ENVIRONMENTAL INNOVATIONS IN SERVICES
MANUFACTURING-SERVICES INTEGRATION AND POLICY TRANSMISSIONS IN THE ITALIAN ECONOMY

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Abstract: We investigate the factors behind the almost unexplored realm of environmental innovation adoption in services, using an Italian dataset derived from CIS2008. It has been suggested the environmental innovations in services does not necessarily lead to greater sustainability. If services are examined through the lens of manufacturing-services integration and push and pull effects, the picture of sustainability in relation to services is somewhat gloomier. We test whether this integration is relevant for environmental innovations and whether, taking account of differences in innovation in different services industries, environmental policies for manufacturing may transmit 'induced innovation' effects to services. We show that the 'drivers' of environmental innovation in carbon abatement and energy efficiency vary across services industries, and that cooperation, training, EMS and public funding play a key role. The integration of services and manufacturing through push and pull effects, and the environmental policy transmission effect from manufacturing to services generally do not seem to have a major influence on the diffusion of environmental innovations. Where an effect is significant, it would seem to result in more negative than positive effects on eco-innovations. It seems likely that the structural EI deficits in manufacturing firms are transmitted to services through manufacturing-services integration. This is a crucial consideration for management and policy.

Keywords: environmental innovation, services, push and pull effects, EU emission trading.

1. INTRODUCTION

The increasing share of services in advanced economies and the greater efficiency of production processes especially, in manufacturing and energy industries partly driven by more stringent environmental policies, are key drivers of sustainability and the decoupling of economic growth. The conventional view is that the immateriality of services production is bringing about better environmental performance. As a result, services are mostly not subject to environmental regulations. However, in the EU at least, there is a suggestion that increased tertiarisation (ETC/SCP, 2012) is not leading necessarily to lower environmental impacts. In fact, innovation and environmental efficiency in the (lighter) services industries need to be assessed alongside an analysis of the (growing) interlinks between services and manufacturing. For example, the intensity of intermediate inputs bought from other sectors has increased (ETC/SCP, 2012). Intermediate inputs, which are growing more than value added and output (Figure 1), are a sign of increasing integration (EC, 2009).

(figure 1 here)

Services are one of the fastest growing inputs, and outsourcing relationships between manufacturing and services continue to increase. Understanding the emergence and adoption of innovation is crucial for understanding economic performances in strongly interrelated economies. Innovation diffuses through many mechanisms, including industry interdependency, is one of them[1] In the specific field of environmental-economic performance, environmental innovations (EI) that enhance environmental efficiency and increase product value, or improve energy efficiency are very important and may result in win-win situations. EI in services can contribute to mitigating low productivity (Baumol like) dynamics, while ensuring sustainability and competitiveness.

An analysis of the decompositions of changes in resource use (RU) and pollution in the EU, in the twenty years highlight that the 'technology effect' is the main factor balancing increased RU as the driver of economic activity, rather than the 'industry mix' effect driving environmental efficiency gains (ETC/SCP, 2012). The weakness of the industry mix effects is explained by industry trends in Europe. Contrary to expectations, between the mid-1990s and mid-2000s, the EU increased its share in world manufacturing in certain sectors, which can be

[1] Some new reflections on the meso/sector economic level of investigation in innovation studies are provided by Dopfer (2012), who discusses the key role of sector analyses as bridge between micro and macro innovation dynamics.

classified as ‘brown economy’ industries: pulp and paper, petroleum refining, chemicals, basic metals, motor vehicles. This trend is confirmed by EU specialisation indexes and has been driven largely by the increased specialisation of Germany and the German-centric industrial block comprised of Austria and some Eastern European countries. In addition, fixed investment in the brown-economy industries seems to have increased in the mid-2000s. We need to investigate whether this increased investments have resulted in greener manufacturing: especially in Germany, the leader of European manufacturing and of the green economy.

The shift towards a service economy in Europe has not led to sustained emissions reductions. The increased interdependence between services and industry (each exerting push and pull multiplier effects resulting in increased inputs from other macro-sectors, EC, 2009, see Figure 2) results in higher RI even in immaterial service sectors. In certain ‘materials intensive’ services, such as transport, more extensive production networking and higher inputs of intermediate goods involves wider circulation of goods and transport over greater distances. Ultimately, the indirect emissions accounted for by services can outweigh their total economic effects (accounting for some 30%), making the size of the environmental effect comparable to manufacturing (Mazzanti et al. 2012). Given the role of services in and their interdependence with manufacturing, we need more comprehensive analysis of the innovation effects in open innovation systems.

(figure 2 here)

Studies show that services have a small impact on the environment (Levinson, 2009); however, their ‘total and integrated effects’ at the level of the economy (e.g. the pull effect on manufacturing, i.e. the intermediate inputs supplied to services from manufacturing) is much larger (Kander, 2005[2]). These integrated effects can contribute up to 75% of the total emissions attributed to services.[3] Energy consumption can be under estimated by official statistics that do not take account of indirect (life cycle) effects related to services consumption (pull effects). The idea of ‘non materiality’ is often used to characterise service oriented economies; however, empirical analyses should assess the effect of services integrated in trade sectors. Fourcroy (2011) highlights the possibility that ‘the most service intensive countries, are as a whole, are greater

[2] The dynamics of structural change can be insufficient to assure the achievement of long run sustainability which points to the need to investigate the dynamics of environmental innovation in services, and the role of policy.

[3] The extensive input output analysis conducted by Moll et al. (2007) shows that electricity, gas and hot water production, agriculture, and transport and communication services in the EU contribute most in terms of direct and indirect pressures on the environment.

consumers of energy, with a larger ecological footprint, than countries whose service sector is less developed'.

Although the attention to EI by innovation scholars has increased, few of them have investigated their role and impact in services. This is due partially to lack of data, but derives also from the assumption that the effect on the environment of services is 'light' and that services contribute little in terms of environmental innovation and emissions reductions. Most US studies (Brunnermeier and Cohen, 2003) focus on manufacturing (Levinson, 2009). In Europe, EI is studied mostly based on Community Innovation Survey (CIS) data, which has become the main source of data on firms in the EU (Breschi et al., 2000).

This paper examines EI in services and investigates some economic and environmental facts related to the (tertiarised) economy. It highlights the importance of analysing both services and manufacturing to assess their contributions to the sustainability of economies through increased innovation and higher efficiency. The paper is structured as follows. Section 2 presents some key issue related to services-manufacturing integration and its relevance for economic-environmental performance. Section 3 presents the dataset and research questions, and descriptive analyses of EI in services based on CIS2008. Section 4 introduces the empirical model and presents the econometric estimates. Section 5 concludes.

2. EI IN SERVICES AND MANUFACTURING-SERVICES INTEGRATION

Definitions of eco-innovation (Kemp, 2010, 2000; Kemp and Pearson, 2007) tend to highlight the 'eco' attributes of individual new processes, products and methods from a technical and ecological perspective. For example, the MEI (Measuring Eco-Innovation) research project defines eco-innovation as 'the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life-cycle, in a reduction of environmental risks, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives'. The inclusion of new organisational methods, products, services and knowledge oriented innovations in this definition differentiates from the definition of environmental technologies as 'all technologies whose use is less environmentally harmful than relevant alternatives'. Organisational methods are linked closely to education and training and human capital. EI is neither sector nor technology specific, therefore, and can be part of any economic activity not just those included in the rather loosely defined ‘eco-industry’ sectors. EI is not limited to environmentally motivated innovation, but also includes the ’unintended’ eco-effects of any innovation. When considered outside the purely technical dimension of (improved) environmental impacts, EI can be seen to have a *systemic and behavioural dimension* that is consistent with both the conventional economic approach to innovation tout court and extensive evidence on the systemic dimension of EI (Horbach, 2008).

A major challenge in research on EI is to establish robust techno-ecological measures of individual EIs and the eco-impact of innovations, together with the economic dimension of EI as a behavioural process. On the adoption side, the coincidence of several innovations may increase the link between environmental and economic goals (Mazzanti and Zoboli, 2009a,b, 2010). These are based on variously intended joint investment in ‘innovation inputs’, to achieve increasing returns to scale, sharing of inputs across firms, and clustering of EIs. EI and other types of innovation are needed to achieve improved performance, for example, environmental-economic decoupling, characterised by better economic performance and reduced environmental impact. These kinds of joint investment allow the integration of technical measurements of single EI within a broader socio-economic perspective, that includes different ‘eco-innovating actors’.

The literature on EI drivers, the complementarity of EIs with other techno-organisational factors and the effects of EI on economic performances primarily deals with manufacturing industries (Mazzanti and Montini, 2010; Horbach and Oltra, 2010). This is because of their huge contribution to pollution and their more stringent environmental regulation than other industries. Environmental regulation can potentially promote EI as suggested by Porter’s hypothesis (Costantini and Mazzanti, 2012; Wagner, 2007; Ambec *et al.*, 2010). The huge body of evidence that has accumulated since the seminal contribution from Rennings (2000) shows that EI is stimulated by many factors: local factors such as networking (Cainelli *et al.*, 2011b), policy (Rennings and Rexhauser, 2011), international links among firms, and structural elements such as sector and size.

Studies on manufacturing have been justified by the higher environmental impact and innovative propensity of the ‘hard industries’. However, the increasing share of services in all the advanced economies and the strict interrelationships between manufacturing and services (outsourcing, supply of intermediate inputs, etc.), means there should be more emphasis on the role of services in the realm of the environment and EI. It is also necessary to study innovation and EI at a more specific level, given that the diffusion of innovation is the main contributor to mitigating or compensating for the productivity slowdown based on Baumol's disease, which characterises most services industries (although with important differences across sectors). We need to fill some of the gaps in our knowledge of services environmental related performance.

This paper provides evidence on EI in services, which we consider unique given the lack of research attention on innovation in services generally (Cainelli *et al.*, 2006). Cainelli *et al.* (2011a) provides some insights from their study of the 'motivations' for green innovations (CIS2,3), but we need to recognise that services are an important locus of innovation and play an integral part in the innovation systems of modern economies (Metcalfe and Miles, 1999). Gallouj and Savona (2009) provides a survey of research since 1990, highlighting the need to study the 'specificity' of services innovation. The specificity of EI (organisational, radical e.g. CO2 abatement, emissions abatement) in different service industries (trade, finance, etc.) constitutes a piece in a puzzle that has not been completed.

Services and manufacturing should not be analysed in isolation. They have many interconnections, and their importance has been increasing due to the process of tertiarisation that characterises the advanced economies. The importance of analysing services as interconnected with manufacturing is underlined by the effort to investigate economic and environmental performance together, within a 'whole economy' perspective. For example, in Italy, the CO_2 emissions intensity of the economy has improved more in terms of output than in terms of value added. This implies that the share of value added in output has decreased over the period of increased tertiarisation (1990-2007), and that an increasing intensity of intermediate inputs in the economy is a sign of stronger (sector) interconnections. This is a 'stylised fact' needs to be considered in any analysis of innovation. Innovation adoption is characterised more and more by 'open' innovation systems, which among other thing imply an increased importance of external sources of innovation, from cooperation activities to outsourcing related innovation, etc. Manufacturing-services are a gateway for the adoption of innovation by firms. In EI contexts, this is related also to the role of environmental regulation to tackle market failure. In open systems, pressure from policy can affect multiple sectors and whole countries. The more stringent regulation associated with manufacturing sectors can be extended to other industries as a result of economic interconnections. The design of policy is crucial for shaping innovation dynamics (Brouillat and Oltra, 2011).

The emphasis in environmental policy is motivated by the fact that most direct polluting emissions are generated by manufacturing, and in particular by specific industries such as metallurgy, chemicals, ceramics and energy. The assumption that a changing industry mix in the economy will generate a greener economy needs further investigation: between 1995 and 2007 manufacturing in the EU decreased from 20% to 17% measured as share of GDP, while market and non-market services represented more than 71% in the EU27. The evidence on the 'property' of the industry mix for achieving better environmental performance is ambiguous, and especially the part played by services in environmental efficiency gains. If we look at the interdependencies between services and manufacturing shown by input-output (I-O) tables and inter-industry 'multipliers', we observe that manufacturing is the driver of many services activities, and vice versa (European Commission, 2009). This is strong evidence of integration and highlights the increasing role of intermediate inputs already mentioned. More specifically, as the client, manufacturing creates a pull effect on other sectors (measured by the share of its production value accounted for by inputs bought from a specific sector), market services production triggered by manufacturing final demand (in a Leontief world). At the same time, there is a push effect of manufacturers on other sectors (pull effect of services) when services acquire inputs from manufacturing sectors.

In other words, in an I-O environment, 'integration' is represented by the share of intermediate inputs that one sector derives from another (activated by demand); for example, 23% of intermediate inputs of agriculture come from the food sector, while 32% of inputs of the food sector come from agriculture.

As a client, EU manufacturing pulls on average 17% of its total production; the values for Italy are very high (19.5%), second only to Sweden. All industrialised countries present high values. The push of manufacturing on services is also very high in Italy (10.9%), which is towards the top of the EU ranking (EU average 8%), and only slightly lower than the values for Poland and Sweden. Thus, Italy is a good case for analysing the importance of the manufacturing-services interlinks in economic and environmental terms.

The high relevance of EI in services and the potential translation of innovation effects from manufacturing to services (and vice versa) become apparent if we study environmental effects. If we consider final demand for services rather than direct emissions (as in NAMEA accounting), the (vertically integrated) impact on pollution is much higher than the economic effect. This means that: (i) taking account of sector interdependence, services do not decouple economic growth from pollution; the effect of pollution becomes much larger;[4] (ii) the share of direct emissions is around 20% - the direct and indirect effects sums to 35%, comparable to manufacturing effects. Some estimates using environmentally extended I-O data show that this share has increased since 1995 (Mazzanti *et al.*, 2012) and similar evidence for the US (Shu, 2006), shows that even netting services of transport, the most 'material' and emissions-intensive services branch is increased (Figure 3).

(figure 3 here)

Work that decomposes finds that, although it is clear that service specialised economies benefit from it on environmental grounds, this ‘light’ specialisation is not *per se* a source of ‘environmental comparative advantage’; technological factors and efficiency improvements are as or even more important (Mazzanti and Montini, 2010).

There are four intertwined reasons for a focus on services as a source of EI. These are: (i) lack of knowledge on EI processes and their heterogeneity across service industries; (ii) increasing importance of services in advanced economies and their connections with other industries (associated with historically lower innovation intensity); (iii) need to understand whether 'push and pull' services-manufacturing interconnections are relevant for explaining EI; and (iv) the not negligible environmental impact of services within a 'full economy' perspective.

Understanding EI in services is crucial for policy on manufacturing as well as services (e.g. carbon taxes) and also for services-specific measures (emissions trading in services, EMS, voluntary agreements), and for a more holistic view of how service based advanced economies can make progress towards sustainable and competitive performance.

Lack of evidence on EI performance in services is due in part to the lack of data on innovation at the sector and micro levels. However, this is improving due to the increased attention at EU level on EIs as a key factor in sustainable competitiveness. Our investigation in this paper on the drivers of EI in different sectors is based on an extended dataset of Italy. We are interested also in whether cross-industry heterogeneity is higher for services than for manufacturing,[5] as suggested by Butnar and Llop’s (2011) and Marin and Mazzanti‘s (2012) sector

[4] The pull effect of final services demand on emissions through inter industry linkages is higher than the economic multiplier (EEA, 2012).

[5] Miles (2008) shows that the diversity of service activities means that service innovations and innovation processes take various forms. He finds that ‘Only a small segment of service innovation conforms to the typical manufacturing-based model, in which innovation is largely organized and led by formal research and development

decomposition and disaggregation analyses of environmental performance in the service industry. Their industry by industry analyses allows identification of the EI drivers in specific service sectors. In this paper, we also investigate the role of policy as a driver of EI.

We want also to test the importance of the indirect effects from industry to services of various economic integration and environmental policies. We exploit I-O tables following Miles (2008) who studies innovation in services using I-O tables. I-O tables provide information on services-manufacturing interrelationships. We use an indicator of policy stringency related to the EU Emissions Trading Scheme (ETS) (the main EU environmental policy instrument introduced in 2006; Borghesi, 2010), constructed using data on EU ETS emissions allowances and National Accounting Matrix with Environmental Accounts (NAMEA) data, to investigate whether there is an indirect policy effect from manufacturing to services. The idea is that the more stringent the EU ETS policy applied to manufacturing sectors and the stricter the vertical integration between two sectors (e.g. metallurgy – an ETS sector, and trade – a service industry) the higher will be the likelihood that EI in services (trade in this example) is also stimulated. Although we would not expect to find strong effects, due in part to the originally less stringent EU ETS formulation, it is true that firms offering 'services' to manufacturing sectors that are subject to environmental policy and are developing and adopting green strategies, might need stronger incentives to also adopt green innovation processes.

3. RESEARCH QUESTIONS AND DATA

The paper addresses two main research questions. Our hypotheses relate to services as polluting industries where there is a need for significant EI (Desmarchelier et al., 2010). Baumol (2010) stressed in his famous 'cost disease' that the rising prices for services may lead to frequent substitution of goods rather than the purchase of maintenance and repair services, with the result that the total level of materials use and emissions intensity increases.

First we test the hypothesis (H1) that the set of 'explanatory factors' of EI varies across the main services sectors. This is a simple testable hypothesis relating to the observed heterogeneity in EI adoption and the different emissions intensity of the various service branches (Mazzanti and Montini, 2010b). H.1 can be subdivided into two complementary hypotheses.

(R&D) departments and production engineering. Project management and on-the-job innovation are common ways of organizing service innovation'.

H1.A: We would expect more relevant roles for public policy and collaboration over CO_2 reduction and that innovation in the more emissions intensive sectors (such as transport), to be more radical and to require more incentives.

H1.B: Linked to the above, we would expect a major role to be played by cooperation activities among business services firms: that is, the stronger the link between the service sector and manufacturing, the more important will be collaboration (Montresor and Vittucci Marzetti, 2011). This applies especially to 'producer services' within the standard OECD classification (ISIC sectors 50 to 74, especially financial, and communications and business services).

Hypothesis (H2) is also subdivided.

H2.A tests whether if two or more services-manufacturing sectors are interconnected the more likely that this will drive EI. This effect, more generally, is produced by the intrinsic higher EI intensity of industrial firms as a result of their worse environmental performance. Even in the absence of policy, industrial firms are motivated by cost reductions to be more energy efficient, and this is a more effective motivation than the presentation of CO_2 abatement as benefiting the public good. Thus, the higher the services-manufacturing captured by our I-O data, the higher should be the incidence of EI also in services.

H2.B refers to the increasing interlinking between services and manufacturing – the push and pull effects – as a way of promoting more stringent regulation in services. That is, links to industry branches that are subject to more stringent environmental regulations may have indirect effects on EI in services. The absence of such an effect may be due the lack of a transmission effect and/or less strict manufacturing policies (the evidence on the extent to which environmental policy drives EI is ambiguous).

Hypotheses 2A and B also refer to 'spillover effects'. There are several seminal studies on spillovers that provide a historical 'background'. Griliches (1992) suggests various ways of weighing spillover effects (e.g. by distance, by capital/labour ratio to capture specialisation and knowledge proximity) and refers to work by Brown and Conrad (1967) who captured vertical borrowing through the use of I-O tables. Brown and Conrad capture the closeness of industries evidenced by their purchases from one another.

In order to test this 'spillover economic/policy effect', we construct an industry specific index by multiplying the share of intermediate inputs that characterises each services-manufacturing interconnection (e.g. the share of intermediate inputs used in the chemicals industry coming from the finance sector),[6] by an index of manufacturing environmental policy stringency. The industry index captures the main environmental policy currently implemented in the EU on green house gas (GHG) emissions, that is, the main EU industry ETS. For a detailed explanation of how the policy indexes for sectors under the ETS policy are constructed see the appendix. We exploit data on emissions and allowances provided by the Italian Ministry of the Environment, and NAMEA. Briefly, the higher the level of emissions and the lower the allowances and the more stringent the policy. Desmarchelier et al. (2010) use simulations within an evolutionary framework to assess whether EI is stimulated by policy. We empirically test a set of policy indicators (see appendix) in order to test the sensitivity of our results. We also test for the 'interaction' effects in H2 on the total sample of services firms and for every industry.

To our knowledge, this is the first econometric test of EI to be done on a large dataset (Italian CIS 2008) that includes the service firms in a large economy. We link this micro based data-source with I-O tables (year 1995) in order to investigate the extent to which services-manufacturing inter connections are the motivation for EI.

We address the research questions by exploiting the CIS2008 dataset for the service industry in Italy. The 2008 survey was administered to thousands of firms and for the first time asked explicitly about EI adoption.[7] These data are the first large scale, consistent, consolidated information on EI in services.[8]

Our main data are actually from two statistical sources. The 5th wave of the Italian CIS for the years 2006-2008 asked about EI adoption based on the definition of EI developed by the Measuring EI (MEI) project funded by the EC 6th Framework Programme (Kemp, 2010). The 2006-2008 survey included 8,161 service firms employing more than 1.5 million. Tables 1-4 report the distribution of firms and the proportions of firms adopting ECOEN and ECOCO by

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6 All I-O tables and data are available on request from the authors.

7 Cainelli *et al.* (2011a) exploit information on the 'environmental motivations' for innovation from early CIS to study the productivity impact of environmentally motivated technological adoption in Italy, and find negligible effects. Aghion *et al.* (2009) is also based on CIS 'environmental' data.

8 To our knowledge, this is the first large scale firm based analysis providing evidence on eco (policy) innovation drivers in services, based on recently released CIS data (Horbach *et al.*, 2011 analyse CIS 2006-2008 data for Germany, focusing on manufacturing). Through a focus on firm based reasoning, which allows deeper investigation of innovation dynamics, we complement studies as Butman and Llop (2011) who decompose scale, technology and demand effects on services emissions at sector level. The study by Marin *et al.* dynamically compares industry and services performances using I-O tables and NAMEA data. They show that there has been a general shift towards services in the ten years 1995-2005 in relation to CO2, NOx and SOx induced emissions. There was a weak reduction in industrial activities producing these pollutants, in 1995 to 2005, perhaps based on efficiency improvements in production processes and product design , although a composition effect cannot be ruled out.

industry and geographic area. The majority of service firms are in branches G-I and the most eco innovative sectors are Finance and Insurance (K), Hotel and Restaurants (I) (with 12% and 9% and 11% and 9% respectively of share of firms adopting eco innovation in energy efficiency and CO_2 abatement). The main sectors, such as Trade (G) and Transports and Logistics (H), show shares of respectively 8% and 6% (same % for energy efficiency and CO_2). The North-Eastern regions of Italy, which have a high proportion of export-oriented small and medium sized firms, have shares of 10% and 9%, while the shares for the islands are only 6%. However the differences are small than for EI in industry.

The second statistical source is I-O tables. The integration between services and manufacturing is tested by exploiting I-O tables providing information on sector integration 'shares' (% of inputs acquired from another sector). We match this information with firm level CIS data (matching firm and sector data is an accepted practice in labor and innovation economics. Many studies, as example, on wage drivers, merge individual and firm and sector data. Cluster correlation techniques deal with it in econometric assessments to take account of the specificity).

These merged firm-sector data are needed to investigate our research. We need additional data, such as specific information on the stringency of environmental policy (EU ETS) in manufacturing sectors,[9] in order to test H2. This enables us to verify whether the EI effect which is transmitted to services is higher, if integration *and* the stringency of environmental policy in the related manufacturing sector are also higher.

(tables 1-4here)

4. ECONOMETRIC EVIDENCE

4.1. The modelling strategy

In our econometric specification, we estimate a probit model as follows:

[9] What is lacking from the 'EU ETS – induced innovation' related literature is a robust econometric study of a relevant EU industry. Italy is major industrial country that provides such a case. Compared to case studies, econometrics show whether an empirical regularity exists after controlling for various (size, sectoral) factors and multiple drivers of EI.

$$\Pr(Y_i = 1/X) = \Phi(X'\beta)$$

where Φ is the cumulative distribution function of the standard normal distribution and Y_i is a dummy variable that takes the value 1 if a service firm *i* introduces an EI and 0 otherwise. X is the set of covariates described in Table 4. In order to robustly estimate the factors correlated with EI we include a rich set of covariates capturing elements of 'external innovation sources' (information, cooperation, group membership), public policy actions, internal practices of organisational change aimed at enhancing economic performances (training, EMS, see Wagner, 2007). R&D is included as a pivotal input in the 'innovation function'. The inclusion of such a rich set of covariates mitigates the problem of omission of relevant variables which could be a source of endogeneity. Note that we estimate a probit model, which, rather than reporting the coefficients, reports the marginal effects, that is, the changes in the probability of an infinitesimal change in each independent, continuous variable and, by default, reports discrete changes in the probability for the dummy variables.

4.2. HETEROGENEITY IN INNOVATION ADOPTION

Tables 5-10 present the evidence for EI drivers in the full sample of firms (Table5) and various sub-sectors. The evidence for the full sample of firms is interesting. Cooperation and information related factors are highly important for triggering EI in both cases (ECOEN, ECOCO): relationships with clients and suppliers – which link to the integration of services-manufacturing, and support of associations are key factors. Note also that while environmental management systems are positively correlated with both types of EI, energy efficiency is correlated only with internal sources of change, such as training and research and development (R&D), while CO_2 abatement seems to be motivated by public funding (H1a). This is coherent with the public good – less appropriable – nature of CO_2 technologies. Energy efficiency is firmly engrained in internal processes aimed at increasing economic – and we would suggest environmental – performance (Costantini and Mazzanti, 2012) in a Porter-like direction (Ambec and Lanoie, 2008; Wagner, 2007). Labour productivity is negatively related to EI adoption: the evidence shows that firms which, in 2006, had lower levels of productivity have been more intensive adopters of EI. This can be a reaction to resolving the problem of low productivity through adoption of green technology. Further research could test the hypothesis of whether more labour intensive firms present higher levels of EI adoption. The role of training suggests some insights along these lines.

The negligible role of R&D is not surprising (see Horbach and Oltra, 2010 on EI in Germany and France based on CIS2008); R&D is measures general absorptive capacity. Specific environmental R&D as well as external sources are needed to stimulate CO_2 and radical change. The fact that energy efficiency, which is more appropriable, relates to R&D, is coherent with recent theoretical and empirical developments on mixed public goods (Rubbelke and Markandya, 2008; Kotchen, 2005).

We focus next on sub-industries. Table 6 presents estimates for Trade (G), which includes around 50% of the sample. In this case, the role played by specific cooperation / information activities are reduced, while the key role of associations and innovation oriented cooperation activities remains. Training related to ECOEN and EMS related to ECOCO are shown also to be important. Again, energy efficiency seems relatively more related to the 'embeddedness' of EI in internal business 'high performance work practices'.

Table 7 focuses on Transport and Logistics (H), which is the most polluting services sector. We note the absence of EI drivers in the area of 'cooperation/information'. Some of the poor EI performance in sector H, which is responsible for Italy's non-compliance with Kyoto targets, is based on the lack of collaborative links to 'inform' EI adoption. The key drivers of EI for energy efficiency and CO_2 are EMS/ISO , which confirms the strong correlations found by other authors (Ziegler and Nogareda, 2009), and public funding for $CO_{2, \text{which}}$ suggests that public policy for transport aimed at reducing CO_2 is relevant (H1a), but probably not sufficient to achieve completely successful outcomes.

Sectors Hotel and Restaurants (I), Information and Communication Services (J) and Finance and Insurance (K) are relevant since they show strong integration with manufacturing. We analyse the aggregation 'I' and 'K+J' (which are similar in size) in Tables 8-9. Hotel and Restaurants (I) firms benefit the most from relationships with suppliers and clients which demonstrates the role of manufacturing firms on the push and pull sides of the interaction. For ECOEN explanatory power is biased towards 'cooperation/information' side, and again the integration between technological EI and environmental management systems emerges for CO_2. For Information and Communication Services (J) and Finance and Insurance (K), it only interesting the role of cooperation (connected to our H1b) and EMS/ISO.

To sum up, among the full sample of firms, the largest firms present the most striking results, showing similarities but also clear differences between ECOEN and ECOCO driving factors. However the results for the analyses of sub branches are also interesting. Their heterogeneity – strengths and weaknesses – should be taken into account by both policy makers and managers of services firms. Notable is that in the largest sector, G, cooperation/information forces prevail and policy has no impact on EI; policy (as expected) is relevant in sector H, transport (H1a), although in this case, the lack of 'cooperation forces' would seem to suggest a correctable bias, given the importance of the sector for achieving environmental targets. H highlights the key role of EMS/ISO, which is evident also in other cases (note that in all cases the adoption of environmental management systems – before 2006 – is a necessary factor explaining the adoption of CO_2 abatement technology in 2006-2008). Sectors I-K show an overall prevalence of effects related to networking and interactions with other agents (H1b). This is proof of the need to further analyse the effects on EI of manufacturing-services integration through push and pull effects.

(tables 5-10 here)

4.3. THE MANUFACTURING-SERVICES LINKS AND TRANSMISSION BY ENVIRONMENTAL POLICY

Tables 11 and 12 report evidence for ‘manufacturing vs services’ push and pull effects, first as vanilla interactions modelled on the basis of I-O tables (to test H2a), and then with the integration of stringency indicators (H2b). The procedure is: (i) we create industry specific indicators for services with regard the most polluting manufacturing sectors (paper, metallurgy, ceramics, coke and refineries) which also are ‘ETS’ sectors; (ii) we include this indicator in our regressions as an additional covariate. Given that its inclusion does not alter the statistical significance of the other covariates, we only report the coefficient and eventual statistical significance of the effect.

We focus on three types of firms: (i) all firms; (ii) transport firms; and (iii) business services firms. The ‘push1’ effect refer to whether or not EI is stimulated by an integration characterised by the provision of services to the paper and card-board sector (push effect); ‘pull1’ refers to the weight of the paper sector in relation to provision of intermediate goods to services (pull effect). We estimate the push and pull effects for H and JK with some interesting results. Overall, the push and pull interactions are not relevant sources of EI. Only 6 out of 24 cases are above the 5% significance threshold. Among those,’pull2’ and ‘push1’ are significant in two cases, though with a negative sign of the coefficient. This means (Table 11) that the relationships between the coke and refinery industries with services as a whole, and with business services are a break to EI, and that paper and card-board are lined to both transport and business services and also break EI. The level of specificity in this analysis is evident. Further research could use case-studies and interview evidence to complement our findings. The positive effects are confirmed. In fact, the relationship between transport and coke and refinery (inputs provided by transport) seems to stimulate EI in the important transport sector. Overall, these interactions do not seem to follow a positive pattern towards enhanced competitiveness. Manufacturing-services integration perhaps is based on a cost reduction strategy (e.g. through outsourcing). The relatively poor performances of services in terms of total emission (see Introduction) might be attributable in part to this low EI content of the manufacturing-services integration highlighted here.

'Less integrated' service firms show a higher probability of adopting EI, which should provide hints for management and for policy decisions. However, policy seems to have little influence on these firms. The results are very robust to the different policy indicators used and inserting the indicators in log form does not alter the results. The 'policy weighted' push and pull effects present a significant number of negative effects: 25 out of 36 tested effects show significant coefficients, with a balance of push and pull effects. Services firms that which are more integrated with heavily regulated sectors - mainly ceramics and metallurgy - are less likely to adopt EI. This is a rather counter intuitive result, but may be due on the one hand to the proven lower EI intensity in the ceramic sector at the national level (see Borghesi *et al.*, 2012 analyses on manufacturing EI), and on the other hand to the 'weak' innovating incentive provided by manufacturing-services integration. Policy stringency in itself possesses EI properties, but what we highlight is that it may encounter brakes and filters:

It may produce 'negative' short run reactions in sectors such as ceramics, that can be explained by dimensional constraints, defensive behaviour (buying ETS quotas instead of innovating), and a manufacturing-services integration that is probably characterised by cost reduction strategies rather than high performance oriented investment, which is typical of Italian ‘productivity stagnation’. This also may explain the rather negative performance of Italian firms in terms of the economy and the environment (Marin and Mazzanti, 2012).

(tables 11-12)

5. CONCLUSIONS

The paper adopted a micro firm perspective to analyse the factors correlated with EI in services, primarily CO_2 and energy efficiency related innovations. To our knowledge, this is the first empirical study in which EI has been explored from an 'environmental' perspective. We used the CIS data for 2006-2008 (CIS2008) that provides explicit information on EI adoption in manufacturing and services. While several analyses of manufacturing have been published since 2000, based mainly on German data, services have received less attention perhaps due to their supposed lighter environmental impact. Nevertheless, the increasing integration between manufacturing and services in terms of push and pull multiplier effects (intermediate goods increasing role), the well known 'productivity disease', and new evidence on the non negligible polluting effects of services if indirect emissions are taken into account, all call for investigation of how services contribute to a sustainable society. Moreover, services typically are environmental policy free. It is possible that, in the future, environmental policy might include services. In the meantime, we tried to assess whether manufacturing oriented environmental policy related to energy intensive sectors influences innovation in services through push and pull effects. We hypothesized that manufacturing services integration stimulate (or hinder) innovation in services. We also investigated whether the Porter-like induced policy effects in manufacturing can be transmitted to services by integration forces focusing on the main EU policy, ETS for CO_2 allowances, which has applied to the main polluting sectors since 2005.

Probit analyses of 8,161 Italian services firms showed that the 'drivers' of EI in carbon abatement and energy efficiency vary across service industries, with a core role played by cooperation, training, environmental management systems and public funding. We compared the Trade and Transport sectors showing that the latter had the harsher environmental effects and less EI and the regressions showed a significantly lower number of drivers of EI.

The integration of services and manufacturing through push and pull effects and the environmental policy transmission effect from manufacturing to services seem to be EI motivating only in very specific situations. This is our main result for integration effects that links to research hypotheses H2a and b.

When integration effects are significant, this seems to negatively rather than positively affect EI. The only positive effect we found was the push effect coke and refinery, a high energy intensive sector: buying intermediate goods from this sector seems to enhance the likelihood that it will adopt EI. The negative effects are quite widespread across sector categories of push/pull effects. It should be noted that on the basis of our main evidence (all services firms), integration does not influence EI. Significances emerge only for sub sectors. We found high sector based specificity indicating the need to investigate manufacturing-services integration in detail.

EU ETS policy analysis reinforces these effects. More (negative) effects are highlighted, mainly on the side of pull effects, at least for energy efficiency: ETS manufacturing sectors subject to a more stringent policy, buying goods from service sectors does not stimulate EI. Also, the effect of service firms buying goods from metallurgy and coke and refinery reduces EI adoption. This complements the evidence on the low innovative effects of ETS so far. It is likely that rather than stricter regulation, the structural EI deficits of manufacturing firms are transmitted to services through integration. This is important for management and policy. It would seem that the more integrated services firms are with manufacturing sectors subject to strict regulation, the less likely they will adopt EI directed to greater energy efficiency and CO_2 abatement. Further research is needed on : (i) the role of increased integration of manufacturing-services in relation to innovation and environmental performances based on micro and sector data; (ii) analysis of other EI needed to achieve a sustainable and competitive society (e.g. waste reduction) according to Europe2020 aims; (iii) panel based analysis of data which may require national surveys.

Appendix

Box 1 – The construction of ETS policy indexes

We construct a series of ETS policy indicators that are aimed at capturing the stringency of the policy in its first allocation phase. We exploit two main sources of information: NAMEA sector emissions data (Costantini et al., 2011) released by ISTAT (over 1990-2008, we exploit 2000-2005 data) and information on the allocation decision, provided by official documents of the Italian Ministry of the Environment (available in Italian upon request). We use two measures of stringency with some ancillary modifications, in both cases aimed at implementing a sensitivity analysis. Use of multiple indexes is required for sensitivity analysis. The two indicators produce the same result slightly different perspectives. The first indicator is:

$$s_1 = T \times s_i - EUA_i$$

where EUA_i = tradeable permits (European Union Allowances) of sector *i*; T = national emission target (Kyoto target: given that 2005 is our pivotal year, we weighted the Italian -6.5% reduction accordingly, thus taking account of two-thirds of Italy's total target ; $s_i = \frac{e_i}{\sum e_j}$ = emissions share of sector i; ei = emissions of sector i; Σej = total emissions.
The alternative indicator is:

$$s_2 = \frac{e_i}{EUA_i}$$

To highlight the connection between the indicators s1 and s2, note that the former can also be rewritten as:

$$s_{1bis} = \frac{[T \times s_2 \times EUA_i]}{\sum e_j} - EUA_i \text{ or, equivalently,}$$

$$s_{1bis} = EAU_i\left[(T \times s_2)/\sum e_j - 1\right]$$

For s_2, we constructed three alternatives: (i) 2005 NAMEA emissions/allocated quotas; (ii) 2000-2005 average NAMEA emissions/ allocated quotas; (iii) Ministry of the environment reported 2000 emissions /allocated quotas. Our preferred main indicator is (i).

For s_1, we defined a version taking 2005 as benchmark year for the Kyoto target (2/3 of total reduction) and a version with the proper final Kyoto target of -6.5%. Then, s1bis was calculated taking both NAMEA 2000-2005 average emissions and the Ministry of the Environment emissions figures. In the econometric analysis below we run regressions using a dummy variable that takes the value 1 for sectors under ETS (DE1: paper and cardboard without printing branch; DF, DI, DJ) and value 0 for all other sectors. If the dummy value is 1, we compute the stringency indicators mentioned above. The inclusion of both the ETS dummy and the stringency indicators in the EI regressors allows us to distinguish the impact on EI deriving from the presence of the ETS, from the effect generated by regulation stringency.

The values of all stringency indicators by sector branches and the dataset (for any replication of results) are available upon request from the authors.

Table A.1 – The indexes values in the three cases

ETS sectors	S_1	S_2	S_{1bis}
Paper and card board	1.033	0.932	1.887
Coke and refinery	0.905	0.979	3.962
Ceramics	1.433	0.974	30.604
Metallurgy	1.477	1.064	13.396

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Table 1 – Distribution of firms and employees by industry

	Firms		Employees	
	N.	%	N.	%
Trade (G)	3,437	42.1	691,586	43.4
Transport and Logistics (H)	1,255	15.4	225,690	14.2
Hotel and Restaurants (I)	1,473	18.0	103,354	6.5
Information and Com. Services (J)	630	7.7	34,495	2.2
Finance and Insurance (K)	803	9.8	481,006	30.2
Renting and Housing (L)	152	1.9	4,533	0.3
Scientific and Technical activities (M)	320	3.9	45,172	2.8
Travel Agencies and Business Support Services (N)	91	1.1	8,654	0.5
Total	**8,161**	**100.0**	**1,594,490**	**100.0**

Table 2 – Distribution of eco innovative firms by industry

	ECOEN		ECOCO		Total	
	N.	%	N.	%	N.	%
G	270	39.2	276	44.5	3,437	42.1
H	78	11.3	81	13.1	1,255	15.4
I	160	23.2	128	20.6	1,473	18.0
J	45	6.5	26	4.2	630	7.7
K	97	14.1	74	11.9	803	9.8
L	8	1.2	7	1.1	152	1.9
M	22	3.2	21	3.4	320	3.9
N	9	1.3	7	1.1	91	1.1
Total	**689**	**100.0**	**620**	**100.0**	**8,161**	**100.0**

Table 3 – Distribution of eco innovative firms by geographic area

	ECOEN		ECOCO		Total	
	N.	%	N.	%	N.	%
North-West	200	29.0	210	33.9	2,509	30.7
North-East	245	35.6	219	35.3	2,526	31.0
Centre	143	20.8	106	17.1	1,700	20.8
South	70	10.2	53	8.5	864	10.6
Islands	31	4.5	32	5.2	562	6.9
Total	**689**	**100.0**	**620**	**100.0**	**8,161**	**100.0**

Table 4 – Descriptive statistics and description of dependant variables (*) and covariates

	Mean	Std.Dev	Description
Ecoen*	0.084	0.278	Innovation in energy efficiency
Ecoco*	0.075	0.264	Innovation in carbon abatement
Sentg	0.258	0.437	Internal information sources
Ssup	0.223	0.416	Information by suppliers
Scli	0.144	0.351	Information by clients
Scom	0.105	0.307	Information by competitors
Sins	0.130	0.336	Information by research lab
Suni	0.043	0.196	Information by universities
Sgmt	0.027	0.164	Information by public research lab
Scon	0.106	0.308	Information by conferences
Sjou	0.090	0.287	Information by journals
Spro	0.109	0.311	Information by industry associations
Co	0.082	0.275	Firms with innovation oriented cooperation activities
Rtr	0.191	0.393	Firms that invest in training
Group	0.322	0.467	Firm belonging to a business group
Grow_sales	0.074	0.342	Turnover growth 2006-2008 current prices
Lprod06	11.952	1.017	Labour productivity 2006
Rd	0.093	0.291	R&D activities intra muros
Funloc	0.053	0.225	Firm that receives public funding from regional / local agencies

Table 5 – Determinants of EI: all service sectors

Estimation method: probit	ECOEN		ECOCO	
	dF / dx	*t-value*	dF / dx	*t-value*
Sentg	0.010	1.02	-0.002	-0.27
Ssup	0.025***	2.77	0.035***	3.84
Scli	0.027***	2.87	0.021**	2.28
Scom	-0.002	-0.27	-0.012	-1.45
Sins	-0.001	-0.22	-0.018**	-2.35
Suni	0.001	0.08	-0.011	-0.85
Sgmt	-0.024	-1.64	0.027	1.54
Scon	0.007	0.74	0.002	0.28
Sjou	0.022**	1.96	0.019*	1.78
Spro	0.037***	3.77	0.055***	5.37
Co	0.020**	1.96	0.023**	2.43
Rtr	0.024***	2.72	0.009	1.19
Group	0.002	0.36	-0.005	-0.79
Growth_sale	0.002	0.25	0.0006	0.08
lprod06	-0.008***	-3.09	-0.004*	-1.83
Rd	0.016*	1.74	0.004	0.49
Funloc	0.017	1.54	0.025**	2.31
envid_1	0.031***	2.67	0.091***	7.29
Size dummy	Yes		Yes	
Geographic dummy	Yes		Yes	
Industry dummy	Yes		Yes	
N. obs.	8,161		8,161	
Pseudo R^2	0,109		0,107	

*** significant at 1%; ** significant at 5%; * significant at 10%
Note: standard errors are robust to heroschedasticity

Table 6 – Determinants of EI: Trade (G)

Estimation method: probit	ECOEN		ECOCO	
	dF/dx	*t-value*	dF/dx	*t-value*
Sentg	-0.0009	-0.07	-0.017	-1.25
Ssup	0.014	1.12	0.038***	2.65
Scli	0.018	1.29	0.016	1.10
Scom	-0.014	-1.10	-0.004	-0.31
Sins	-0.018	-1.51	-0.024**	-2.09
Suni	0.027	1.07	-0.010	-0.50
Sgmt	-0.028	-1.36	0.030	1.18
Scon	0.016	1.00	0.017	1.14
Sjou	0.011	0.71	0.007	0.46
Spro	0.034**	2.33	0.071***	4.29
Co	0.028*	1.87	0.030**	1.99
Rtr	0.057***	3.94	0.024*	1.81
Group	0.001	0.11	-0.014	-1.47
Growth_sale	0.019*	1.75	0.020*	1.78
lprod06	-0.007*	-1.84	-0.004	-1.11
Rd	0.012	0.91	-0.003	-0.25
Funloc	0.009	0.50	0.023	1.21
envid_1	0.017	0.92	0.083***	3.95
Size dummy	Yes		Yes	
Geographic dummy	Yes		Yes	
Industry dummy	Yes		Yes	
N. obs.	3,437		3,437	
Pseudo R^2	0.088		0.110	

*** significant at 1%; ** significant at 5%; * significant at 10%

Note: standard errors are robust to heroschedasticity

Table 7 – Determinants of EI: Transport and Logistics (H)

Estimation method: probit	ECOEN		ECOCO	
	dF / dx	*t-value*	dF / dx	*t-value*
Sentg	-0.009	-0.45	-0.027	-1.42
Ssup	0.037*	1.66	0.061**	2.48
Scli	0.025	1.28	0.020	0.91
Scom	-0.005	-0.31	-0.024	-1.37
Sins	0.003	0.18	-0.005	-0.32
Suni	-0.025	-1.11	-0.032	-1.12
Sgmt	-0.020	-0.77	0.068	1.10
Scon	0.009	0.42	-0.021	-1.20
Sjou	0.050*	1.83	0.032	1.31
Spro	0.006	0.34	0.042*	1.80
Co	0.025	1.09	0.015	0.74
Rtr	-0.005	-0.36	-0.003	-0.18
Group	0.005	0.40	0.014	1.05
Growth_sale	-0.007	-0.43	0.007	0.50
Iprod06	-0.0009	-0.15	0.003	0.69
Rd	0.043*	1.83	0.025	1.18
Funloc	0.004	0.19	0.077***	2.62
envid_1	0.073***	2.84	0.115***	4.14
Size dummy	Yes		Yes	
Geographic dummy	Yes		Yes	
Industry dummy	Yes		Yes	
N. obs.	1,255		1,255	
Pseudo R^2	0.150		0.146	

*** significant at 1%; ** significant at 5%; * significant at 10%

Note: standard errors are robust to heroschedasticity

Table 8 – Determinants of EI: Hotels and Restaurants (I)

Estimation method: probit	ECOEN		ECOCO	
	dF / dx	*t-value*	*dF / dx*	*t-value*
Sentg	0.032	1.24	0.006	0.28
Ssup	0.064**	2.55	0.050**	2.03
Scli	0.059**	2.29	-0.002	-0.11
Scom	0.025	1.03	-0.001	-0.07
Sins	0.012	0.55	-0.021	-1.05
Suni	0.032	0.64	0.029	0.68
Sgmt	-0.001	-0.04	0.018	0.38
Scon	-0.0004	-0.02	0.020	0.72
Sjou	-0.016	-0.66	0.017	0.59
Spro	0.069***	2.61	0.033	1.40
Co	-0.019	-0.78	-0.011	-0.48
Rtr	-0.003	-0.17	0.036	1.58
Group	0.010	0.60	-0.006	-0.42
Growth_sale	-0.043*	-1.67	-0.033	-1.33
lprod06	-0.016**	-2.07	-0.015**	-2.03
Rd	-0.011	-0.49	-0.014	-0.64
Funloc	0.014	0.61	0.011	0.51
envid_1	0.043	1.38	0.088***	2.84
Size dummy	Yes		Yes	
Geographic dummy	Yes		Yes	
Industry dummy	Yes		Yes	
N. obs.	1,473		1,473	
Pseudo R^2	0.160		0.092	

*** significant at 1%; ** significant at 5%; * significant at 10%
Note: standard errors are robust to heroschedasticity

Table 9 – Determinants of EI: Information and Communication Services (J)+ Finance and Insurance (K)

Estimation method: probit	ECOEN		ECOCO	
	dF / dx	*t-value*	dF / dx	*t-value*
Sentg	0.026	1.00	0.020	1.05
Ssup	0.033	1.41	0.026	1.57
Scli	0.020	0.77	0.045**	2.12
Scom	0.001	0.04	-0.016	-0.95
Sins	-0.003	-0.16	-0.012	-0.73
Suni	0.004	0.11	-0.017	-0.76
Sgmt	-0.033	-0.87	0.002	0.08
Scon	0.003	0.12	-0.017	-0.99
Sjou	0.037	1.24	0.040*	1.69
Spro	0.054*	1.85	0.061***	2.67
Co	0.045	1.52	0.049**	2.00
Rtr	0.009	0.44	-0.019	-1.22
Group	0.020	1.12	0.010	0.70
Growth_sale	-0.008	-0.39	-0.015	-1.01
Iprod06	-0.017**	-2.31	0.0002	0.05
Rd	0.021	0.80	0.019	0.89
Funloc	0.020	0.62	0.037	1.30
envid_1	0.021	0.73	0.043*	1.77
Size dummy	Yes		Yes	
Geographic dummy	Yes		Yes	
Industry dummy	Yes		Yes	
N. obs.	1,433		1,433	
Pseudo R^2	0.116		0.144	

*** significant at 1%; ** significant at 5%; * significant at 10%
Note: standard errors are robust to heroschedasticity

Table 10 – Determinants of EI: Scientific Activities (M)+ Travel Agencies (N)+ Renting and Hosing (L)

Estimation method: Probit	ECOEN		ECOCO	
	dF / dx	*t-value*	*dF / dx*	*t-value*
Sentg	0.040	1.12	0.050	1.16
Ssup	-0.050***	-3.02	-0.008	-0.27
Scli	0.019	0.64	0.093**	2.04
Scom	-0.011	-0.41	-0.037	-1.43
Sins	0.199**	2.00	-0.022	-0.94
Suni	-0.047***	-2.76	-0.020	-0.47
Sgmt	-0.039	-1.45	0.078	0.91
Scon	-0.023	-0.89	-0.006	-0.24
Sjou	0.199***	2.98	0.007	0.22
Spro	0.030	0.78	0.069	1.45
Co	0.027	0.62	0.001	0.05
Rtr	0.037	1.15	-0.024	-1.00
Group	-0.022	-1.25	-0.011	-0.58
Growth_sale	0.005	0.21	-0.012	-0.82
lprod06	0.007	0.81	-0.006	-0.71
Rd	0.082*	1.92	0.032	0.84
Funloc	0.012	0.32	0.006	0.17
envid_1	-0.008	-0.24	0.113***	2.73
Size dummy	Yes		Yes	
Geographic dummy	Yes		Yes	
Industry dummy	Yes		Yes	
N. obs.	563		563	
Pseudo R^2	0.238		0.142	

*** significant at 1%; ** significant at 5%; * significant at 10%

Note: standard errors are robust to heteroskedasticity

Table 11 – Push and pull effects (without ETS policy)

ALL-ECOEN	Coeff.	t	JK-ECOEN	Coeff.	t	H-ECOEN	Coeff.	t
pull1	-0.002	1.23	pull1	-0.11	1.83	pull1	0.0002	0.6
pull2	-0.009	4.62	pull2	-0.1	2.7	pull2	0.002	0.4
pull3	-0.004	1.89	pull3	-0.11	1.47	pull3	-0.002	0.4
pull4	-0.003	1.92	pull4	-0.004	0.87	pull4	0.001	0.31
push1	0.16	1.64	push1	0.006	0.5	push1	0.001	0.22
push2	0.005	1.02	push2	0.003	0.44	push2	0.003	0.76
push3	0.03	0.61	push3	-0.006	1.18	push3	-0.009	0.55
push4	0.001	0.16	push4	-0.006	0.94	push4	0.004	0.42
ALL-ECOCO	Coeff.	t	JK-ECOCO	Coeff.	t	H-ECOCO	Coeff.	t
pull1	-0.00009	0.06	pull1	0.003	0.6	pull1	-0.1	0.91
pull2	-0.0004	1.24	pull2	-0.002	0.6	pull2	-0.24	1.56
pull3	-0.001	1.48	pull3	0.003	0.45	pull3	-0.23	1.18
pull4	-0.001	0.91	pull4	0.001	0.3	pull4	-0.008	0.59
push1	-0.13	1.14	push1	-0.23	1.97	push1	-0.031	2.2
push2	0.008	1.12	push2	-0.006	0.99	push2	0.39	5.74
push3	-0.0004	1.2	push3	-0.15	2.24	push3	-0.18	1.67
push4	0.004	0.48	push4	0.17	1.59	push4	0.65	1.79

1= paper and card board; 2= coke & refinery; 3= ceramic; 4= metallurgy

Table 12 – Push and pull effects (with ETS policy indicators interacted with push and pull effects, see appendix)[10]

ETS1 (s1)			**ETS2 (s2)**			**ETS3 (s1bis)**		
ALL-ECOEN	Coeff.	t	ALL- ECOEN	Coeff.	t	ALL- ECOEN	Coeff.	t
pull1	-0.009	**2.65**	pull1	-0.009	**2.58**	pull1	-0.009	**2.42**
pull2	-0.011	**2.53**	pull2	-0.11	**2.55**	pull2	-0.1	**-3.74**
pull3	-0.14	**3.13**	pull3	-0.13	**2.65**	pull3	-0.12	**-2.87**
pull4	-0.009	**2.14**	pull4	-0.009	**2.31**	pull4	-0.008	**2.28**
push1	-0.013	1.44	push1	0.012	1.27	push1	-0.12	1.3
push2	-0.015	**2.65**	push2	-0.15	**2.63**	push2	-0.14	**2.59**
push3	0.004	0.59	push3	0.002	0.35	push3	0.002	0.39
push4	-0.02	**4.3**	push4	-0.21	**4.03**	push4	-0.015	**2.91**
ALL- ECOCO	Coeff.	T	ALL- ECOCO	Coeff.	t	ALL- ECOCO	Coeff.	t
pull1	-0.0044	1.69	pull1	-0.004	1.72	pull1	-0.004	1.7
pull2	-0.005	1.65	pull2	-0.005	1.66	pull2	-0.004	1.73
pull3	-0.006	1.88	pull3	-0.005	1.73	pull3	-0.005	1.76
pull4	-0.004	1.36	pull4	-0.009	**2.31**	pull4	-0.003	1.39
push1	-0.014	**2.09**	push1	-0.014	**1.98**	push1	-0.014	**2.02**
push2	-0.008	1.74	push2	-0.008	1.76	push2	-0.008	1.77
push3	0.0002	0.5	push3	-0.0019	0.43	push3	-0.0015	0.36
push4	-0.012	4.33	push4	-0.013	3.46	push4	-0.01	**3.33**

1= paper and card board; 2= coke & refinery; 3= ceramic; 4= metallurgy

[10] We multiply the ETS policy index with the I-O related share of final demand attributed to the specific sector. The higher the integration and/or the stringency, the higher the composite index.