tested spillover effects arising from both overall neighbouring firms and from neighbouring firms within the same sector. More than sector features, it is the location in the municipal area that supports EI diffusion. See Figure 4 in the Appendix which sketches how the four ‘spillover-oriented’ variables are conceptually constructed.

12 In Chapter 5 of his above-mentioned volume, Putnam stresses that 'although regional governments were established in 1970 [...] the regions themselves had far deeper historical roots. Over the period 1000-1500 a.C., an unprecedented form of self-government emerged in the towns of Northern Italy: the 'commune' (that is to say, the municipality) that represented a new form of political and social organisation of life, even in economic terms. In the words of Putnam (1993, p.124), 'by the twelfth century communes had been established in Florence, Venice, Bologna, Genua, Milan and virtually all the other major towns of Northern and central Italy, rooted historically in these primordial social contracts'. As communal life evolved, craftsmen and tradesmen were of key importance for the development of those areas. Mostly relevant 'to provid[ing] self-help and mutual assistance of social as well as [to] strictly occupational purposes' (p.125).

13 The full sets of results are at disposal from the authors upon request.

employee and (3) revenues per employee.[14] As the tables show, EIs fitted values, namely, the probabilities deriving from the first stage of the analysis, turn out to be positively and significantly correlated to two of the three dependent variables (production volume and revenues per employee) for both years. In particular, tab.2a reports the EIs fitted value from the probit model in the first stage (EI_Fitted_Prob); tab.2b shows, instead, the EIs fitted value steming from the biprobit model in the first stage (EI_OrgProd_Fitted_Biprob) that relates EIs and changes in organisation of production (OrgProd). The reason why we focus on this joint probability is that it is only for such a couple of innovation variables that a relation emerges, as shown by the significance level of the rho coefficient in tab.1. In other words, EIs and organisational changes in production are the only innovations that are likely to be jointly adopted within the firms[15].

As tab.2a suggests, our results support H2 since we find a positive and significant relation between EIs fitted value from the probit model in the first stage (EI_Fitted_Prob) and two out of three indicators of firm's productivity. Also H3 turns out to be supported by our results, since the joint probability of introducing EIs and organisational changes in production is positively and significantly related to the same dependent variables (tab.2b). Notice, moreover, that the coefficients associated to EI_OrgProd_Fitted_Biprob in tab.2b are always greater than those associated to EI_Fitted_Prob in tab.2a. This suggests that when EIs are integrated with complementary organisational changes, their correlation with the economic performance of the firm is larger than in the case of simple and "isolated" EIs.

Beyond eco- and organisational-innovation, other relevant factors that emerge from the analysis are the firms' export level, their emission intensity, their geographical location and the sector they belong to. As for the export variable, its positive sign confirms the importance of having access to foreign markets for ER firms, particularly during the years 2010 and 2011 in which the internal demand tended to collapse due to the on-going economic crisis, while the foreign aggregate demand tended to increase. This result is consistent with the findings of previous studies in the literature that also emphasize the crucial role played by exports as a driver of firms' economic performance in this region (Antonioli et al., 2010).

CO_2 emission intensity in 2005 is also positively and significantly related to all the dependent variables taken into account. This is likely to reflect the fact that the largest and best performing

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14 Beyond these performance indicators, we also used a profitability measure given by EBITDA on sales. In that case, however, no relations emerged with EIs, possibly suggesting that the effects of EIs on profitability take longer to emerge than those on other performance indicators. Results are not reported for space constraint, but they are available from the authors upon request.

15 Table 2b shows that the results of the joint probability of introducing both EIs and OrgProd (Pr(EIs=1; OrgProd=1)). As robustness checks, however, we also run our regressions including the conditional probability of introducing EIs given OrgProd (Pr(EIs=1 | OrgProd=1)) and the marginal probability of introducing EIs (Pr(EIs=1); marginal success probability for equation 1). The results hold true for all the types of EIs fitted being used, but they are not reported for space constraint. They are available from the authors upon request.

firms were also generally more polluting in 2005, namely, before the European Emission Trading Scheme (EU-ETS) on GHG emissions came into force. While the actual effectiveness of the EU-ETS and its impact on firms' performance is currently the object of debate in literature (Cainelli et al., 2013), it seems plausible to claim that the largest (and therefore also most polluting) firms in 2005 were still better performing than the rest of the market in 2010 from an economic viewpoint, whether still relatively more polluting or not.

Differently from the estimation results in stage 1 (see previous section 3.1), the set of 'province dummy' proves statistically significant for some dependent variables in stage 2. This is not surprising since most productive firms tend to concentrate in Emilia (BOMOREPR accounting for about 72% of all firms in our sample), while the area of Romagna (RARNFC) has relatively little/no industries, therefore also little Value Added (VA), which can explain its worse performance in terms of VA per employee.

Finally, some sectors[16] (particularly food, coke and chemical) show a strongly positive correlation with the performance indicators. While the benchmark sector (metallurgy) was severely affected by the crisis, in fact, these sectors showed a significantly better trend, as expected, due to the sustained inner or foreign demand for their products (food and energy, respectively).

4. Conclusions

In a regional setting that is characterised by historically high innovation intensity and relevant local environmental impacts, we study the role of agglomeration economies, namely knowledge/innovation spillovers, as a potentially relevant force behind the adoption of environmental innovations. The increasing literature on EIs has devoted little (if any) attention to the possible effects of agglomeration economies. The latter, however, are crucial, especially in areas where the richness of districts and networking influences the overall performance of firms. We analyse the role of EIs through a survey-based dataset that covers various high performance work practices and innovative strategies. Original geographical information on firms' location and data regarding economic and environmental performances allows us to verify two main interconnected and testable research questions. First, whether 'local external conditions', primarily geographical agglomeration, influence EI diffusion. Second, whether the consequent diffusion of EIs exert any impact on the firm's productivity.

As to the first question, we find that local conditions do play a substantial role, namely firms that are located in the same municipality of more eco innovative firms tend to adopt eco innovations with higher probability. This highlights the relevance of agglomeration economies and local

16 The results for sectors are not reported in the tables for scope constraint, but they are available from the authors upon request.

institutional conditions in providing concrete (innovative) contents to the green economy paradigm. EI adoptions correlate not only to internal firm features (e.g. training, sector structural features) but also to 'external' factors, among which we emphasise for the first time the role of specific geographical elements. Firms receive support for EI adoption from being located in a defined municipality. This is coherent with the historical importance of 'communes' in the economic development of northern Italy, a backbone of the 'district'-based model of capitalism. Municipal level spillovers tend to prevail over other geographical factors as well as over sector belonging. It is mainly within the municipal area that EI adoption spreads. Our findings suggest that EIs can be a key source of growth for regional systems, particularly when spurred by local spillovers, and an important way out of the ongoing crisis.

EIs tend to be adopted in correlation to some other of the firm's techno-organisational strategies. Among those, innovations related to the organisation of production (team work, quality circle, etc..) appear the most relevant factor in this strategic 'green' integration of practices. This outcome reinforces the possibility of integrating EIs within firms' production processes, so that EIs are not merely end of pipe in nature (e.g. filters to abate emissions), but require a full reshaping of the techno-organisational frontier.

As to the second question, we observe that the productivity performances of firms tend to be higher for enterprises that jointly adopt EIs *and* organisational innovations: the greening of the economy passes, therefore, through a full reorganisation of the productive process. EIs are not an isolated strategy even when firms do not face strict environmental policy constraints as in the Italian context. Innovations that occur in small and medium-sized firms are an important part of the story for the success or failure of the new green economic paradigm. This result is even more relevant in the Italian case in which the opportunities offered by green technology invention and adoption might contribute to reverse the current critical stagnation of labour productivity.

Future research might proceed along these lines by further extending the analysis of spatial factors, as well as by investigating the EI effects on other 'social' aims of the firm, including among others employment and environmental performances.

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Tables and figures

Tab.1 – Results from first stage probit and biprobit					
	Probit	Biprobit			
	EI	EI and Proc	EI and Prod	EI and OrgLab	EI and OrgProd
	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
		For the case Pr(EI =1, Proc=1)	For the case Pr(EI =1, Prod=1)	For the case Pr(EI =1, OrgLab=1)	For the case Pr(EI =1, OrgProd=1)
Size dummies	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes
BOMOREPR	-0.049	-0.021	-0.026	-0.031	-0.028
	(0.083)	(0.047)	(0.045)	(0.062)	(0.057)
RARNFC	0.024	0.019	0.021	0.024	0.025
	(0.078)	(0.047)	(0.045)	(0.061)	(0.056)
Export	0.044	0.035	0.055	0.032	0.035
	(0.055)	(0.037)	(0.036)	(0.047)	(0.044)
CO2_05_VA_PROV	-0.118	-0.077	-0.082	-0.098	-0.084
	(0.089)	(0.062)	(0.060)	(0.075)	(0.070)
Train_Cov_Perm	**0.182*** **	**0.135*** **	**0.124*** **	**0.162*** **	**0.152*** **
	(0.042)	(0.028)	(0.028)	(0.035)	(0.032)
ICT	0.102	**0.118** **	**0.099* **	0.096	0.105
	(0.078)	(0.053)	(0.052)	(0.066)	(0.064)
RandD	-0.001	0.031	0.045	0.001	-0.002
	(0.042)	(0.027)	(0.028)	(0.035)	(0.032)
FDI_BRIC	0.035	0.018	0.037	0.028	0.031
	(0.059)	(0.037)	(0.036)	(0.042)	(0.041)
VAEMP0305	**0.274*** **	**0.195*** **	**0.170*** **	**0.232*** **	**0.220*** **
	(0.066)	(0.051)	(0.049)	(0.056)	(0.055)
Share_EI_Municipality	**0.863*** **	**0.551*** **	**0.530*** **	**0.732*** **	**0.669*** **
	(0.110)	(0.062)	(0.059)	(0.071)	(0.065)
N	535	535	535	535	535
chi2(df)	100.294(18)	196.84 (36)	201.10(36)	493.25(36)	139.67(36)
Atrho	\	0.035	-0.112	0.274	**0.353** **
		(0.111)	(0.115)	(0.186)	(0.140)

Robust to heteroskedasticity standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Tab.2a – Results for the second stage of the analysis: EIs fitted values from the probit model included

	(1)	(2)	(3)	(4)	(5)	(6)
	VAEMP10	VAEMP11	OUTEMP10	OUTEMP11	REVEMP10	REVEMP11
Size dummies	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes
BOMOREPR	-0.014	0.023	**0.200****	0.121	**0.161***	0.159
	(0.067)	(0.073)	(0.086)	(0.103)	(0.089)	(0.102)
RARNFC	**-0.209*****	**-0.141***	**0.153***	0.030	-0.017	-0.063
	(0.064)	(0.073)	(0.093)	(0.118)	(0.090)	(0.103)
Export	**0.167*****	**0.204*****	**0.136***	**0.147***	**0.168****	**0.261*****
	(0.058)	(0.072)	(0.073)	(0.077)	(0.066)	(0.085)
CO2_05_VA_PROV	**0.276*****	**0.260*****	**0.231***	**0.366****	**0.310****	**0.496*****
	(0.071)	(0.085)	(0.128)	(0.145)	(0.122)	(0.140)
FDI_BRIC	-0.066	-0.038	0.040	0.029	-0.016	-0.022
	(0.055)	(0.051)	(0.068)	(0.065)	(0.074)	(0.079)
Train_Cov_Perm	0.004	0.051	-0.020	-0.058	-0.002	-0.003
	(0.042)	(0.041)	(0.044)	(0.058)	(0.052)	(0.063)
ICT	0.046	0.007	-0.029	-0.047	-0.070	-0.047
	(0.087)	(0.094)	(0.087)	(0.095)	(0.107)	(0.100)
Techno	0.042	0.266	-0.096	-0.112	0.189	0.203
	(0.163)	(0.180)	(0.197)	(0.225)	(0.213)	(0.233)
EI_Fitted_Prob	0.031	0.036	**0.184****	**0.220*****	**0.169***	**0.177***
	(0.070)	(0.056)	(0.092)	(0.084)	(0.088)	(0.099)
_cons	3.776***	3.787***	1.102***	1.058***	4.700***	4.564***
	(0.103)	(0.108)	(0.135)	(0.172)	(0.131)	(0.154)
N	535	535	535	535	535	535
chi2(df)	294.185(20)	198.277(20)	189.128(20)	172.289(20)	201.274(20)	277.032(20)
AdjR2	0.240	0.206	0.233	0.281	0.239	0.285

*; **; *** significant at 10%, 5%, 1% respectively; bootstrapped standard errors in parenthesis; Dummy variable reference groups: Metallurgy for sectors; SIZE_4 (>250 employees); Two near regional border provinces for geographical dummies Piacenza and Ferrara

Tab.2b – Results for the second stage of the analysis: EIs fitted values from the biprobit model included						
	(1)	(2)	(3)	(4)	(5)	(6)
	VAEMP10	VAEMP11	OUTEMP10	OUTEMP11	REVEMP10	REVEMP11
Size dummies	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes
BOMOREPR	-0.014	0.024	**0.202***	0.122	**0.162****	**0.160****
	(0.074)	(0.073)	(0.106)	(0.096)	(0.077)	(0.072)
RARNFC	**-0.210*****	**-0.141****	0.154	0.030	-0.016	-0.062
	(0.070)	(0.067)	(0.113)	(0.090)	(0.088)	(0.086)
Export	**0.167*****	**0.204*****	**0.135****	**0.146***	**0.168****	**0.261*****
	(0.065)	(0.061)	(0.061)	(0.080)	(0.075)	(0.092)
CO2_05_VA_PROV	**0.276*****	**0.261*****	**0.232***	**0.367*****	**0.311*****	**0.496*****
	(0.079)	(0.085)	(0.138)	(0.133)	(0.107)	(0.129)
FDI_BRIC	-0.066	-0.038	0.038	0.028	-0.017	-0.023
	(0.053)	(0.043)	(0.079)	(0.066)	(0.076)	(0.071)
Train_Cov_Perm	0.004	0.050	-0.024	-0.062	-0.005	-0.006
	(0.044)	(0.049)	(0.052)	(0.053)	(0.058)	(0.064)
ICT	0.045	0.006	-0.036	-0.053	-0.076	-0.053
	(0.079)	(0.103)	(0.092)	(0.080)	(0.096)	(0.116)
Techno	0.042	0.266	-0.098	-0.112	0.188	0.203
	(0.153)	(0.178)	(0.222)	(0.241)	(0.201)	(0.263)
EI_OrgProd_Fitted_Biprob	0.032	0.042	**0.217****	**0.251*****	**0.196***	**0.203***
	(0.085)	(0.075)	(0.095)	(0.094)	(0.109)	(0.111)
_cons	3.777***	3.787***	1.101***	1.058***	4.700***	4.564***
	(0.110)	(0.105)	(0.139)	(0.146)	(0.126)	(0.136)
N	535	535	535	535	535	535
chi2	276.917(20)	211.182(20)	187.431(20)	256.902(20)	302.216(20)	334.761(20)
r2_a	0.240	0.206	0.234	0.281	0.240	0.286

*; **; *** significant at 10%, 5%, 1% respectively; bootstrapped standard errors in parenthesis; Dummy variable reference groups: Metallurgy for sectors; SIZE_4 (>250 employees); Two near regional border provinces for geographical dummies Piacenza and Ferrara

Appendix

Tab.A1- Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Dep. First Stage					
EI	535	0.19	0.39	0	1
Process	535	0.69	0.47	0	1
Product	535	0.70	0.46	0	1
OrgProd	535	0.81	0.39	0	1
OrgLab	535	0.95	0.22	0	1
*Dep. Second Stage**					
VAEMP11	535	4.00	0.44	1.04	5.65
VAEMP10	535	4.01	0.40	2.19	5.36
OUTPUTEMP11	535	1.52	0.51	-2.16	4.36
OUTPUTEMP10	535	1.52	0.47	0.43	4.24
REVEMP11	535	5.26	0.60	1.74	7.62
REVEMP10	535	5.30	0.49	3.43	7.37
Covariates					
Sizedummies	535	\	\	0	1
Sector Dummies	535	\	\	0	1
Geographicaldummies	535	\	\	0	1
Export	535	0.33	0.31	0	1
FDI_BRIC	535	0.09	0.28	0	1
VAEMP0305	535	4.03	0.26	2.98	5.39
CO2_VA_PROV	535	0.31	0.23	0.07	1
R&D	535	0.79	0.40	0	1
Train_Cov_Perm	535	0.38	0.37	0	1
ICT	535	0.48	0.21	0	1
Techno	535	0.22	0.11	0	0.59
Share_EI_Municipality	535	0.20	0.22	0	1
EI_Fitted_Prob	535	0.11	0.17	0	0.91
EI_OrgProd_Fitted_Biprob	535	0.18	0.23	0	0.97

* For the accounting variables the missing values have been replaced by interpolated values

Tab.A2 - Variables Construction

Variables	Construction
Dep. First Stage	
EI	Dummy: 1 if firms introduced an environmental innovation; 0 otherwise
Process	Dummy: 1 if firms introduced a process innovation; 0 otherwise
Product	Dummy: 1 if firms introduced a product innovation; 0 otherwise
OrgProd	Dummy: 1 if firms introduced a production-organisation innovation (quality circles, team working, JIT, TQM); 0 otherwise
OrgLab	Dummy: 1 if firms introduced a labour- organisation innovation (e.g. job rotation, widening of employees competences, increased employees responsibility, wage premia reduction of hierarchical layers); 0 otherwise
Dep. Second Stage	
VAEMP11	Value added per capita (in log) in 2011
VAEMP10	Value added per capita (in log) in 2010
OUTEMP11	Output per capita (in log) in 2011
OUTEMP10	Output per capita (in log) in 2010
REVEMP11	Revenues per capita (in log) in 2011
REVEMP10	Revenues per capita (in log) in 2010
Covariates	
Sizedummies	Size dummies by employee: size_1 20-49 empl.; size_2 50-99 empl.; size_3 100-249 empl.; size_4 > 249 empl.
Sector dummies	Sector dummies based on two digit NaceRev.1 classification (Food, Machinery, NonMetallicMineralProd, CokeChemical, WoodRubberPlasticOther, Textile, Shoes, PaperPrinting, Metallurgy). Sectors were grouped according to the RAMEA grouping.
Geographicaldummies	Dummies of geographical location of the firm: NUTS 3 territorial units (9 provinces excluded extra region firms) were grouped into 3 clusters: CentralProv, EastProv, NearBordersProv
Export	Percentage of turnover made on international markets
FDI_BRIC	Dummy: 1 if firm invested in BRIC countries; 0 otherwise
VAEMP0305	Average value added per capita (in log) on the period 2003-2005
CO2_VA_PROV	CO2 emissions/Value Added by Province
R&D	Dummy: 1 if firm invested in R&D; 0 otherwise
Train_Cov_Perm	Percentage of permanent workers covered by training programmes
ICT	Composite index capturing the diffusion of complex ICT systems of management (ERP, EDI, SCM) and the number of activities covered by ICT (sell and buy, cooperation with suppliers and clients, management of orders and online selling)
Techno	Composite index capturing the extension of technological innovation activities, ranging from input ones (e.g. cooperation with research organisation, R&D activities and acquisition of new technologies) to output ones (e.g. introduction of new product and processes, radical or incremental innovations)
Share_EI_Municipality	Considering a firm j the variable is constructed as the percentage of firms introducing EIs and belonging to the same municipality of firm j, normalized according to the total number of firms belonging to the same municipality
EI_Fitted_Prob	Fitted probability of introducing EIs stemming from the probit model of the first stage of analysis
EI_OrgProd_Fitted_Biprob	Fitted probability of jointly introduce EIs and OrgProd stemming from the biprobit model of the first line of analysis: Pr(EIs=1;OrgProd=1))

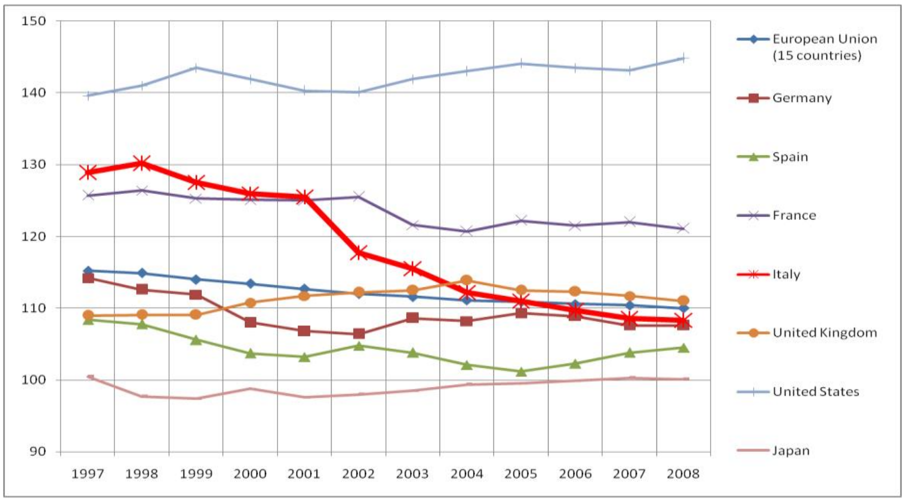
Table.A3 - Population and sample distribution (%) by sector and size

Population distribution (%)	Size					
Sector	20-49	50-99	100-249	250+	*Total*	*Total (a.v.)*
Food	5.65	1.94	1.16	0.64	9.39	*382*
Textile, Leather and Shoes	6.17	1.47	0.71	0.37	8.73	*355*
Wood, paper, chemical and rubber and other industries	12.8	3.54	1.9	0.84	19.08	*776*
Non metallicmineralproducts	3.81	1.23	1.18	0.79	7.01	*285*
Metallurgy	16.99	3.29	1.18	0.25	21.71	*883*
Machinery	21.44	6.37	4.06	2.24	34.1	*1387*
Total	66.86	17.85	10.18	5.11	100	
Total (a.v.)	*2720*	*726*	*414*	*208*		*4068*
Sample distribution (%)	Size					
Sector	20-49	50-99	100-249	250+	*Total*	*Total (a.v.)*
Food	3.18	2.80	1.68	1.12	8.79	47
Textile, Leather and Shoes	3.18	0.93	1.50	0.93	6.54	35
Wood, paper, chemical and rubber and other industries	7.66	5.23	3.74	1.50	18.13	97
Non metallicmineralproducts	1.50	3.36	0.93	2.06	7.85	42
Metallurgy	9.16	4.67	2.62	0.56	17.01	91
Machinery	12.52	15.51	8.22	5.42	41.68	223
Total	37.20	32.52	18.69	11.59	37.20	
Total (a.v.)	199	174	100	62		*535*

Tab.A4 - Correlations among the main non dichotomous covariates

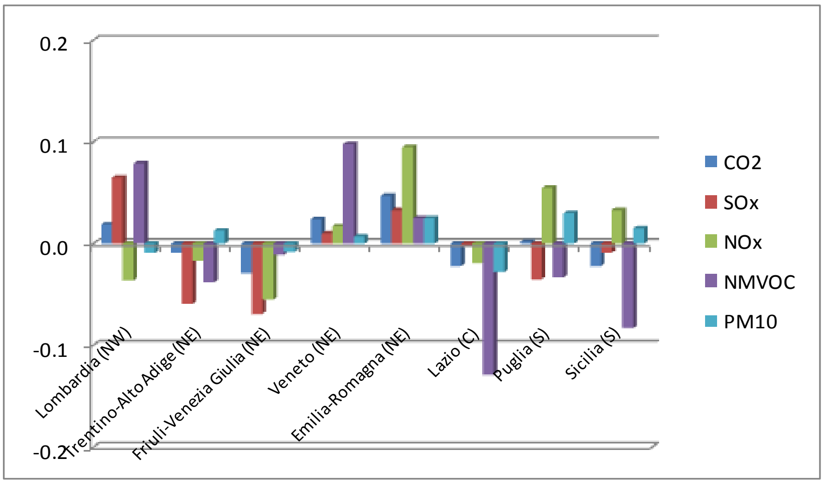
Train_Cov_Perm	1.00								
ICT	0.13	1.00							
Techno	0.23	0.41	1.00						
Export	0.00	0.19	0.22	1.00					
CO2_VA_PROV	0.09	-0.06	0.05	-0.04	1.00				
Share_EI_Municipality	0.11	0.05	0.14	0.00	0.09	1.00			
VAEMP0305	0.08	0.04	0.17	0.18	0.26	0.08	1.00		
EI_Fitted_Prob	0.35	0.16	0.25	0.09	0.07	0.87	0.25	1.00	
EI_OrgProd_Fitted_Biprob	0.37	0.20	0.27	0.11	0.07	0.85	0.26	1.00	1.00

Figure 1 – Labour Productivity trends in the EU



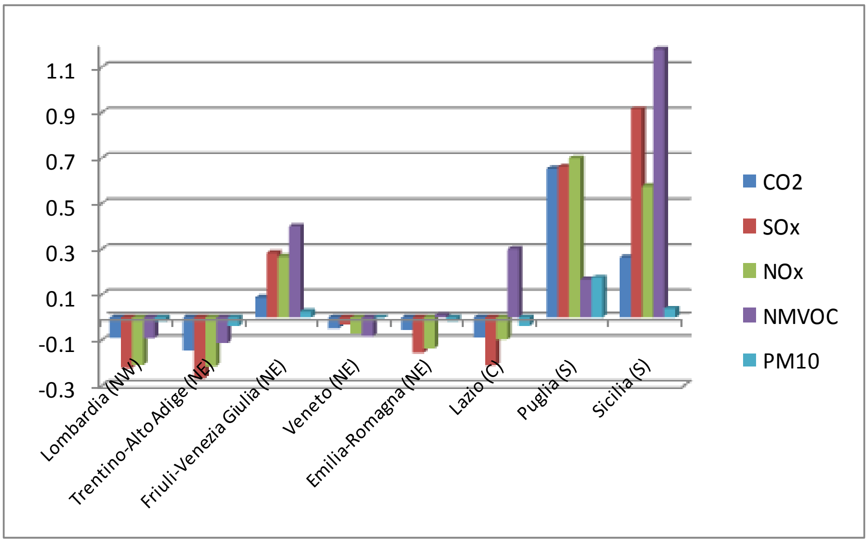
Source: Istat

Figure 2 - Shift share analysis - Regional gaps in terms of productive structure (structural component). Negative values represent performances better than the national average.



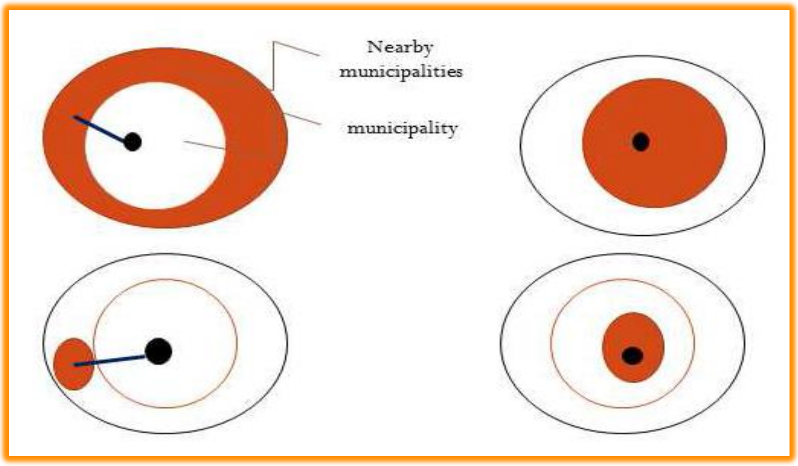
Source: Costantini et al (2013) from NAMEA data, Istat

Figure 3 - Shift share analysis - Regional gaps in terms of efficiency of production (efficiency component). Negative values represent performances better than the national average.



Source: Costantini et al (2013) from NAMEA data, Istat

Figure 4 – Four shares of Eco-innovation diffusion



Note: The shares of EIs diffusion are calculated in 4 different ways: 1) contiguous municipalities, all sectors (left-up), 2) contiguous municipalities, same sector (left-down), 3) same municipality, all sectors (right-up), 4) same municipality, same sector (right-down). The orange area indicates the firms taken into account in each case.

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