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 (EI) is crucial to greening the economy and achieving win win environmental – economic gains. EI are extensively related to various meso conditions which are external to the firm. The latter mainly refer to stakeholder's pressures, policy pressures, and spatial spillovers at the local and global level. Notwithstanding the importance of micro levers that back EI, we here especially focus the attention to relatively overlooked issues such as local spatial spillovers. These are relevant since growth depends upon the development of strong idiosyncratic regional factors – agglomeration economies are one important element - that must be integrated with the challenges posed by global markets. We analyse a rich dataset that covers the innovative activities and economic performances of firms in the Emilia Romagna Region in Italy, a manufacturing district rich area. We analyse firm's performances through a two steps conceptual model. First, we look at the relevance of spatial levers, namely whether agglomeration of EI adoption induces EI in a given firm. Second, we test whether EI have significantly increased firm economic performances. We observe that the role of agglomeration turns out to be fairly local in nature, given that spillovers are significantly inducing innovation within the municipality boundaries, which is coherent with the district based Marshallian economies of North Eastern Italy. Regarding economic performances, firms' productivity is positively related to EI adoption while profitability indicators are unrelated: export oriented firms that adopt EI and organizational change as strategies show a better economic performance. EI turn out as a potential key source of growth in the green economy to challenge the ongoing crisis.

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

1. **Introduction**

Environmental innovations (EI) are a key factor for the advancement of an economy towards a greener and more competitive economy. As it is well known, in fact, sustainable economic growth depends upon a constant investment in technological and organizational new ways of managing production. The EI potential is embedded within a very broad set of related factors and economic, social, environmental effects (Gilli et al., 2013; Rennings, 2000). One of the most

recent definitions of eco-innovation (used in the paper as synonymous of environmental innovations) presents 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. It is a wide concept that might encompass various dimensions of change (Kemp and Pontoglio, 2011).

As some authors have pointed out (Horbach, 2008; Horbach and Oltra, 2010), the empirical works on the drivers of EI should focus, therefore, on factors that can be categorised both as internal (e.g. training) and as external (e.g. cooperation with other agents) including among the latter both sector/structural features and policy levers (Borghesi et al., 2012; Veugelers, 2012). Horbach et al. (2012) recently frame the factors correlated to EI around the dimensions of regulation, market push factors, technological factors and firm's specific features.

This papers aims at enriching the discussion over the relational/spatial factors (De Marchi, 2012) that might be behind EI adoption and diffusion[1] in economically agglomerated regional settings. Despite very recent works (Horbach, 2013) the analysis of EI in regional settings is overlooked. Nevertheless, spatial and geographical effects might well be relevant omitted factors.

In line with the increasing EU emphasis on climate change and resource efficiency (following the EU roadmap launched in 2011), great relevance is assigned to the role of EI and its diffusion at sector and spatial levels (Gilli et al., 2013 for analyses on the EU), which is driven by local and global determinants and then drives economic-environmental performances (Costantini and Mazzanti, 2013).

Spatial and spillover effects arise crucially important under a perspective that defines 'regional competitive advantages' as a key factor to achieve sustainability and competitiveness aims. It is well known that the role of SMEs and district based industry is relevant in many EU industrial economies. Environmental and innovation economics scholars should deepen the analysis of how EI spreads and is adopted in economic environments that are rich in SMEs (Brioschi et al., 2002; Cainelli and Zoboli, 2004; Mazzanti and Zoboli, 2009). Too much emphasis has probably been placed on the behavior of large firms (e.g. corporates). This would allow fruitful integration between environmental economics and regional studies as well. In this regard, it is noticeable to observe that a sector based and regional perspective is coherent with new policy and growth approaches in the EU. More 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 to a more balanced perspective that accounts for both joint regional - sector based 'smart' specialization which explicitly accounts for climate change and environmental related issues in light of EU 20-20-20 strategy on environmental and energy targets (Iammarino and McCann, 2006; Costantini and Mazzanti, 2013). A more specific conceptual reference that is relevant is to the 'regional systems of innovation' approach (Iammarino, 2005). This approach investigates what are the key elements of regions that foster innovations (Cainelli, 2008; Cainelli and Iacobucci, 2007).

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

Taking stock of the past literature on the drivers and effects of environmental innovations, which has recently touched 'regional issues' (Cainelli et al., 2012), we attempt to originally extend the analysis of EI adoption and diffusion in two main ways. This effort is coherent with what stated by Truffer and Coenen (2012): *'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'*[2].

We aim at capturing along such lines the way EI levers are found beyond the firm's boundary, namely in the firm's territorial institutional and economic features. This extends the set of factors that favor the adoption of EI (Horbach et al., 2012) and strictly embeds EI within a regional setting environment. We then study the effects of EI, eventually integrated with other firm's strategies, on the economic performances[3]. We place a strong interest and focus on SME, that represent the large majority of firms and the heart of the industry in most EU countries. This focus is evidently important in countries such as Italy where the industry is historically structured upon a web of small and medium enterprises, that are often 'organised' in districts and exploit networking and cooperation activities as sources that enhance competitiveness through knowledge transfer (Boschma and Lambooy, 2002; Beaudry and Breschi, 2003). The analysis is framed around two main conceptual steps.

First, we introduce into the EI dimension the spatial dimension, namely the role that local spillovers might play in local systems of production. We aim at studying which geographical factors are relevant in supporting EI in regional systems characterized by high density of firms agglomerated in districts. This has been a somewhat overlooked issue regarding EI, but it is relevant given the complementarity of EI with techno-organizational change in a broader meaning (Antonioli et al., 2013). EI is not only a technical box, but a factor rather embedded within firm's institutional features and the territory the firm belongs to. Those local features then interplay and integrate with the global challenges firms – and sectors as loci of idiosyncratic innovation generation - face, namely exposure to international markets and for the sake of this paper the new challenges posed by climate change, an economic-environmental-technological issue.

Secondly, we explore the 'economic effects' of such EI adoption by firms, namely its impacts on labour productivity and sales, either if taken alone or if EI is integrated with other innovative strategies that create complementarity sets of actions (Antonioli et al., 2013; Hall et al., 2012). On the heels of the works by Porter (Ambec et al., 2010; Ambec and Barla, 2006; Ambec and Lanoie, 2008), researchers have traditionally looked at the competitiveness effects of EI adoption in the heavier manufacturing sectors (we refer to the seminal paper by Jaffe et al., 1995, and the recent paper on Italy by De Marchi and Grandinetti, 2013, De Marchi et al., 2013).

[2] For a broad discussion on regional studies and sustainability transitions issues we also refer to Benneworth et al. (2012).

[3] Further research might also assess the effect of innovation (and economic performances) on environmental performances when micro data on emission and waste indicators are available (Earnhart and Lizal, 2010; Marin and Mazzanti, 2013).

Summing up, the main aims of the empirical work are (i) to assess whether regional systems rich of agglomeration economies are a pre-condition for eco innovation diffusion, (ii) to investigate whether EI is integrated with other techno-organizational strategies and finally (iii) to analyse whether EI – taken alone or in integration with other innovations – impact on firm's productivity and profitability performances. The chains of tested correlations help shading light on the extent to which regional industrial systems are able to move towards a green economy oriented development, wherein environmental and economic performances are brought together by the diffusion of and the integration of various innovations, including EI.

We carry out the 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. The survey is temporally comparable with the CIS 2006-2008. In addition, we remarked that knowledge of firm's information in relation to its spatial location and balance sheets allows a deeper understanding of the 'firm behaviour'. We deliberately introduced 'CIS-like' questions[4] (see Borghesi et al., 2012; Cainelli et al., 2012 and Antonioli et al., 2013 for discussions on the EU CIS issues) on EI issues, as we had been following the process that brought to the formulation of EI questions in CIS5 (Kemp and Pearson, 2007). To study the EI effects on economic performances (Horbach and Rennings, 2012; Cainelli et al., 2011) we merge the innovation dataset with original balance account sheets at firm level. The investigation of the productivity effects of EI and whole firm's strategies is prominent given the 'productivity crisis' suffered by Italy. To additionally control for environmental regional features that act as precondition for the innovation activity, we also merge the innovation dataset with emission data.

The Emilia Romagna Region is a case worth being investigated under many respects. 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 EI is a core firm's strategy and whether the 'Emilian model' founded on dense agglomeration economies and strict based competitive advantages (Cainelli, 2008) is moving towards a greener economy. Though the region still remains relatively competitive, it has harshly suffered the 2009 crisis – through a collapse in exports – and is now on the way to find a new industrial setting and new competitiveness sources. EI might be a relevant part of this new development. On the other hand, though the region innovative capacity is helping its environmental performances (Costantini et al., 2013), the heavy industrial structure penalizes the overall performance, which is not so excellent in the Italian scenario, if compared to the average. The emissions per value added indicators place the region slightly above the national average. One explanation is that the environmental production efficiency is currently not sufficient to compensate for the scale and composition structure of the economy (Figures 1 and 2[5]). The diffusion of EI and its integration in firm's production processes is a key factor being analysed, given that EI is linked to the two market failures (under provision of innovation and over production of externalities) and might generate higher environmental and economic performances. The region is then a good case study

4 All questions are available upon request.

5 The two figures highlight that the region is more or less in line with the Italian average. Though the pure efficiency of production is higher than the average, this is only sufficient to compensate for the heavy economic structure. Looking at the future development, further increases in efficiency are needed to more than compensate the regional performance.

to analyse the process of a relevant industrial environment rich of small and medium enterprises towards the green economy path. A ‘new’ growth path that might potentially generate value to an economic system (the Italian one) that has suffered a ‘productivity stagnation’ over the past 10-13 years (Figure 3)[6]. Through the Emilia Romagna region performance has been better than the Italian one in the last decade, critical aspects for the current and future scenarios of this industrial macro region are present as well, one among others the necessity to complement the competitive advantages in historical strong sectors (main heavy manufacturing sectors, as ceramics, machinery) by the development of new sectors and new strategies within old sectors.

The paper is structured as follows. Section 2 presents the main research hypotheses and the data. Section 3 outlines empirical model and comments on econometric evidence. Section 4 concludes.

2. The set of Research hypotheses and the data

Though the role of external to the firm factors (e.g. cooperation with other firms, see Cassiman and Veugelers, 2002 for a seminal work)) have recently been studied even in the ‘environmental innovation’ literature (Cainelli et al., 2012; De Marchi, 2012), the understanding of those forces, in addition to market, technology and regulatory drivers (Horbach et al., 2012) is relatively still in its infancy. This is relevant to bring together the objective of greening the economy within industrial landscapes that are structured around small and medium firms. The analysis of spatial and sector spillovers (spatial and cognitive proximity driven, Costantini et al., 2013) as a potential omitted relevant covariate in innovation functions is even more relevant given that some key recent studies find that the internal resources devoted to R&D are not among the factors that impact on innovation adoption (Cainelli et al. 2012; Horbach and Oltra, 2010, Horbach, 2008; Borghesi et al., 2012). Including additional factors that are ‘external’ to the firm is thus crucial to further investigate EI realms.

Firms may in fact receive and exchange innovation inputs and knowledge at various geographical levels: regional, province, municipality, districts. ‘Eco innovation commons’, that is royalty free access to patented innovations or adoption of innovations new to firm and developed by (nearby) firms (Hall and Helmers, 2013) can contribute to the diffusion of EI in a territory, with impacts on its economic and environmental performances. The boundaries within which agglomeration economies eventually operate must be strictly assessed at empirical level and highly depends upon the institutional and economic features of a region. We exploit the original information on the location of firms we possess to test in this paper whether ‘within municipality’ or ‘outside municipality’ spillover impact on the adoption of innovation in firms, taking into account the fact that often the ‘district’ agglomeration is contained within a municipality boundary (in Italy). Building on the aforementioned reasoning and on the relevant literature, we define H1.

[6] Figures 4 and 5 additionally show that this ‘crisis’ is somewhat correlated to laggardness in environmental performances (Marin and Mazzanti, 2013).

H1 – The closeness to other firms that adopt EI might influence the diffusion of Innovation through knowledge transfer and the presence of homogeneous institutional conditions in a given territory.

The relationship between EI and its eventual economic effects is an important part of possibility to integrate sustainability and competitiveness (Costantini and Mazzanti, 2013). Although environmental innovations are a source of sustainability since they might reduce the environmental impact of firms, namely augmenting their efficiency, their economic impacts are a possible outcome, that the literature revolving around the Porter hypothesis has stressed since the early 90's (van Leuwenen and Mohnen, 2013). Within the difficulties of coherently merging innovation and economic data, the literature has witnessed specific studies that has challenged the analysis of the relation between economic, innovation and environmental performances (see Cainelli et al., 2010 for a survey), for Italian manufacturing and services firms (Cainelli et al., 2011study the productivity effects of environmental strategies and firm's green features), Czech firms (Earnhart and Lizal, 2010, who study the environmental-economic performances), large stock market German firms (Oberndorfer et al., 2013, who study the extent to which stock market value incorporate green firm's features). Those research directions extend the literature on the determinants of EI. What is possibly lacking in the current status of the literature – including the cited works - is the assessment of the economic effects of specific environmental innovations (Kemp and Pontoglio, 2011) instead of more general 'green investments'[7] or 'green actions' by firms[8]. These comments leads to H2 and H3, the side of EI effects.

We here exploit a CIS like survey[9] we derive from a survey on the firms of a macro region in Italy, to offer insights on the extent to which EI are really integrated within firm's strategies as to impact on firm's economic performances. We test the following H2 for two years: 2009 (the peak of the recession) and 2010 (the first recovery after the recession)[10] to understand whether EI had impacts in two different years of the economic 'crisis'[11]. We use both productivity and profitability indicators to enrich the evidence given our data availability and present some sensitivity tests. This is the side of the tale that touches on the economic effects of environmental innovations.

7 Along somewhat different conceptual lines, Antonietti and Marzucchi (2013) analyse the extent to which the impacts on productivity determine by environmental strategies then generates diverse internationalisation activities.

8 The CIS usually prevents from carrying out such an assessment given the privacy statement. CIs micro data are either aggregated or anonymous.

9 We have replicated most questions, though also adding new information with respect to Cis, which allows us testing more hypotheses in relation to the integration between EI and other firm's strategies.

10 The choice of the years is justified both on data availability and economic reasons. Balance sheets data are available for the interviewed firms over 2002-2010. To mitigate endogeneity problems, we select the dependant variable so to set a lag with respect the innovation adoption.

11 That caused in Italy, Germany and the Region we analyse itself a collapse of GDP in 2009 of around 6%, largely dependent upon the export performances.

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

H3 - The more EI is correlated to other techno organizational strategies of the firm, the higher the probability that economic performances are positively influenced.

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, North East of Italy (Cainelli et al., 2012). The sample is a stratified sample by size, sector and geographical location of the firms and it is representatives of the firms population (see tab. A1 in appendix). We focus on relatively larger firms given the complexity and richness of data we aimed to gather (techno-organisational innovation, eco innovations, international strategies, HRM; the full 12 pages questionnaire is available upon request). Interviews were carried out in 2009 by a professional company specialised in polls and surveys. To allow comparison with the EU CIS5, we covered 2006-2008. Eco innovations questions specifically aim at replicating the CIS section on eco innovation.

Given the aim of the paper, we originally merge the Emilia Romagna survey with balance accounts sheets that are available at firm level for the period 2002-2010[12]. The time span allows considerable flexibility in the use of such data, both as EI covariate (using data before 2006) and as the main dependent variable to test the impact of EI on productivity and profitability – economic performance - in 2009 and 2010.

The rich set of information we have at our disposal allows us to use a relatively large block of controls in order to ‘absorb’ 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 innovation variables on technological, organizational and ICT spheres (see tab.A2 and A3 for a full description of the covariate and their descriptive statistics). The main non-dichotomous regressors included in in our estimations, as described in the next section, do not seem to generate problem of severe multicollinearity as emerges from the correlations reported in Tab.A4 in appendix.

3. The evidence: What is behind eco innovations and its economic effects

We employ a two stage procedure to provide evidence regarding H1-H3 testable implications. First, we investigate the factors that are behind EI through a full regional lens. The main addition we provide to the literature on the drivers of EI is the inclusion of a 'spatial referred' term (Share_EI_Municipality) that absorb omitted heterogeneity from a statistical point of view and gives information on the role of agglomeration as a force behind the adoption of EI in local

[12] 2011 data will be available at the end of 2013.

industrial systems. In this first econometric stage, the factors behind EI are studied both taking innovations on a separate basis (probit models) and by verifying the relevance of correlation between various innovations (e.g. EI and technological innovations) through the implementation of bivariate and multivariate probit. This scheme follows Hall et al. (2012) recent analysis of italian firms. 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 as shown in following sub-section 3.1, Share_EI_Municipality is the 'spatial referred' as described above and e is the error term.

The second part of our empirical exercise directly rely on the use of accounting variables to construct dependents that proxy labour productivity and on the use of predicted values of the first stage regressions into the second stage economic performance equation. We focus on diverse proxies of labor productivity: value added per employee (VAEMP), output per employee (OUTPUTEMP) and revenues per employee (REVEMP). All the three productivity indicators are measure on the 2009 and 2010 years. The diachronic nature of the second stage specification, given that the covariates are measure on the time span 2006-2008, help us in mitigating potential enogeneity problems due to simultaneity (Michie and Sheehan, 2003):

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

where PERF indicates each performance indicator, CONT is again a set of controls and INNO is here a full set of innovation indexes, which are 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 to introduce environmental innovation given by the first stage, and, more specifically, it is the probability to jointly introduce EI and other innovations (Process, Prod, OrgProd and OrgLab) since it comes from the multivariate probit estimation, u is the error term and the subscripts t and t-1 indicate that the covariates are measure with a temporal delay with respect to the dependents.

3.1 The factors correlated to EI in a regional setting

We follow a two-stage procedure: first we perform (multi)probit estimations taking EI as dependent variable, and then we use the fitted values of EI deriving from the first stage to evaluate their correlation with several alternative indicators of firms' productivity.

Table 1 shows the results of the estimations performed at the first stage. Columns (2) to (7) report the probit (column 2), bi-probit (columns 3 to 6) and multi-probit estimations respectively. As the table shows, the valued added per employee in the past (2003-2005) as well as the training of the employees turn out to be statistically significant and positively correlated to EI in

all estimated regressions. 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 perform also 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 more and better trained workers are likely to be also more productive, which may spur the adoption of EI by the firm, thus possibly generating a virtuous circle.

A particularly interesting result emerging from the analysis is that the share of firms performing EI within each municipality (Share_EI_Municipality)[13] is always statistically significant and positively related with the probability of adopting EI. This suggests the existence of a positive spillover effect of EI within the municipalities in ER: being located in a municipality with a higher share of EI enhances the probability of each firm of adopting EI. Notice that this does not apply at the province level as the dummies for the provinces of Emilia (BOMOREPR) and of Romagna (RARNFC) are not statistically significant in all estimated regressions of stage 1.[14] The existence of EI spillover effects at the municipality level can probably be explained by the particularly large size of the ER municipalities, that are about twice as large as those in Veneto and 4 times larger than the municipalities of Lombardia and Piemonte (the other main industrial regions in Northern Italy). The relevance of the municipality context for EI, moreover, is consistent with the findings of the literature on the Italian industrial districts that generally shows a long-standing trend towards firms' agglomeration and specialization within single municipalities (Brioschi et al., 2002). It is also coherent with the well-known 'social capital' and civicness that Putnam (1993) highlights in its seminal book. The Emilia Romagna region is at the top of the civicness ranking (p.97) and institutional performance (p.84). This social capital glue (Cainelli et al., 2007) also creates the pre-condition for firms to engage in solid networking. The 'space' is relevant in many dimensions, not only as a 'distance' concept: the proximity of firms and agents in a context that offers reliability in terms of socio-institutional performances goes beyond the mere space element. The ‘municipalities’ factor we find is interesting since if one the one hand can be explained by the recognised larger size of regional local authorities, on the other hand recalls the importance of municipalities in the development of Italian capitalism at least in the North (Putnam, 1993; Bennett..). Putnam in chapter 5 of the mentioned book comments on the 'roots of civic community' and civic legacies of medieval Italy. He stresses that 'although regional governments were established in 1970 [...] the regions themselves had far deeper historical roots. Italy had been since the fall of the Roman world and especially after the dark ages a 'geographical expression, a congeries of small city-states' (p. 121). If on the one hand fragmentation leads to economic backwardness, Putnam argues that this has not always been the case: innovative political structures also emerged over those centuries. In the towns of Northern Italy, unprecedented forms of self-government emerged over 1000-1500 a.c. The new form of

[13] We recall the variable is the average adoption share (that is bounded between 0 and 100) of firms located in the same municipality. We also tested the same variable, calculated on the firms located in contiguous municipalities.

[14] The same applies to the share of firms adopting EI across neighboring municipalities that is also not statistically significant in all estimated regressions. This seems to confirm that EI spillover effects in ER tend to occur within single municipalities rather than across them. We tested spillover effects belonging both to the overall neighboring firms and to the neighboring firms in the same sector. Results do not change. More than sector features, it is the location in the municipal area that supports the EI diffusion. See Figure A1 that sketches how the two ‘spillover’ oriented variables are conceptually constructed.

political and social organisation of life even in economic terms was the 'commune', that is the municipality. In the words of Putnam (1993, p.124), 'by the twelfth century communes has been established in Florence, Venice, Bologna, Genua, Milan and virtually all the other major towns of northern and central Italy, rotted 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 provide self-help and mutual assistance of social as well as for strictly occupational purposes' (p.125).

We notice that estimations were performed taking as benchmark sector the most polluting one (metallurgy). This sector is also particularly innovative in ER (ranking second among all sectors in terms of EI after Wood, rubber, plastic and Coke and refinery). The negative (and statistically significant) sign of the Food and Machinery sectors, therefore, reflects the relatively less EI performed by the latter sectors with respect to the benchmark sector.

3.2 The economic performance impact of eco innovations

Table 2 shows the correlation of several covariates (including EI) on three alternative performance indicators that refer to 2010[15]: (1) the production volume, (2) the valued added per employee and (3) the revenues per employee[16]. As the table shows, EI turns out to be positively and significantly correlated to two of the three dependent variables (production volume and the revenues per employee). Organizational innovation, moreover, can also play a role in improving the firm's performance, though its positive coefficient turns out to be statistically significant only for the first performance indicator.

Beyond eco- and organizational-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 to the export variable, its positive sign confirms the importance for ER firms of having access to foreign markets, particularly during a year (2010) in which the internal demand tended to collapse due to the on-going economic crisis. 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).

The 2005 CO_2 emission intensity 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 better performing firms were also generally more polluting in 2005, namely, before the European Emission Trading Scheme (EU-ETS) on GHG emissions came into action. While the actual effectiveness of the EU-ETS and its impact on the firms' performance is currently the object of debate in the 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 from an economic viewpoint than the rest of the market in 2010, whether still relatively more polluting or not.

[15] Regressions regarding 2009 are available upon request. Results do not change. We retain 2010 in the text given that 2009 was a strong idiosyncratic year in terms of economic cycle. 2010 is the first ‘normal’ year after the 2009 downturn.

[16] Profitability indicators do not significantly correlate with innovation variables. This was expected given that they are influenced also by other factors compared to productivity. Results are available upon request. For the sake of brevity we do not include the related tables.

Differently from the estimation results in stage 1 (see previous section 3.1), the set of ‘province dummy’ turns out to be 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 VA, which can explain the worse performance in terms of VA per employee.

Finally, some sectors (particularly food and 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 and/or foreign demand for their products (food and energy, respectively).

4. **Conclusions**

We study, in a regional setting that is characterised by historically high and circumscribed innovation intensity and relevant local environmental impacts, the role of agglomeration economies, that is knowledge / innovation spillovers, as a potential relevant force behind the adoption of environmental innovations. The increasing literature on EI has rarely if at all tackled the eventual effect of agglomeration economies, which are nevertheless crucial especially in areas where the richness of districts and firm’s networking influence the overall performance of firms. We analyse EI’s role for manufacturing firms 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 allow verifying a chain of testable implications. First, whether ‘local external conditions’, primarily geographical agglomeration, influence EI diffusion. Second, and consequentially, whether the diffusion of EI exert any impact on firm’s productivity and profitability.

First, we do find that local conditions 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 institutional conditions to provide concrete (innovative) contents to the green economy paradigm. EI adoptions correlate to internal firm’s features (e.g. Training, sector structural features) and to ‘external’ factors, among which we stress for the first time the role of specific geographical elements. Firms receive support to EI adoption from being located in 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. Nevertheless, municipal level spillovers tend to prevail over other geographical factors as well as over sector belonging. It is within the municipal area that EI diffuse.

EI also tend to be adopted in correlation to some other firm’s techno-organizational strategies. Among those, innovations related to the organization of production (team working, quality circle, etc..) appear the most relevant factor in this ‘green’ strategic integration of practices. This outcome reinforces the possibility of a potential integration of EI within firm’s production

processes - when EI are not merely of end of pipe nature - that recent works highlighted (Antonioli et al. 2013).

Second, we observe that the productivity performances of firms tend to be higher for enterprises that jointly adopt EI *and* organizational innovations: the greening of the economy passes through a full reorganisation of the productive process. EI is not an isolated strategy even when firms do not face strict environmental policy constraints as in the Italian context. Voluntary or not, the fact some economic performances are positively influenced by correlated eco and non-eco innovations provides a rationale to challenge the green economy societal change. Innovations that occur in small and medium firms are a relevant part of the story we can write. This result is even more relevant if we think about the possibility to exploit the opportunities that are offered by green technology invention and adoption to reverse the current critical stagnation of labor productivity in Italy.

Further research might proceed along those lines by further extending the analysis of spatial factors on the one hand, and by investigating EI effects on other firm's social aims, employment and environmental performances among others.

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Table 1 – The factors behind the adoption of EI (first stage)

	Probit	Bi-Probit								Multi-Probit				
	EI	EI-Proc		EI-Prod		EI-OrgProd		EI-OrgLab		EI	Proc	Prod	OrgProd	OrgLab
size_1	-0,201	-0,196	-0.693***	-0,197	-0.479*	-0,202	-0,339	-0,211	0,565	-0,198	-0.656***	-0,39	-0,357	0,384
	(-0.68)	(-0.63)	(-2.72)	(-0.63)	(-1.83)	(-0.65)	(-1.15)	(-0.68)	(1.17)	(-0.66)	(-2.58)	(-1.48)	(-1.20)	-0.91)
size_2	-0,438	-0,432	-0,00275	-0,436	-0,196	-0,448	-0,205	-0,44	-0,236	-0,442	0,0265	-0,12	-0,227	-0,412
	(-1.60)	(-1.52)	(-0.01)	(-1.54)	(-0.79)	(-1.58)	(-0.72)	(-1.55)	(-0.56)	(-1.61)	(0.11)	(-0.48)	(-0.81)	(-1.27)
size_3	0,167	0,18	0,109	0,158	0,156	0,208	-0,39	0,155	0,24	0,181	0,149	0,263	-0,421	0,0357
	(0.61)	(0.61)	(0.42)	(0.54)	(0.57)	(0.71)	(-1.33)	(0.53)	(0.51)	(0.66)	(0.57)	(0.94)	(-1.40)	(0.09)
Food	-0.604**	-0.603*	-0,108	-0.603*	0,152	-0.622*	-0,366	-0.602*	0,452	-0.598*	-0,119	0,148	-0,391	0,527
	(-1.98)	(-1.75)	(-0.43)	(-1.76)	(0.61	(-1.80)	(-1.46)	(-1.75)	(1.08)	(-1.95)	(-0.48)	(0.64	(-1.61)	(1.53)
Machinery	-0.493**	-0.491**	-0,125	-0.509**	0.349**	-0.460**	0,187	-0.487**	0.834***	-0.477**	-0,14	0.348**	0,169	0.783***
	(-2.19)	(-2.23)	(-0.76)	(-2.31)	(2.15)	(-2.08)	(1.09)	(-2.21)	(2.82)	(-2.08)	(-0.87)	(2.16)	(0.97)	(3.3)
NonMetallic	-0,46	-0,453	0,109	-0,466	0,229	-0,424	-0,17	-0,466	0,699	-0,433	0,144	0,302	-0,203	0,512
	(-1.40)	(-1.22)	(0.4)	(-1.27)	(0.87)	(-1.16)	(-0.63)	(-1.26)	(1.55)	(-1.29)	(0.55	(1.19)	(-0.76)	(1.27)
CokeChemical	-0,472	-0,475	0,0141	-0,458	0,0913	-0,512	0,0504	-0,471	5,574	-0,462	0,0102	0,0494	0,00545	3.871***
	(-1.23)	(-1.18)	(0.05)	(-1.15)	(0.29)	(-1.27)	(0.15)	(-1.17)	(0.01)	(-1.18)	(0.03)	(0.16)	(0.02)	(6.91)
WoodRubberPlasticOther	-0,182	-0,18	-0,254	-0,186	-0,0613	-0,174	0,00532	-0,193	0,279	-0,183	-0,263	-0,0551	0,0201	0,282
	(-0.65)	(-0.62)	(-1.10)	(-0.65)	(-0.28)	(-0.61)	-0,02	(-0.67)	(0.74)	(-0.65)	(-1.19)	(-0.24)	(0.09)	(0.87)
CentralRegion	-0,256	-0,258	0,163	-0,251	0,0332	-0,245	0,102	-0,234	0,622	-0,236	0,173	-0,0313	0,0615	0,476
	(-0.68)	(-0.68)	(0.55)	(-0.66)	(0.11)	(-0.65)	(0.32)	(-0.62)	(1.31)	(-0.64)	(0.58)	(-0.11)	(0.2)	(1.02)
EastRegion	0,0975	0,0912	0,0891	0,108	0,0802	0,091	0,27	0,109	0,449	0,0928	0,111	0,0751	0,213	0,284
	(0.27)	(0.25)	(0.31)	(0.3)	(0.28)	(0.25)	(0.84)	(0.3)	(0.93)	(0.26)	(0.38)	(0.27)	(0.73)	(0.57)
Export	0,19	0,188	0,116	0,188	0.503**	0,16	0,184	0,182	-0,569	0,152	0,12	0.454*	0,213	-0,408
	(0.65)	(0.61)	(0.51)	(0.62)	(2.15)	(0.52)	(0.74)	(0.59	(-1.45)	(0.52)	(0.48)	(1.89)	(0.86	(-1.16)

CO2_VA_PROV	-0,511	-0,514	-0,0013	-0,5	-0,181	-0,512	0,0693	-0,509	0,156	-0,525	0,0134	-0,247	0,0148	0,029
	(-1.09)	(-1.04)	(-0.00)	(-1.02)	(-0.46)	(-1.04)	(0.16)	(-1.03)	(0.23)	(-1.12)	(0.04)	(-0.68)	(0.04)	(0.04)
R&D	-0,0432	-0,0507	0.632***	-0,0351	0.823***	-0,104	0,249	-0,0424	0,131	-0,0918	0.622***	0.853***	0,241	0,129
	(-0.19)	(-0.21)	(4.12)	(-0.15)	(5.32)	(-0.43)	(1.54)	(-0.18)	(0.49)	(-0.41)	(3.86)	(5.62)	(1.49)	(0.52)
Train_Cov	1.018***	1.023***	0.348**	1.008***	0,225	1.034***	0,289	1.019***	1.435***	1.028***	0.339*	0,227	0,282	1.410***
	(4.33)	(4.6)	(2.01)	(4.55)	(1.3)	(4.67)	(1.55)	(4.59)	(3.1)	(4.52)	(1.93)	(1.29)	(1.49)	(3.76)
ICT	0,573	0,575	1.062***	0,6	0.633*	0,597	0.756**	0,571	1.540**	0,644	1.078***	0.607*	0.748*	1.485***
	(1.37)	(1.44)	(3.2)	(1.5)	(1.92)	(1.48)	(2.22)	(1.43)	(2.4)	(1.53)	(3.31)	(1.88)	(1.92)	(2.67)
FDI_BRIC	0,15	0,152	-0,0647	0,152	0,297	0,162	0,138	0,15	0,0972	0,164	-0,0232	0,367	0,163	0,16
	(0.56)	(0.52)	(-0.25)	(0.52)	(0.99)	(0.56)	(0.45)	(0.52)	(0.19)	(0.61)	(-0.09)	(1.28)	(0.58)	(0.4)
Share_EI_Municipality	4.737***	4.740***	-0,114	4.725***	-0,06	4.686***	0,271	4.741***	0,576	4.688***	-0,106	-0,0884	0,273	0,464
	(8.62)	(9.14)	(-0.40)	(9.14)	(-0.21)	(9.13)	(0.87)	(9.12)	(1.06)	(8.77)	(-0.40)	(-0.30)	(0.92)	(0.9)
VA_EMP0305	1.561***	1.568***	0,344	1.559***	-0,0701	1.555***	0.575**	1.540***	0,371	1.536***	0,38	-0,021	0.584*	0,295
	(4.28)	(3.62)	(1.28)	(3.64)	(-0.25)	(3.56)	(2.07)	(3.57)	(0.84)	(4.15)	(1.36)	(-0.08)	(1.79)	(0.86)
Cons	-8.225***	-8.252***	-1,772	-8.229***	-0,274	-8.175***	-2.033*	-8.149***	-1,972	-8.120***	-1.961*	-0,484	-1,979	-1,304
	(-5.09)	(-4.51)	(-1.56)	(-4.54)	(-0.23)	(-4.44)	(-1.72)	(-4.47)	(-1.06)	(-5.01)	(-1.67)	(-0.42)	(-1.46)	(-0.86)
N	529	529		529		529		529				529		
Rho	\	0,0489		-0,103		0,343		0,253				\		
chi2_c	\	0,185		0,816		6,358		0,938				84,98		
athrho: BiProbit		0,0489		-0,104		0.358**		0,258		0.312**		0.666***		0.414***
		-0,43		(-0.90)		-2,4		-0,93		-2,49		-6,65		-3,09
athrho: MultiProbit														
EI-OrgProd										0.312**				
										-2,49				
Proc-Prod												0.666***		
												-6,65		
OrgProd-OrgLab														0.414***

-3,09

*; **; *** significant at 10%, 5%, 1% respectively; z stats in parenthesis; Dummy variables reference groups: Metallurgy for sectors; SIZE_4 (>250 employees); Two ner regional borders provinces for geographical dummies Piacenza and Ferrara.

Textile, Shoes and PaperPrinting dropped because predict failure perfectly; Only significant atrho reported for the multivariate probit

Table 2 – Performance effects (second stage)

	OutputEMP2010	VAEMP2010	RevenuesEMP2010
size_1	-0,0057	-0,0803	0,108
	(-0.07)	(-1.26)	(1.41)
size_2	0,00602	-0,0221	0,0766
	(0.09)	(-0.39)	(1.12)
size_3	0,0435	-0,0174	0,108
	(0.63)	(-0.28)	(1.51)
Food	0.874***	0.450***	0.862***
	(8.42)	(6.73)	(9.63)
Machinery	0,0481	0.181***	0.204***
	(0.97)	(3.69)	(3.99)
NonMetallic	0,0867	0.141**	0.169**
	(1.24)	(2.07)	(2.01)
CokeChemical	0.498***	0.412***	0.634***
	(4.83)	(4.97)	(6.01)
WoodRubberPlasticOther	0.146*	0,0151	0.140*
	(1.73)	(0.22)	(1.76)
Textile	0.308**	-0,125	0,185
	(2.42)	(-1.30)	(1.39)
Shoes	0.406***	-0,0158	0.377***
	(3.53)	(-0.16)	(2.61)
PaperPrinting	0.202*	0,0124	0,193
	(1.96)	(0.11)	(1.36)
CentralRegion	0.196*	-0,0103	0.171*
	(1.89)	(-0.14)	(1.9)
EastRegion	0,11	-0.201***	-0,0336
	(1.03)	(-2.89)	(-0.35)
Export	0.119*	0.181***	0.161**
	(1.68)	(2.98)	(2.17)

CO_2_VA_PROV	0.272**	0.252***	0.366***
	(2.1)	(3.11)	(3.16)
FDI_BRIC	0,0221	-0,0644	-0,0358
	(0.3)	(-1.17)	(-0.49)
Org	0.374**	0,0366	0,229
	(2.2)	(0.24)	(1.31)
Train_Cov_Indet	-0,0587	0,0185	-0,028
	(-1.02)	(0.38)	(-0.47)
ICT	-0,103	0,0239	-0,111
	(-1.10)	(0.27)	(-1.13)
Tecno	-0,341	0,0773	0,128
	(-1.43)	(0.45)	(0.59)
EI_Fitted_MultiProb	*0.325***	*0,0253*	*0.250**
	(2.43)	(0.19)	(1.68)
Cons	0.975***	3.673***	4.555***
	(6.52)	(32.68)	(30.73)
N	529	529	529
F(d.f.)	6.353(21)	10.59(21)	8.798(

*; **; *** significant at 10%, 5%, 1% respectively; t stats in parenthesis; Dummy variables reference groups: Metallurgy for sectors; SIZE_4 (>250 employees); Two near regional borders provinces for geographical dummies Piacenza and Ferrara.

Appendix

Tab.A1- Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Dep. First Stage					
EI	529	0.20	0.40	0	1
*Dep. Second Stage**					
VAEMP09	529	3.83	0.47	1.02	5.86
VAEMP10	529	3.91	0.43	0.59	5.36
OUTPUTEMP09	529	1.43	0.51	0.21	4.08
OUTPUTEMP10	529	1.43	0.49	0.33	4.24
REVEMP09	529	5.16	0.55	3.45	7.80
REVEMP10	529	5.22	0.49	3.33	7.27
Covariates					
Size dummies	529	\	\	0	1
Sector Dummies	529	\	\	0	1
Geographical dummies	529	\	\	0	1
Export	529	0.33	0.31	0	1
FDI_BRIC	529	0.09	0.29	0	1
VAEMP0305	529	3.96	0.27	2.91	5.32
CO2_VA_PROV	529	0.31	0.23	0.07	1
R&D	529	0.80	0.40	0	1
Train_Cov_Indet	529	0.38	0.37	0	1
ICT	529	0.48	0.21	0	1
Org	529	0.26	0.14	0	0.75
Techno	529	0.22	0.11	0	0.59
Share_EI_Municipality	529	0.20	0.23	0	1
EI_Fitted_MultiProb	529	0.11	0.17	0.00	0.91
Process	529	0.69	0.46	0	1
Product	529	0.70	0.46	0	1
OrgProd	529	0.81	0.39	0	1
OrgLab	529	0.95	0.22	0	1

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

Tab.A2 - Variables Construction

Variable	Construction
Dep. First Stage	
EI	Dummy: 1 if firms introduced an environmental innovation; 0 otherwise
Dep. Second Stage	
VAEMP09	Value added per capita (in log) in 2009
VAEMP10	Value added per capita (in log) in 2010
OUTPUTEMP09	Output per capita (in log) in 2009
OUTPUTEMP10	Output per capita (in log) in 2010
REVEMP09	Revenues per capita (in log) in 2009
REVEMP10	Revenues per capita (in log) in 2010
Covariates	
Size dummies	Size dummies by employees: 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.
Geographical dummies	Dummies of geographical location of the firm: NUTS 3 territorial units (9 provinces excluded extra region firmsl) were grouped in 3 clusters: CentralProv, EastProv, NearBordersProv
Export	Percentage of turnover made on international markets
FDI_BRIC	Dummy: 1 if firm invested 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

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 metallic mineral products	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	3.21	2.84	1.70	1.13	8.88	47
Textile, Leather and Shoes	2.84	0.95	1.51	0.95	6.24	*33*
Wood, paper, chemical and rubber and other industries	7.56	5.29	3.78	1.51	18.15	*96*
Non metallic mineral products	1.51	3.40	0.95	2.08	7.94	*42*
Metallurgy	8.88	4.73	2.65	0.57	16.82	*89*
Machinery	12.48	15.69	8.32	5.48	41.97	*222*
Total	36.48	32.89	18.90	11.72	100	
Total (a.v.)	193	174	100	62		*529*

Tab.A4 - Correlations among the main non dichotomous covariates

	1	2	3	4	5	6	7
1 Org	1						
2 Train_Cov_Indet	0.2244	1					
3 ICT	0.3906	0.1212	1				
4 Techno	0.4303	0.2196	0.4025	1			
5 Share_EI_Municipality	0.0146	0.0961	0.0489	0.1341	1		
6 VAEMP0305	0.1471	0.0666	0.038	0.1437	0.0551	1	
7 EI_Fitted_MultiProb	0.2405	0.3702	0.2854	0.3513	0.7156	0.2752	1

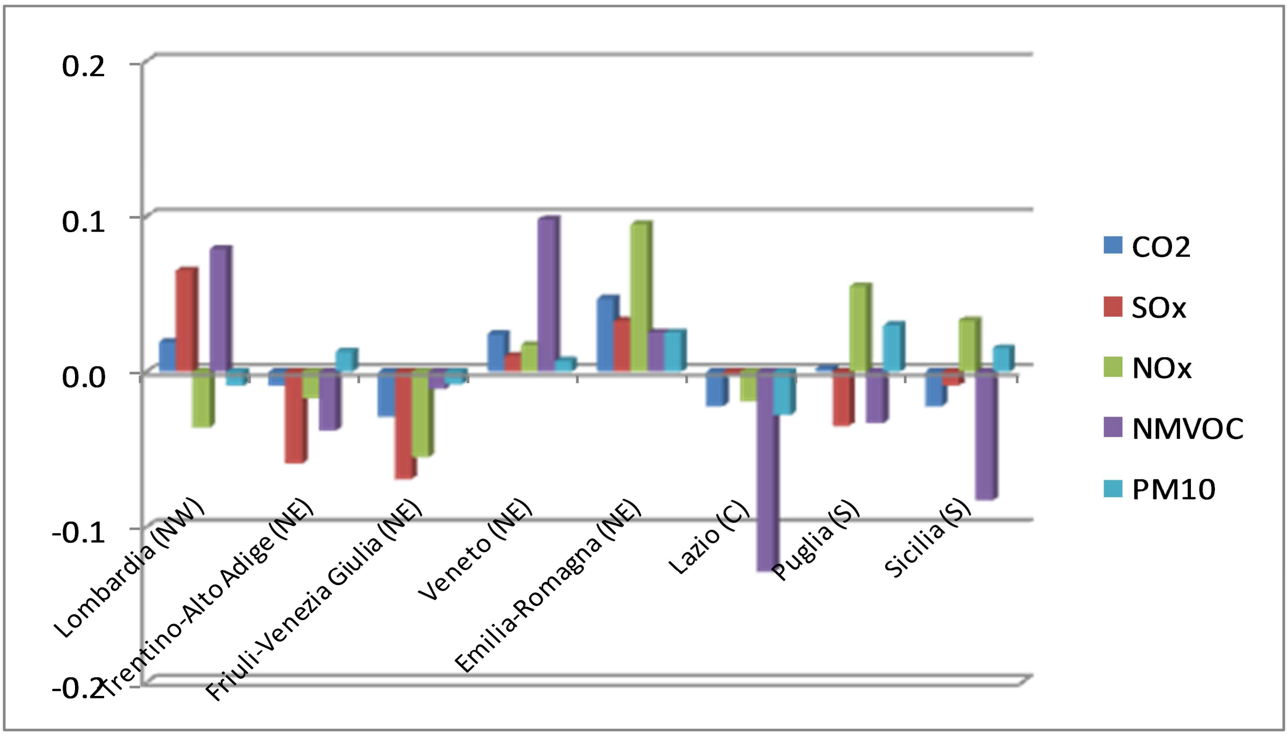
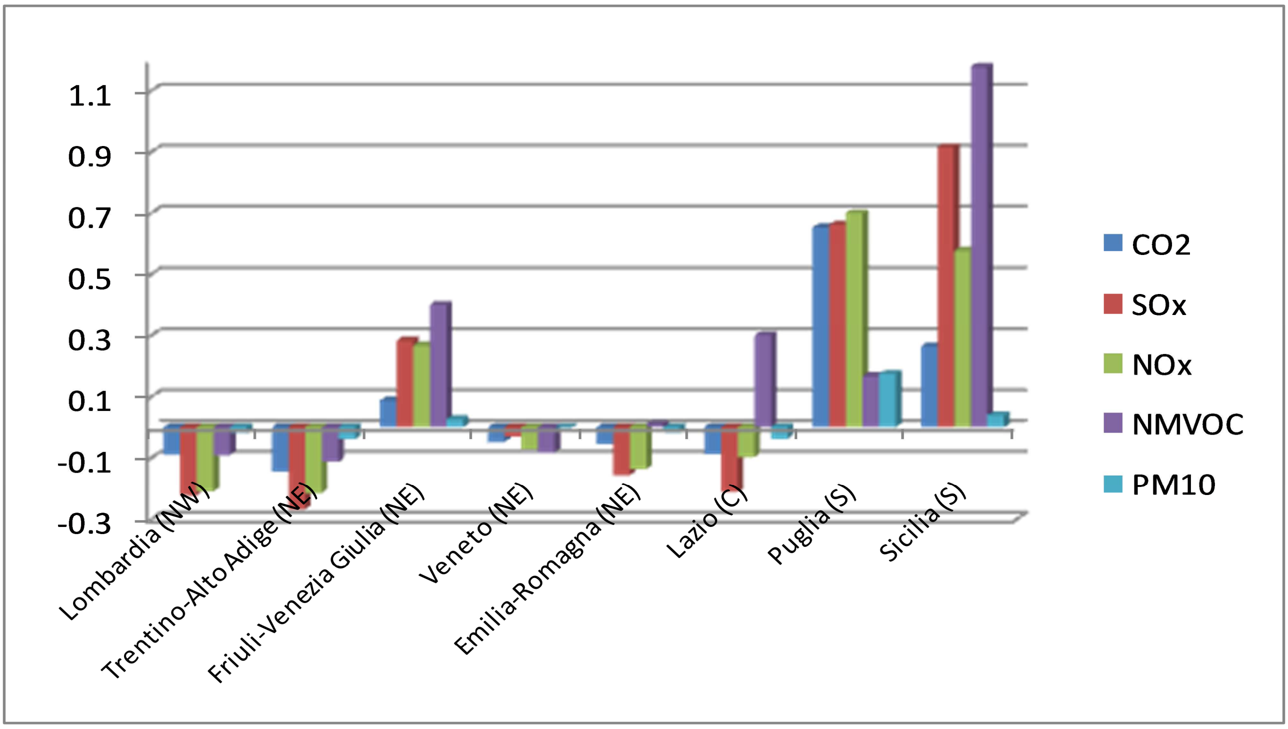


Figure 1 - Shift share analysis - Regional gaps in terms of productive structure (structural component). Negative values represent that performances are better than national average

Figure 2 - Shift share analysis - Regional gaps in terms of efficiency of production (efficiency component). Negative values represent that performances are better than national average



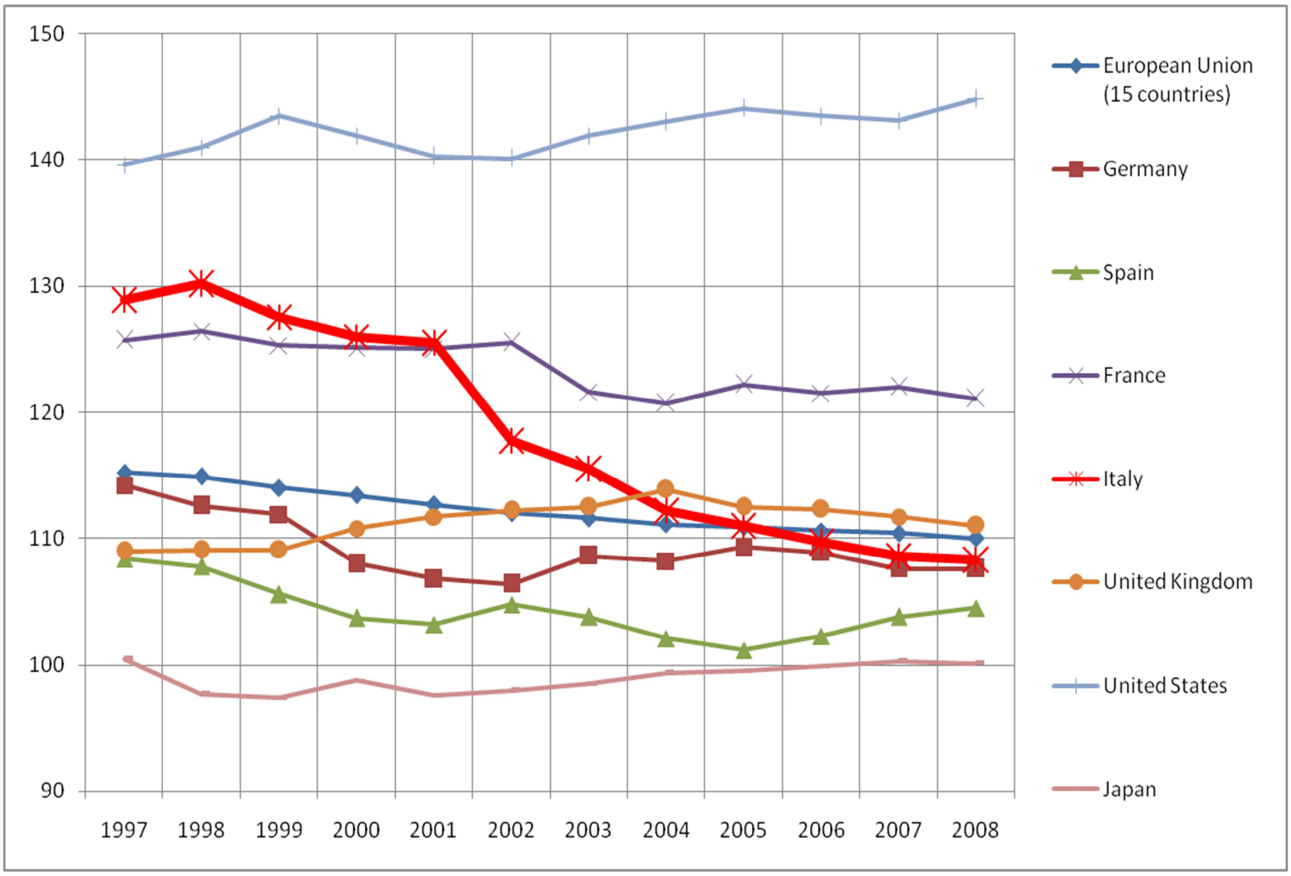


Figure 3 – Labour Productivity trends in the EU

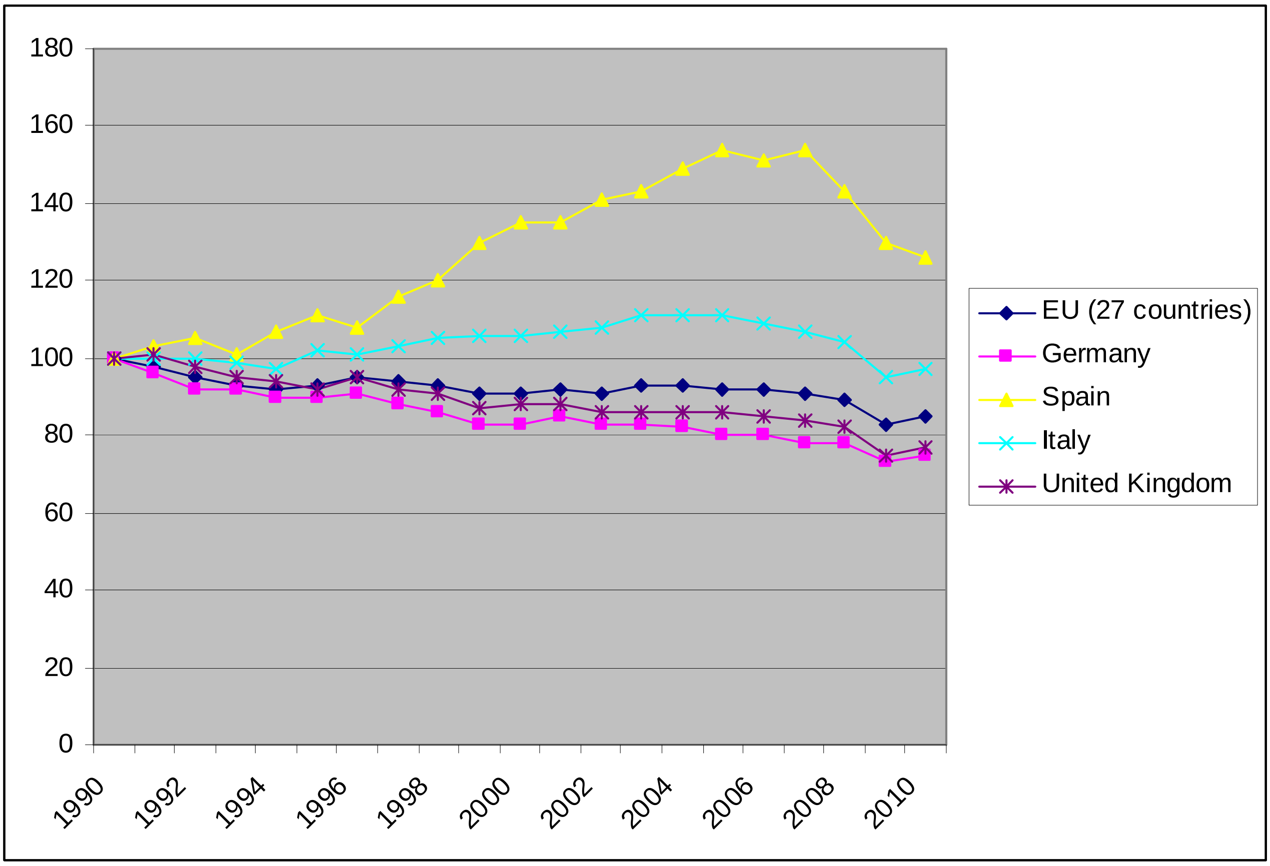


Figure 4 - GHG trends in the EU

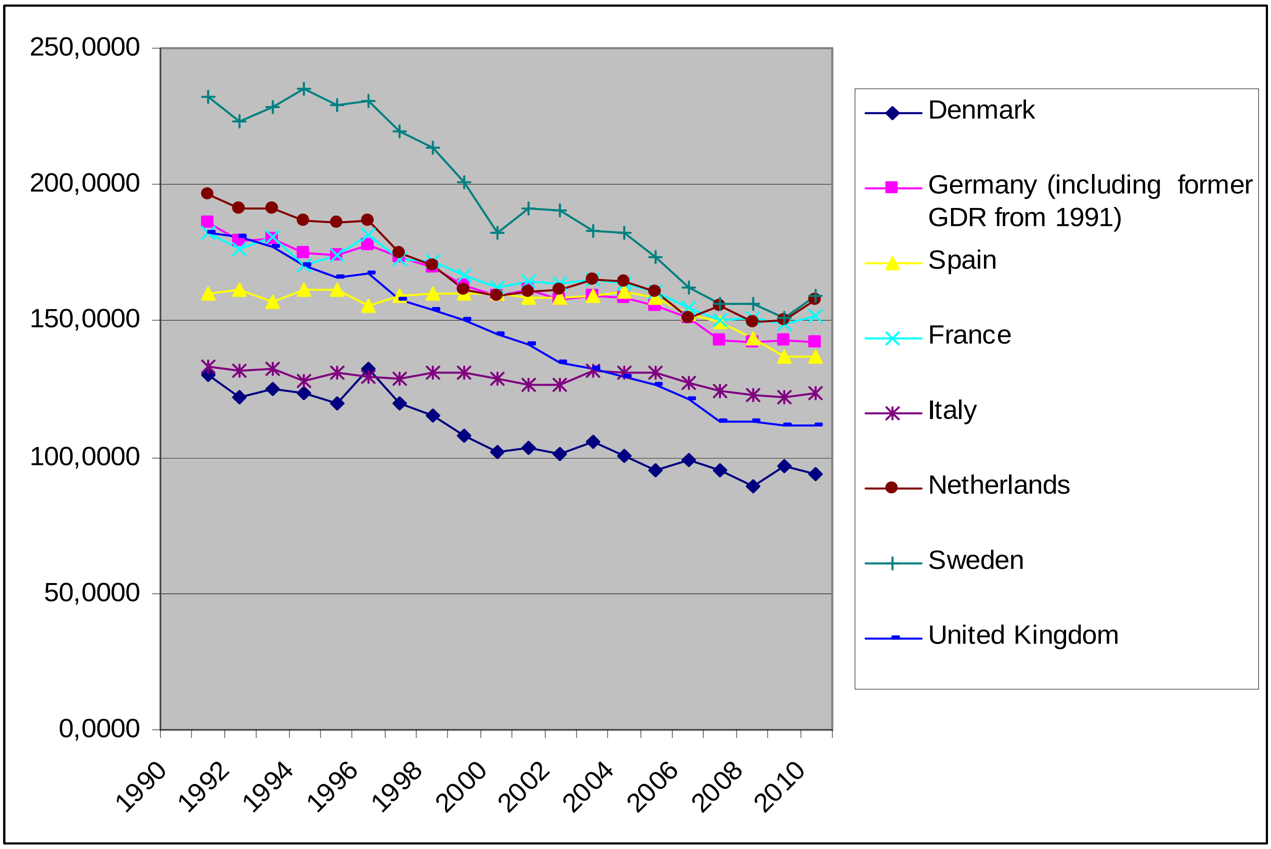


Figure 5 - Energy efficiency trends in the EU

Figure A1 – Four shares of Eco innovation diffusion: contiguous municipality all sectors (left-up), contiguous municipality all same sector (left-down), same municipality all sectors (right-up), contiguous municipality same sector (right-down)