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Analysis

Towards a green economy through innovations: The role of union involvement☆

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ABSTRACT

In this paper, we address the overlooked issue of whether and how industrial relations might play a role in the process of greening the economy, primarily through the levers of innovation adoption and organisational change. We address our objective econometrically, assessing the quality of industrial relations as a driver of environmental innovation adoption, through the use of micro-data on manufacturing firms. The results yield two interesting main findings: being a unionised firm is not associated with the adoption of environmental innovation; however, when we consider the industrial relations climate, we observe a positive relationship between a cooperative industrial relations climate (union involvement) and the propensity to introduce environmental innovation. Two models are relevant: a managerially oriented model (unions are informed) and a participatory model (unions bargain on innovation adoption). The contents of environmental innovations are also important: union involvement is more relevant for adopting more complex and radical innovations to abate CO_2 and EMS and ISO practices.

1. Introduction

The XXI Conference of the parties of United Nations Framework on Climate Change (UNFCCC) ended in December 2015 with some new directions for countries and economic agents that might be taken to cope with Green House Gases (GHG) emissions. Though the very diversified static and dynamic benefits/costs assessments across countries prevented the Conference from reaching a global/country based agreement on emission reductions, the architecture is framed around 'Intended nationally determined contributions': it identifies governments actions towards medium-long term commitments. These actions may include innovation-oriented actions and strategies (for updates see *climateobserver.org/open-and-shut/ind*). As for the implementation of climate policies (e.g. mission trading), the climate policy architecture will be more and more based upon bottom up efforts by countries and regions. This framework, which needs a good enforcement and monitoring effort, is possibly the only feasible outcome. We note it gives more chances and room for actions to countries, regions – and to various agents and stakeholders – to flexibly define abatement strategies in order to minimise costs and enhance economic/innovation outcomes. The role of industries, unions and other institutions and networks is widened, as well as their responsibility towards climate strategies. The role of regional entities is further enhanced in 'federal' countries.

Within this framework the challenges faced by trade unions in recent years, primarily due to the economic crisis that continues to impact EU labour markets (there are about 21.5 million unemployed men and women at present in the EU-28), have likely diverted some union 'energy' away from green issues, through the diffusion of collective bargaining on environmental topics, towards issues concerning the adverse effects of the economic crisis on labour markets and workers, e.g., the Framework for Action on Youth Employment (http://www.etuc.org/r/20). The Italian case is an example. The disruptive power of the crisis could also have undermined the well-established and structured social dialogue that has matured in recent

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decades among EU social partners[1] Unions are among those crucial actors in the implementation of reforms and measures to cope with the challenges imposed by the crisis (Eurofound, 2009). Moreover, when green arguments and industrial relations are jointly considered, the main challenge for unions[2] becomes how to integrate green and labour issues in the post-recession scenario (Uzzell et al., 2011).

Because unions play a relevant role in shaping both the EU policy agenda and, at the micro level, in influencing firms' adoption of environmental innovations (EIs, henceforth), we are interested in investigating the capacity of unions to influence the adoption of EIs (see Cainelli et al., 2012, for analyses on internal and external firm factors), which is a critical issue concerning the deployment of actual and future policies intended to fulfil the 2050 energy roadmap objectives. EIs are crucial for decoupling economic growth from environmental pressures (Borghesi et al., 2015a,b; EEA, 2014). We distinguish the effect of union involvement in firms' decisions with respect to the type of EI pursued, namely the degree of ' public good' content in the EI. Corradini et al. (2014) and Gilli et al. (2014) stress that CO_2-abating innovations are characterised by a larger share of public good output with respect, for example, to energy efficiency, the ' rents' of which are generally much more appropriable by firms. In addition, regarding the ' radicalness' of an innovation, it is worth assessing the differences among more radical EIs, e.g., CO_2 abatement, EMS/ISO, and end-of-pipe innovations (Carrillo-Hermosilla et al., 2010) (emission abatement). We disentangle innovations oriented at reducing global public bads (CO_2) and innovations that increase ' environmental efficiencies', which provide more appropriable rents in production (Mazzanti and Zoboli, 2009). Energy and materials feature a larger share of appropriable economic returns (Corradini et al., 2014). Regarding public goods such as CO_2, it is inherent a strong role played by spillovers and cooperation with other agents: the lower the private component in public goods, the more difficult to find solutions relying on internal resources. External sources of innovation/information play a stronger role. In addition, it is worth stressing that CO_2 is not reduced by end of pipe technological solutions. The reduction of CO_2 emissions and of GHG is more complex and implies a full restructuring and reorganisation of firm's assets and aims (Marin and Mazzanti, 2013). The involvement of other firms, stakeholders and unions capabilities could then be more relevant. Hence, unions involvement might be more relevant and necessary when EIs are highly radical and complex.

This work is structured as follows. The next section provides a review of the extant literature. In the third section, we specify the main research hypotheses and the applied methodology. The following section is devoted to the results description. The final section provides concluding remarks.

2. Background Literature

Do unionised firms, and among them those with good industrial relations (firm level unions involvement), provide more environmental benefits through the EIs adoption?

From a theoretical side, the usual assumption made on the linkage between unions and innovation is to regard unions as an element of the economic system that may, positively or negatively, influence a firm's innovative capacity. The positive or negative impact can be due, in the words by Freeman and Medoff (1979, 1984), to the ' two faces of unionism'. Unions act both in accordance to their ' monopoly face', which is usually associated to the negative effects of unionism, and in accordance to their 'collective voice', which highlights the value enhancing role of unions (Hirsch, 2004). The 'monopoly face' label stands for the possibility, for unions, to exploit their monopoly power on labour in order to rise wages and extract rents from firms' extra-profits, while the 'collective voice' label stresses the role of unions as a labour market institution that may favour innovation adoption, supporting firm development. Hence, on the one hand, unions may generate misaligned incentives, according to the conceptual framework depicted by several scholars from the Freeman and Medoff works onwards, which are analysed using conceptual tools belonging to (neo)classical economic theory.

2.1. The Potential Negative and Positive Impact of Unions on Innovation Activities

Bradley et al. (forthcoming) put forward three main reasons underpinning the 'monopoly face' of unions. First, they could generate hold up problems (Grout, 1984). The rent-seeking behaviour of the union has the aim of capturing returns from investment in tangible and intangible capital, but also from investments in innovation, reducing management's incentive to invest. As Hirsch (2004) clearly illustrates, if unions 'tax' investments in long-lived capital, R&D and other innovative activities, then the firms, internalising this unions behaviour, tend to reduce investment in such activities and capital. In particular, as innovative activities are concerned, the degree of appropriability of the quasi-rents associated to the innovation investments will guide the firms investments decision. Second, because unionisation may reduce the probability of dismissal, even in the presence of shirking, the latter would be 'encouraged' to some extent, thereby reducing productivity and lowering the innovation propensity of workers. Finally, as unions tend to reduce the gaps in wages among workers, the most talented workers would choose non-unionised firms to maximise the wage gains secured by their abilities. More generally, the wage premium causes distortions in relative factor prices, which in turn produce a dead-weight welfare loss (Hirsch, 2004).

The 'collective voice' (or institutional response face) of unions has positive implications for the firm performance to the extent that the management is responsive and supportive to union voice (Freeman and Medoff, 1984). Unions, as an element of the governance structure of firms, may positively influence innovation activities because, protecting workers against dismissal, trigger innovation activities, since employees are less concerned by any risky and uncertain innovation processes that the management intends to pursue. Moreover, unions are receptive towards organisational changes that aim to ameliorate the workforce well-being and help retain trained staff (Doucouliagos and Laroche, 2013), which represent firms specific human capital asset that may improve the absorption capacity of the firm towards new technologies.

2.2. The Role of Unions Involvement on Innovation Activities

Although the above arguments on the effect of unionisation on innovation are insightful, we contend that in empirical works there is a missing link between unionisation and innovation that is too often neglected: the firm-level dialogue between management and unions, which is a crucial factor for the deployment of the positive effects of the unions 'collective voice'. This dialogue, which can be

[1] Here, we refer to trade unions and employers or their representative organisations. The social partners are involved in the social dialogue, which can also be considered a tripartite dialogue involving a third partner: the government. Although a promising topic for future research, we are not strictly interested in the tripartite social dialogue, as our focus will be on union involvement in managerial decision-making processes, focusing our attention on the micro-level dialogue between management and workers through the mediation of firm-level union representatives.

[2] A series of unstructured interviews to union members belonging to different union confederations, both at European and Italian levels were conducted. From these interviews to union representatives and policy advisers we were able to extract highlights and considerations of interest for the comprehension of the complex phenomenon represented by the relation between green and labour market issues in a context of a (Just)transition towards a low carbon economy.

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Table 1
Union involvement in the decision-making process along six dimensions of innovation (402 obs.).

Innovation dimension	Degree of involvement	Freq.	%
Organisational innovations	No involvement	50	12.44
	Information	229	56.97
	Consultation	83	20.65
	Bargaining	40	9.95
Training	No involvement	56	13.93
	Information	219	54.48
	Consultation	96	23.88
	Bargaining	31	7.71
Technological Innovation	No involvement	61	15.17
	Information	237	58.96
	Consultation	77	19.15
	Bargaining	27	6.72
ICT implementation	No involvement	82	20.4
	Information	220	54.73
	Consultation	73	18.16
	Bargaining	27	6.72
Environmental innovation	No involvement	74	18.41
	Information	224	55.72
	Consultation	77	19.15
	Bargaining	27	6.72
Internationalisation strategies	No involvement	96	23.88
	Information	211	52.49
	Consultation	70	17.41
	Bargaining	25	6.22

regarded as the unions' involvement[3] in the decision-making process at firm level may be considered a crucial moderating factor, the particular relevance of which emerges when it makes unionisation a favourable element for innovation. As pointed out by Doucouliagos and Laroche (2013) there are several moderating factors (e.g. labour market regulation) that explain the ambiguous findings of the empirical literature on the effect of unions on innovation (Menezes-Filho and Van Reenen, 2003; Freeman, 2007; Laplante and Harrisson, 2008; Walsworth, 2010; Fang and Ge, 2012; Chun et al., 2015).

In the vast literature on the determinants of innovation, the components of the institutional context have been widely studied, especially by scholars investigating national systems of innovation (see among others: Groenewegen, 2006; Sharif, 2006; Guan and Chen, 2012) or regional systems of innovation (e.g.: Cooke et al., 1998; Doloreux, 2002). One of these components is the system of industrial relations[4] and its characteristics that may influence one of the firm level factors, namely unions involvement, which can turns the unions influence on innovation from negative to positive. In line with Metcalf (2003), we argue, as stated above, that when unions and management have non-adversarial relations and establish win–win strategic behaviour in pursuing common goals and gains, then the union's presence at the firm level can spur innovation activity instead of hampering it (Metcalf, 2003). Cooperation, consultation and bargaining between management and unions on relevant issues, including innovation strategies, create a participatory industrial relations climate that may foster and nurture innovation. Therefore, it can be argued that the impact of unions on innovation is mediated by their involvement in the firm's governance structure; however, the impact must be empirically verified, given the absence of univocal theoretical insights.

3. Research Questions and Quantitative Evidence

3.1. Setting the Research Questions

Based on the previous literature, it is interesting to test whether unionisation is related to the propensity to adopt EIs, where environmental innovation assumes, in accordance to a pretty consolidated literature, the following definition: it is an innovation which benefits the environment and contributes to environmental sustainability (Rennings, 2000), laxly including non-intentional environmental innovation and innovation strategies producing environmental benefits (Triguero et al., 2013; Kemp and Pontoglio, 2011)[5] . As pointed out by the literature (we here mainly refer to 'economics and management' oriented survey based empirical papers (Horbach et al., 2012; Cainelli et al., 2012; Borghesi et al., 2015a; Triguero et al., 2013; Kesidou and Demirel, 2012; Veugelers, 2012) EIs have three main forms (process, product, organisational) and are driven by four main underlying factors[6] : market, technology, regulation and firm specific factors.[7] We do extend the set of drivers by including the role of unions involvement as part of firm's specific factors that also represents a link to the territory and community, which is overlooked in both management and economic literatures as far as we know (Dangelico and Pontrandolfo, 2015; Dangelico, 2015a,b; Horbach et al., 2012; Murillo-Luna et al., 2008), although several works sprang out in the last years about the role of external and internal (to the firm) factors that influence the propensity to introduce environmental innovations: from customers, intended both as final customers and customers in a supply-chain

[3] An important role can also be assigned to the direct employees involvement as shown by Hanna et al. (2000).

[4] We do not focus our attention on factors external to the firm in this work, but we acknowledge their relevance. The study of the role of stakeholders and external factors may be the subject of future works related to the topic of the present paper.

[5] It is interesting to note the specific approach taken by Dangelico and Pontrandolfo (2010), who define green products on the basis of the 'impact' on the environment, namely less negative, null, or positive. This paper is nevertheless not concerned with impact analysis.

[6] For an updated and comprehensive discussion on various definitions and measurement issues for applied research we refer to the new works by Barbieri et al. (forthcoming) and Mazzanti et al. (2016).

[7] There are also works that look at the stimulating role of interactions with actors such as universities, public bodies, other firms (Cainelli et al., 2012), or business and non business actors, which include NGOs (Dangelico and Pontrandolfo, 2015).

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Table 2
Distribution of EIs between unionised and non-unionised firms.

	Unionised			
	No	Yes	Total	Test* for differences in proportions
	%	%	%	Two groups: Non-unionised vs Unionised
	%	%	%	Variable of interest: EI = Yes
ENVINNO				
No	83.7	78.6	80.0	H_a^1 p-value: 0.09
Yes	16.3	21.4	20.0	H_a^2 p-value: 0.18
Total	100.0	100.0	100.0	H_a^3 p-value: 0.91
ENERGY				
No	90.2	83.3	85.2	H_a^1 p-value: 0.02
Yes	9.8	16.7	14.8	H_a^2 p-value: 0.04
Total	100.0	100.0	100.0	H_a^3 p-value: 0.97
CO_2				
No	92.2	87.1	88.5	H_a^1 p-value: 0.05
Yes	7.8	12.9	11.5	H_a^2 p-value: 0.09
Total	100.0	100.0	100.0	H_a^3 p-value: 0.95
EMISSIONS				
No	89.5	84.6	85.9	H_a^1 p-value: 0.06
Yes	10.5	15.4	14.1	H_a^2 p-value: 0.13
Total	100.0	100.0	100.0	H_a^3 p-value: 0.93
EMASISO				
No	92.8	82.8	85.6	H_a^1 p-value: 0.00
Yes	7.2	17.2	14.4	H_a^2 p-value: 0.00
Total	100.0	100.0	100.0	H_a^3 p-value: 0.99

H_a^i where $i = 1, 2, 3$ are the alternative hypotheses. 1 and 3 one-sided; 2 two-sided.
H0 is not accepted when the p-value is less than 0.05.
H0: Proportion of innovators non-unionised = Proportion of innovators unionised.
H_a^1: Proportion of innovators non-unionised < Proportion of innovators unionised.
H_a^2: Proportion of innovators non-unionised ≠ Proportion of innovators unionised.
H_a^3: Proportion of innovators non-unionised > Proportion of innovators unionised.
* Z test with 95% confidence interval. H0 is the null hypothesis;

system (Qi et al., 2013; Simpson et al., 2007) to NGOs (Berrone et al., 2013), passing from the stringency of environmental policies (Frondel et al., 2008), for external factors; from the role of green supply chain integration on the green product and process innovation (Wu, 2013) to the importance of managerial concern as pointed out by Qi et al. (2010), for internal factors. Hence, the first research question concerns the impact that unions may have on EIs, which according to the theoretical framework presented in Section 2, can be either positive or negative:

R1 *Is unionisation positively or negatively related to EIs?*

The definition of the subsequent research question derives from the industrial relations literature, which recognises the indirect employees involvement[8] , through union representatives, (Martin, 1994; Nielsen and Lundvall, 2003) as a factor triggering a firm's propensity to innovate. The question also derives from the conceptual framework depicted in Carrillo-Hermosilla et al. (2010), which recognises the firms' *governance* structure as a critical dimension of EIs. The authors affirm that " successful eco-innovations are highly dependent on the participation of different stakeholders in their development/uptake" (Carrillo-Hermosilla et al., 2010, p.1082). Indeed, as pointed out by Murillo-Luna et al. (2008), the stakeholder pressures impact on environmental strategies and although they do not encompass unions among the analysed agents, they identify the disclosure of environmental information as a key issue. They emphasise 'stakeholder pressures' on management as the main operational factor behind enhanced environmental performance. We argue that the role of unions as 'stakeholders' is not only operating through 'pressures'. Being the unions involvement varied across institutional settings, it may act as (conservative/progressive) external pressure, or internal (conservative/progressive) lever of organisational change. In fact, unions can be considered as mixed stakeholders in terms of objectives. Following (Simpson et al., 2007, p.31) that state "the organisation 's choice of environmental strategy has more to do with the needs of the organisation 's financial stakeholders", we can argue that unions may be included among both 'financial' and 'non-financial' stakeholders, with a strong role of the private benefit side. Indeed, the new issue is that even from the point of view of unions the environment is an economic factor. This is an unromantic but concrete view that may reconcile through innovation and profits the usual employment/wage aim with environmental objectives. The citation from Egri and Pinfeld (1996, p.472) in Simpson et al. (2007) is also relevant: " from the perspective of organisational theory, environmental degradation becomes relevant only when the performance of a focal organisation and the welfare of organisational participants are affected by such concerns". Radical changes derive from organisations that comprehensively perceive and adopt strategies to reconcile by innovating the environment with wages, profits and employment. The radicalness of the challenge may require the action and competencies of both unions and management actors.

We consider unions as important elements of the internal governance structure and, as social actors, interested in the social

[8] We do not focus here on the direct involvement of employees, since our focus is on the role of unions. However, there is an interesting article by Lanfranchi and Pekovic (2014) which points out the relation between the adoption of environmental standards and the wellbeing and perception of usefulness of 'green employees'. The authors also show that the adoption of environmental standards may indirectly influence the employees involvement.

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Table 3
EIs variables.

Variable	Construction
EIs	
Environmental innovation (**ENVINNO**)	Dummy variable: 1 if the firm introduced an environmental innovation, 0 otherwise
Energy/Material reduction per unit of product (**ENERGY**)	Dummy variable: 1 if innovations intended to reduce use of materials and/or energy per output unit (included recycling) have been adopted, 0 otherwise
CO_2 reduction (**CO_2**)	Dummy variable: 1 if innovations intended to reduce CO_2 emissions have been adopted, 0 otherwise
Emissions reduction for soil, water and air pollutants (**EMISSIONS**)	Dummy variable: 1 if innovations intended to reduce emissions affecting soil, water and air have been adopted, 0 otherwise
Adoption of procedures such as EMAS and ISO14001 (**EMASISO**)	Dummy variable: 1 if procedures that structurally identify environmental performance have been adopted, 0 otherwise

benefits provided by EIs[9] . The role of unions and workers involvement in firms decisions enables innovation through the 'organisational culture' factor, where firms'/unions leadership, autonomy of decision making, motivations, and organisational climates are idiosyncratic elements that may promote innovation and change (Crossan and Apaydin, 2010). The relationship between unions and management is relevant to shape innovation cultures (mission, goals, strategy, organisational learning and knowledge management). Hence, cooperative industrial relations, which translates at firm level into participative practices and unions involvement, may also help in overcoming a potential under-investment issue in EIs by the firms (Popp, 2010; Rennings and Rammer, 2009). Firms are private actors that may tend to overlook the social benefits of EIs, which can be considered as impure public goods (Corradini et al., 2014; Barrett, 2006) given the social benefits they entails. If firms do not internalise in their objective function the social benefits generated by EIs, then they could under-invest in EIs with respect to what could be a social optimum level of investment. Firm level unions, as actors representing workers interests and more widely, also the territory/community interests in which they are embedded as the workers they represent, may act as an element that enhance the firm propensity to introduce EIs when industrial relations are participative and the management is receptive to unions voice.

Collaboration and cooperation among stakeholders is a crucial element of the *governance* dimension, and consequently, union involvement and participation in decision making on innovative strategies becomes a crucial element for the EIs development/uptake. The second research question is thus:

R2 *Is union involvement, as part of the governance dimension of the firm, positively related to the adoption of EIs?*

In answering these questions, we are able to verify the association between the degree of union involvement and the adoption of various types of EIs[10] .

3.2. Data and Empirical Strategy

To answer our research questions, we base our analysis on micro-level data from a unique dataset concerning a sample of 555 Italian manufacturing firms with at least 20 employees located in the Emilia-Romagna region (a NUTS 2 level of analysis), which ranks 4th in regional GDP in Italy and as the 3rd-largest regional industrial value added and accounts for approximately of the 7% of the Italian population. The information collected refers to the pre-crisis period (2006–2008). The random sample is stratified by size, geographic location (province level, NUTS 3) and sector. It is well representative of the population, exhibiting only minor distortions (see Table B1).

A multidimensional questionnaire[11] that investigates several dimensions of firm innovation activity, including environmental innovation, and provides information on union involvement in the decision-making process along six dimensions of innovation activity (see Table 1) was used to construct the dataset in order to carry out the present analysis.

The original survey we used to collect our data was carried on by a professional contractor (SWG, http://www.swg.it/en) through CATI (Computer Assisted Telephone Interview) interviews. The respondents were managers/owners involved in the definition of innovation strategies and deployment of adopted innovations. When they lack of some information concerning specific section of the questionnaire (e.g. section on human resource training) they were requested to refer to other managers possessing those information in order to minimise the number of missing values.

As we can see, the presence of union representatives at the firm level (see Table B2 in Appendix B) implies some form of involvement in the decision process: a substantial minority of firms do not involve unions at all (No involvement). Moreover only a small fraction of firms, fewer than the number of firms that do not involve unions, bargains with unions during the decision process regarding changes affecting one of the six innovation dimensions. The large majority of firms inform the union representatives of the changes they plan to introduce, and a non-negligible fraction of firms consult the unions.

Firms appear aware of the importance of union involvement as tool that can facilitate and smooth the adoption of innovations.

Moreover, as Table 2 shows, the unionised firms are more inclined to introduce some type of EIs: the alternative hypothesis that the proportion of firms introducing some type of EIs is larger for unionised firms than for non-unionised (H_a^1) is almost always not-rejected.

We classify EIs into four types[12] : EIs introduced to reduce the consumption of energy (ENERGY), to reduce the emissions of CO_2 (CO_2), to reduce the emissions of other air, soil and water pollutants (EMISSION) and to change the process and obtain green certificates (EMASISO). A general variable is also used to capture whether a firm introduced at least one of the EIs mentioned above (see Table 3).

[9] The unstructured interviews to unions members as illustrated in the CECILIA2050 report (http://www.cecilia2050.eu, Inducing Greenhouse Gases Abating Innovations Through Policy Packages. Ex Post Assessments from EU Sectors) show the importance of the environmental issues for unions.

[10] In addition, we can also indirectly test whether the limited firm-level debate on and union involvement in green issues, as emerged by the unstructured interviews we conducted (here not included for scope constraints), have consequences for EI development/uptake.

[11] Although the questionnaire is an original work, which provides unique information, we referred mainly to the Community Innovation Survey (http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey) as a source for the formulation of some questions (e.g. questions on the adoption of EIs).

[12] For a fine-grained ex-post based definition of green product innovations we refer the interested reader to Dangelico and Pontrandolfo (2010) who propose a Green Option Matrix to identify green product and practices.

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Table 4
Covariates.

Variable	Construction
Controls	
Size dummies	Size dummy by employee: 1 if the number of employees is higher than 250, 0 otherwise
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.
Geo	Geographical location of the firm. Dummy: 1 if the firm belongs to one of the 4 provinces located in the industrialised centre of the Emila-Romagna region (Bologna, Modena, Reggio Emilia, Parma)
EI_DIFF	Share of environmental innovating firms geographically clustered in the same municipality
ICT	Composite index capturing the presence of complex ICT adopted within the firm
TrainCov	Percentage of permanent workers covered by training programmes
OrgProd	Composite organisational index capturing changes in production organisation
OrgLab	Composite organisational index capturing changes in labour organisation
Demand Pull	
Export	Percentage of turnover made on international markets
MarketDem	Sector-based average of firms declaring to have adopted EIs because of market demand
Technology Push	
RD_IN	Dummy: 1 if the firm conducted intramural R&D, 0 otherwise
RD_EX	Dummy: 1 if the firm conducted extramural R&D, 0 otherwise
TechInvest	Dummy: 1 if the firm invested in the acquisition of new technologies, machines or software, 0 otherwise
Environmental Regulation	
Regul	Sector-based average of firms reporting to have adopted EIs because of environmental regulation
Unionisation	
Union	Dummy: 1 if the firm is unionised, 0 otherwise
Unions Involvement	
UnionInv	Index capturing the degree of involvement of the union representatives in relation to innovation strategies. The higher the index, the higher the degree of unions involvement.
UnionInfo	Dummy: 1 if unions are informed of green innovation decisions, 0 otherwise
UnionCons	Dummy: 1 if unions are consulted on green innovation decisions, 0 otherwise
UnionBarg	Dummy: 1 if unions and management bargain over green innovation decisions, 0 otherwise

Regarding the explanatory variables for the decision to introduce EIs, we use information that refers to the *technology push*, *demand pull* and *regulatory determinants* of EIs (see for example Borghesi et al., 2015b; Cainelli et al., 2012; Del Río et al., 2015) . These types of determinants are crucial for EIs, as for other innovations, and hence they are relevant variables for our analysis, but here they are used as background factors, while the main focus is on the role of unionisation and union involvement, which are elements additional to the main determinants of EIs, as they are also relevant for the introduction of other innovations. Table 4 reports the description of the explanatory variables used in the analysis.

The first step of the analysis is to estimate the following 'environmental innovation function' for the entire sample of 555 unionised and non-unionised firms:

$$Prob(Y = 1|\boldsymbol{x}) = \Phi(\boldsymbol{x}'\beta)$$

where Φ is the standard normal distribution; $\boldsymbol{x}$ includes the Controls, INNO variables and a dummy variable capturing the presence of unions at the firm level (Union_d);

The second step of the analysis is to estimate the following 'environmental innovation function' for the 402 unionised firms, accounting for the participatory climate at the firm level:

$$Prob(Y = 1|\boldsymbol{z}) = \Phi(\boldsymbol{z}'\beta)$$

where Φ is the standard normal distribution; $\boldsymbol{z}$ includes the same variables as in the vector $\boldsymbol{x}$ plus past firm performance but excludes the Union_d dummy, which is instead substituted for variables representing union representatives' involvement that capture, first, the union representatives' involvement (UNIONINV) in all strategic spheres listed in the questionnaire (organisation, technology, ICT, training, EIs, internationalisation) and, second, through specific involvement dummies for the EIs (UnionInfoEI, UnionConsEI, UnionBargEI) that capture the presence of information, consultation or bargaining on the strategic decision to implement EIs[13] . As far as UNIONINV index is concerned it is constructed as follows: at first, three indexes of involvement are constructed, each one referred to information, consultation and bargaining respectively (e.g. Information = number of innovation strategies concerning which the management decides to inform union representatives divided by the total number of innovation strategies considered in the question (6); see Q4 in Appendix A). Subsequently the composite UNIONINV

[13] The distinction of unions involvement in this three dimensions is motivated by the fact that such dimensions discriminate in an informative way the modalities according to which union representatives and managers may interact in Italian firms. Since we are here interested in the dialogue between managers and union representatives on firm strategic decision, beside the case of absence of interaction when the index takes the value 0, it is possible that managers simply inform union representatives on their innovation strategies (ex-post interaction which takes place after the managerial decision), consult union representatives (ex-ante interaction, but the decision is left to managers) and bargain with union representatives the way through which pursue innovation strategies (ex-ante cooperative form of interaction between managers and unions). These three dimensions exhaustively encompass the way unions and managers can interact on complex issues such as innovation strategies at firm level in Italy (see Antonioli et al., 2011 and Antonioli et al., 2009 for the use of a similar index in previous works).

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Table 5
Probit results with ENVINNO as dependent variable.

	(1)	(2)	(3)	(4)	(5)
Controls					
Size (d)	Yes	Yes	Yes	Yes	Yes
Sector (d)	Yes	Yes	Yes	Yes	Yes
Geo (d)	Yes	Yes	Yes	Yes	Yes
EI_DIFF	0.707***	0.708***	0.762***	0.766***	0.764***
	(0.062)	(0.062)	(0.072)	(0.072)	(0.072)
OrgProd	0.136***	0.135***	0.132**	0.127**	0.137***
	(0.045)	(0.045)	(0.054)	(0.054)	(0.053)
OrgLab	0.051	0.054	0.092	0.085	0.075
	(0.071)	(0.071)	(0.081)	(0.081)	(0.079)
TrainCov	0.121***	0.120***	0.110***	0.109**	0.119***
	(0.035)	(0.035)	(0.043)	(0.043)	(0.042)
Demand Pull					
Export	0.080*	0.082*	0.130**	0.131**	0.123**
	(0.044)	(0.044)	(0.053)	(0.053)	(0.051)
MarketDem	5.331***	5.395***	5.475***	5.464***	5.201***
	(1.017)	(1.021)	(1.186)	(1.220)	(1.171)
Technology Push					
RD_IN (d)	−0.015	−0.015	−0.052	−0.054	−0.059
	(0.034)	(0.034)	(0.040)	(0.040)	(0.040)
RD_EX (d)	−0.002	−0.002	0.026	0.025	0.027
	(0.028)	(0.028)	(0.032)	(0.032)	(0.031)
TechInvest (d)	0.065	0.065	0.126**	0.128**	0.115**
	(0.046)	(0.046)	(0.057)	(0.057)	(0.059)
Environmental Regulation					
Regul	0.330	0.313	−0.008	−0.015	0.045
	(0.453)	(0.447)	(0.537)	(0.546)	(0.508)
Unionisation					
Union		−0.010			
		(0.030)			
Union Involvement					
UnionInv				0.047	
				(0.054)	
UnionInfo (d)					0.126***
					(0.045)
UnionCons (d)					0.075
					(0.056)
UnionBarg (d)					0.119**
					(0.059)
N	555	555	402	402	402
Pseudo_R^2	0.430	0.430	0.452	0.453	0.471
Chi^2	1060.50 (17)	938.60 (18)	988.28 (17)	916.18 (18)	593.91 (20)
		Hosmer-Lemeshow goodness of fit test: Chi^2 (df)			
	9.52 (8)	10.40 (8)	3.23 (8)	1.75 (8)	5.52 (8)
		Correctly classified			
	87.03%	86.31%	86.82%	87.81%	86.82%

Marginal effects; Standard errors are in parentheses.
(d) for discrete change of dummy variable from 0 to 1.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.10$.

index is constructed as the mean of the three indexes of involvement. So that, the higher the UNIONINV index the higher the degree of unions involvement in the decision making concerning innovation strategies. As reported in Appendix A, the question related to the union representatives' involvement (Q4) allows us to construct further different types of variables that capture union participation in the decision-making process. In particular, in order to isolate the importance of union involvement in spurring EI adoption, we consider how management and unions interact on green strategies[14].

The three binary variables introduced above (UnionInfoEI, UnionConsEI, UnionBargEI) have a further characteristic that allows us to use them jointly in a single specification:the presence of a modality of union involvement excludes the other two (see Table B3 in Appendix B).

In addition, as we are aware of potential endogeneity problems in our specification, we also attempted to estimate models with Instrumental Variables (IVs). We searched for suitable instruments among social aspects potentially related to unionisation and union involvement. Because the major union organisation in Italy (CGIL) is a left-wing union and represents the largest share of unionised workers, we opted for the 'share of left-wing voters in the 2006 general election by municipality in Emilia-Romagna' as instrument for both unionisation and union participation in the decision-making process within the firm. The instrument constructed was not robust:

[14] We also used union involvement variables for other innovation strategies to support the idea that involvement, whether in EIs or other innovation strategies, is a key factor. The main results reported in the next section are confirmed. The results are available from the authors upon request.

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Table 6
Probit results with ENERGY as dependent variable.

	(1)	(2)	(3)	(4)	(5)
Controls					
Size (d)	Yes	Yes	Yes	Yes	Yes
Sector (d)	Yes	Yes	Yes	Yes	Yes
Geo (d)	Yes	Yes	Yes	Yes	Yes
EI_DIFF	0.435***	0.432***	0.495***	0.495***	0.491***
	(0.045)	(0.044)	(0.057)	(0.057)	(0.055)
OrgProd	0.131***	0.133***	0.106**	0.109**	0.112**
	(0.043)	(0.043)	(0.051)	(0.052)	(0.050)
OrgLab	0.065	0.059	0.089	0.092	0.087
	(0.072)	(0.072)	(0.083)	(0.083)	(0.082)
TrainCov	0.099***	0.102***	0.120***	0.121***	0.127***
	(0.031)	(0.031)	(0.039)	(0.039)	(0.039)
Demand Pull					
Export	0.071*	0.067*	0.081*	0.081*	0.065
	(0.039)	(0.040)	(0.047)	(0.047)	(0.047)
MarketDem	5.030***	4.918***	5.615***	5.655***	5.318***
	(0.856)	(0.854)	(1.051)	(1.047)	(0.976)
Technology Push					
RD_IN (d)	0.072*	0.074*	0.061	0.061	0.079
	(0.039)	(0.039)	(0.050)	(0.050)	(0.053)
RD_EX (d)	0.033	0.033	0.055*	0.056*	0.054*
	(0.024)	(0.024)	(0.029)	(0.029)	(0.029)
TechInvest (d)	0.057	0.058	0.056	0.055	0.053
	(0.047)	(0.047)	(0.054)	(0.054)	(0.053)
Environmental Regulation					
Regul	−0.114	−0.081	−0.257	−0.260	−0.206
	(0.372)	(0.376)	(0.461)	(0.457)	(0.432)
Unionisation					
Union		0.025			
		(0.030)			
Union Involvement					
UnionInv				−0.028	
				(0.058)	
UnionInfo (d)					0.085**
					(0.043)
UnionCons (d)					0.004
					(0.059)
UnionBarg (d)					0.068
					(0.061)
N	555	555	402	402	402
Pseudo_R^2	0.393	0.394	0.394	0.394	0.412
Chi^2	844.77 (17)	1048.87 (18)	1065.89 (17)	1013.84 (18)	714.45 (20)
Hosmer-Lemeshow goodness of fit test: Chi^2 (df)	7.10 (8)	9.32 (8)	10.40 (8)	6.77 (8)	10.09 (8)
Correctly classified	88.29%	88.11%	87.06%	87.31%	86.82%

Marginal effects; Standard errors are in parentheses.
(d) for discrete change of dummy variable from 0 to 1.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.10$.

it was too weak to be used in the analysis as a reliable instrument. We obtained the same result using a less-refined instrument: 'the electoral turnover in the general election of 2006 by municipality in Emilia-Romagna'.

4. Results

First, as we can see in Tables 5–9, several 'innovation-related factors' are linked to the probability of EI adoption. First, sector relatedness matters: being a firm in a sector subject to the ETS (a polluting sector) increases the probability of adopting energy-saving EIs. This is always crucial for EIs, since environmental policies often have specific sector features; in addition, heavy manufacturing sectors are often subject to more stringent policies and may tend to innovate more. This is a crucial element for creating synergies between industrial/economic aims and environmental targets (e.g. the aforementioned EU industrial and environmental strategies). Second, the rate of diffusion of EIs within the same municipality influence the probability of adoption for any type of EI. The role of spatial agglomeration and spillovers has been substantially neglected in works on EIs determinants (see the following works for some examples concerning the role of spatial factors: Cainelli et al., 2012; Horbach, 2013; Corsatea, 2014). We here stress the importance of identifying the level of boundaries within which agglomeration economies operate. The results for the EI_DIFF variable suggest the presence of positive spillover effects of EIs within municipality boundaries (Antonioli et al., forthcoming).

Concerning the organisational innovation variables, which are part of the High Performance Work Practices (HPWP), we note the

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Table 7
Probit results with CO_2 as dependent variable.

	(1)	(2)	(3)	(4)	(5)
Controls					
Size (d)	Yes	Yes	Yes	Yes	Yes
Sector (d)	Yes	Yes	Yes	Yes	Yes
Geo (d)	Yes	Yes	Yes	Yes	Yes
EI_DIFF	0.303***	0.301***	0.363***	0.365***	0.364***
	(0.040)	(0.041)	(0.048)	(0.047)	(0.045)
OrgProd	0.135***	0.137***	0.101**	0.095*	0.100**
	(0.041)	(0.041)	(0.049)	(0.049)	(0.047)
OrgLab	0.002	−0.007	−0.003	−0.010	−0.012
	(0.071)	(0.072)	(0.082)	(0.083)	(0.081)
TrainCov	0.084***	0.088***	0.118***	0.116***	0.117***
	(0.030)	(0.031)	(0.036)	(0.036)	(0.036)
Demand Pull					
Export	0.039	0.034	0.047	0.047	0.044
	(0.038)	(0.039)	(0.044)	(0.044)	(0.045)
MarketDem	−2.759***	−2.841***	−3.005***	−2.953***	−3.279***
	(0.606)	(0.667)	(0.686)	(0.667)	(0.795)
Technology Push					
RD_IN (d)	0.039	0.039	0.010	0.010	0.019
	(0.032)	(0.032)	(0.038)	(0.039)	(0.041)
RD_EX (d)	0.030	0.030	0.073***	0.071***	0.072***
	(0.024)	(0.024)	(0.027)	(0.027)	(0.027)
TechInvest (d)	0.021	0.023	0.012	0.015	0.008
	(0.040)	(0.040)	(0.045)	(0.044)	(0.044)
Environmental Regulation					
Regul	3.736***	3.782***	3.882***	3.817***	3.886***
	(0.398)	(0.415)	(0.473)	(0.457)	(0.477)
Unionisation					
UniUnion (d)		0.029			
		(0.029)			
Union Involvement					
UnionInv				0.061	
				(0.050)	
UnionInfo (d)					0.146***
					(0.053)
UnionCons (d)					0.111*
					(0.063)
UnionBarg (d)					0.158**
					(0.065)
N	555	555	402	402	402
Pseudo_R^2	0.301	0.303	0.329	0.333	0.359
Chi^2	971.80 (17)	862.34 (18)	960.44 (17)	898.84 (18)	766.76 (20)
Hosmer-Lemeshow goodness of fit test: Chi^2 (df)	7.48 (8)	9.41 (8)	5.16 (8)	9.11 (8)	8.49 (8)
Correctly classified	89.37%	89.55%	85.56%	88.31%	89.30%

Marginal effects; Standard errors are in parentheses.
(d) for discrete change of dummy variable from 0 to 1.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.10$.

importance of two types of innovations as factors related to EI adoption: changes in production organisation and the coverage of training programmes. These two types of innovations are complementary with respect to the EIs adoption propensity (Antonioli et al., 2013). In addition, HPWP imply strategies where the role of unions is relevant, especially for managing training programmes. However, the role of R&D should not be neglected. Indeed, some specific EIs are related to intramural or extramural R&D[15] Even if other studies tend to under emphasise the role of R&D (Cainelli et al., 2012), and even in this analysis R&D is not the key leading factor, we note that especially for more complex innovation realms (e.g. CO_2), external sources of knowledge are pretty relevant. All in all regarding the link with the broad 'innovation' realm, EIs show integration with other innovation investments both in the input and output sides.

Turning to the main variables of interest to test our research hypotheses, we note that unionisation does not *per se* influence the probability of environmental innovation, as specifications (1) and (2) show (Tables 5–9). The analysis for the full sample of firms, conducted to test the role of simple unionisation on the propensity to introduce environmental innovation, leads us to reject *R1*: unionisation does not influence the probability of environmental innovation adoption. This result is not unexpected, since the empirical literature has provided ambiguous evidence on the role of unions on innovation, as reported in Section 2. Unionisation is anyhow a rough

[15] Specifically, energy-saving and CO_2-reducing innovations are related to both intramural and extramural R&D (Tables 6 and 7), while the organisational changes introduced to acquire green certificates are primarily related to technological investments (Table 9).

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Table 8
Probit results with EMISSIONS as dependent variable.

	(1)	(2)	(3)	(4)	(5)
Controls					
Size (d)	Yes	Yes	Yes	Yes	Yes
Sector (d)	Yes	Yes	Yes	Yes	Yes
Geo (d)	Yes	Yes	Yes	Yes	Yes
EI_DIFF	0.376***	0.375***	0.448***	0.450***	0.443***
	(0.045)	(0.045)	(0.055)	(0.042)	(0.053)
OrgProd	0.091**	0.091**	0.076	0.069	0.074
	(0.043)	(0.044)	(0.052)	(0.052)	(0.051)
OrgLab	0.041	0.038	0.077	0.068	0.063
	(0.075)	(0.076)	(0.087)	(0.088)	(0.086)
TrainCov	0.093***	0.095***	0.111***	0.110***	0.115***
	(0.034)	(0.034)	(0.039)	(0.039)	(0.039)
Demand Pull					
Export	0.053	0.050	0.095*	0.095*	0.099*
	(0.043)	(0.043)	(0.051)	(0.050)	(0.051)
MarketDem	−3.462***	−3.518***	−3.885***	−3.759***	−3.903***
	(0.619)	(0.631)	(0.810)	(0.661)	(0.837)
Technology Push					
RD_IN (d)	0.022	0.022	0.031	0.030	0.027
	(0.036)	(0.036)	(0.051)	(0.051)	(0.053)
RD_EX (d)	−0.001	−0.001	0.047	0.045	0.049*
	(0.027)	(0.027)	(0.030)	(0.029)	(0.029)
TechInvest (d)	0.020	0.020	0.065	0.067	0.060
	(0.043)	(0.043)	(0.057)	(0.056)	(0.057)
Environmental Regulation					
Regul	4.515***	4.541***	4.739***	4.657***	4.706***
	(0.444)	(0.436)	(0.582)	(0.396)	(0.558)
Unionisation					
Union		0.013			
		(0.032)			
Union Involvement					
UnionInv				0.063	
				(0.052)	
UnionInfo (d)					0.079*
					(0.044)
UnionCons (d)					0.085*
					(0.051)
UnionBarg (d)					0.089
					(0.060)
N	555	555	402	402	402
Pseudo_R^2	0.277	0.278	0.341	0.344	0.350
Chi^2	1278.85 (17)	1267.24 (18)	1223.26 (17)	1441.05 (18)	1086.52 (20)
Hosmer-Lemeshow goodness of fit test: Chi^2 (df)	16.43 (8)	13.37 (8)	4.03 (8)	6.84 (8)	4.67 (8)
Correctly classified	87.21%	87.39%	87.81%	87.81%	87.81%

Marginal effects; Standard errors are in parentheses.
(d) for discrete change of dummy variable from 0 to 1.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.10$.

proxy of the involvement and role of workers and their representatives within firm's decisions. In addition, the pretty high unionisation intensity in manufacturing firms in some industrial contexts need deeper investigations on the quality and type of union's role.

In order to put in evidence the moderating role of unions involvement we turn our attention on the unionised firms. The hypothesis we test is a positive linkage, for these kind of firms, between EIs and a participative work environment. Indeed, when we analyse the linkage between industrial relations and EI, for the sub-sample of unionised firms (specifications (3) to (5) in Tables 5–9) we note that specific types of involvement matter. 'Information' and 'bargaining' are related to EI, in the general EI regression (Table 5).

The general result Table 5 shows is original and interesting, but it hides differences in relation to the importance of union's involvement. The adoptions of more complex organisational and technological innovations (EMASISO, CO_2) are the cases where both information and bargaining matter (Tables 7 and 9). In addition, we note that especially for tackling the complex CO_2 abatement, the management and the unions are co-involved through bargaining. Redefining the organisation and restructuring the technological portfolio induces the management to involve the unions in the development of innovation strategies. Two models seem necessary and relevant within a general 'need' of involving workers through unions: one where the management is more self sufficient but inform unions, the other where unions involvement is strong. When t he costs for EIs are higher, intermediate solutions (e.g. unions consultation) do not provide sufficient benefits. Benefits given by unions involvement, even through intermediate solutions such as consultation (only at 10% statistical significance though), seems higher – as expected – when mixed private/public issues are at stake (e.g. reducing a global public good such as CO_2).

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Table 9
Probit results with EMASISO as dependent variable.

	(1)	(2)	(3)	(4)	(5)
Controls					
Size (d)	Yes	Yes	Yes	Yes	Yes
Sector (d)	Yes	Yes	Yes	Yes	Yes
Geo (d)	Yes	Yes	Yes	Yes	Yes
EI_DIFF	0.420***	0.412***	0.459***	0.462***	0.456***
	(0.047)	(0.046)	(0.057)	(0.058)	(0.057)
OrgProd	0.072*	0.071*	0.099*	0.091*	0.102*
	(0.042)	(0.042)	(0.055)	(0.055)	(0.054)
OrgLab	0.095	0.088	0.113	0.105	0.096
	(0.068)	(0.067)	(0.088)	(0.088)	(0.086)
TrainCov	0.070**	0.075**	0.091**	0.089**	0.098**
	(0.032)	(0.032)	(0.042)	(0.042)	(0.041)
Demand Pull					
Export	0.082**	0.074*	0.093*	0.093*	0.087
	(0.041)	(0.042)	(0.054)	(0.054)	(0.054)
MarketDem	5.916***	5.797***	7.338***	7.264***	6.935***
	(0.880)	(0.885)	(1.163)	(1.187)	(1.111)
Technology Push					
RD_IN (d)	−0.037	−0.039	−0.058	−0.061	−0.059
	(0.032)	(0.032)	(0.043)	(0.043)	(0.044)
RD_EX (d)	0.017	0.016	0.038	0.036	0.035
	(0.026)	(0.026)	(0.033)	(0.032)	(0.032)
TechInvest (d)	0.039	0.036	0.105*	0.108*	0.098
	(0.042)	(0.042)	(0.059)	(0.059)	(0.060)
Environmental Regulation					
Regul	−0.550	−0.508	−0.964*	−0.976*	−0.919*
	(0.380)	(0.382)	(0.518)	(0.527)	(0.502)
Unionisation					
Union		0.046			
		(0.031)			
Union Involvement					
UnionInv				0.070	
				(0.058)	
UnionInfo (d)					0.108**
					(0.047)
UnionCons (d)					0.061
					(0.059)
UnionBarg (d)					0.119*
					(0.065)
N	555	555	402	402	402
Pseudo_R^2	0.320	0.325	0.307	0.310	0.321
Chi^2	1170.82 (17)	1389.17 (18)	1270.70 (17)	1183.54 (18)	1328.64 (20)
Hosmer-Lemeshow goodness of fit test: Chi^2 (df)	11.91 (8)	13.64 (8)	7.79 (8)	9.66 (8)	13.02 (8)
Correctly classified	87.75%	87.75%	85.32%	85.07%	85.32%

Marginal effects; Standard errors are in parentheses.
(d) for discrete change of dummy variable from 0 to 1.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.10$.

On the contrary, energy-saving innovations are related only to union information (Table 6): the higher the economic appropriability of EIs adoption (win–win energy solutions), the lower the need to involve through bargain. The management is self sufficient.

Finally, the weakest role of unions-management interactions in terms of statistical significance (10% significance level both for union information and bargaining) is found for emission reducing technologies, where simpler technological (e.g. end of pipe) solutions predominate (Table 8).

In relation to the second research question (*R2*), the evidence we find is not trivial. In fact, it seems that a non-linear relationship between union involvement and EI emerges: a managerially driven approach to introducing EI (when unions are only informed of managerial intent) and an industrial-relations driven approach (when EIs are introduced through a process of bargaining between unions and management), which seem to co-exist in the analysed manufacturing system and to lead to a higher probability of EI adoption. Our results seem to add some more information about the moderating role of participative industrial relations. At firm level it is important that management is receptive to union voice, bargaining with unions on innovation issues, in order to turn the 'effect' of unions on innovation from negative to positive (Metcalf, 2003), however even simple top-down information flows from management to unions are robustly related to the propensity to innovate. This results leave space for further research on the impact of different models of unions involvement on EIs. Finally if we focus our attention on the results for EIs aiming to reduce CO_2 emissions, which largely entails public benefits, unions involvement emerges as a crucial driver. An industrial-relations driven model behind CO_2 innovations strongly emerges: this shows a potential important role

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of firm level unions in the diffusion of EIs that incorporate large public benefits. Putting it another way, firm level unions could be key players in mitigating private under-investments in EIs, mostly when there is a need to support and define innovations which produce public good benefits. This should be (part of) the social role of unions. Future research, through a more detailed definitions of EIs and of unions involvement models could shed more light on this potential unions role, which opens windows on 'industrial relations' driven Corporate Social Responsibility strategies.

5. Conclusions

We analysed the role of unionisation and union involvement in manufacturing firms in relation to the propensity to introduce environmental innovation. The economics, social and policy relevance relates to the active role of unions as innovation players in realities where small and medium firms prevail, which is the case of many industrial contexts. Those economic realities are as much as important as Corporate/MultiNationalEnterprises to cope with the green economy and sustainability challenges. Unionisation does not seem to play a role *per se* as a 'determinant' of EI: firms with union representatives do not have a higher propensity to innovate in the 'green' area.

However, when we analyse the role of the industrial relations climate at the firm level, focusing our attention on the sub-sample of firms with union representatives, we find some strong linkages between some types of unions involvement and EIs. In particular, the strongest relationships emerge with the adoption of CO_2 emissions-reduction technologies and with EMAS and ISO adoption, the two more complex EIs in terms of technological and organisational capability development within a firm. We can speculate that participatory governance may be helpful in augmenting the competencies, including external ones, and the absorptive capacity that firms need to adopt CO_2 emissions-reduction technologies. In these cases, a 'U shaped' relationship emerges: simply informing unions (managerially driven approach to adopting EIs) or bargaining with them on strategic decisions concerning innovation (industrial-relations driven approach to introducing EIs) are positively related to probability of EI adoption, while consulting with unions is not associated with EI adoption (compared to the baseline case of no-involvement).

The evidence is not trivial and original with respect to past studies in this realm: we cannot simply state that a higher degree of union involvement increases the probability of adopting EIs, as we observe a non-linear relationship.

Two competing models of taking strategic decisions at the firm level are found in the analysed firms: a managerially driven approach (informing unions) and a more participation-driven model (bargaining with unions). The two models have different implications for managers and policy makers. On the one hand, it appears that management of manufacturing firms has the required capabilities and knowledge to address innovative challenges without union involvement. On the other hand, we can also argue that participatory governance seems to be effective solutions to the some of the innovative challenges. The role of social dialogue at the firm level is an important driver of EIs and should be taken into account by both policy makers and relevant stakeholders, also because of the role unions could have, through a participative environment, in mitigating the private under-investment in EIs with entails large public benefits. Against the challenges posed by environmental policies and green market developments there is a need to invest in new competences and skills at all levels of firms organisation: managers, workers, union's representatives. Effective and performance oriented industrial relations largely derive from the co-presence of adequate skills, which may be lacking in front of new (environmental) strategies.

Finally, some limitations and further research lines can be listed. One of the main limitations is the lack of panel data availability, which could have provided the opportunity to exploit the longitudinal structure of the panel in order to properly deal with the endogeneity issue. Another limit we here acknowledge concerns again the data. Both on the side of EIs and of unions involvement it might be possible to retrieve more detailed information, possibly not only from a single source (e.g. both from management and union representatives). This would help in refining the analysis and focusing the attention on specific linkages among unions involvement, green innovations and green practices. As a last remark on the possibility to extend the present research, we would like to draw the attention on a further potential step that integrates in the framework of the analysis here presented the labour productivity, the employment and also the skill content of the workers' jobs/tasks, which may be influenced by the EIs adoption, with an important role of unions involvement at firm level as a mediating factor.

Appendix A

Selected questions to depict the information collected for the EI and UNION variables. The answers refer to the period 2006-2008.

ENVIRONMENTAL INNOVATION (EI)

Q1: Did the firms adopt "environmental" products and/or process technological innovations that induced the following benefits?

	Yes/No
1. Reduction in the use of materials and/or energy per output unit (including recycling).	
2. CO_2 emissions reduction.	
3. Emission reductions that improve the quality of soil, water and air.	

ENERGY= 1 if Reduction in the use of materials and/or energy per output unit (included recycling) was marked Yes, 0 otherwise

CO_2 = 1 if CO_2 emissions reduction was marked Yes, 0 otherwise

EMISSIONS= 1 if Emission reductions that improve the quality of soil, water and air, 0 otherwise

Q2: Does the firm employ procedures that structurally identify its environmental performance?

Procedure	Yes/No
1. EMAS	
2. ISO 14001	
3. Others such as LCA, ISO14040, ……(specify)	

EMASISO= 1 if EMAS or ISO14001 or Others is marked Yes, 0 otherwise

UNIONISATION AND INDUSTRIAL RELATIONS

Q3: Do you have union representatives at the firm level: ❑ Yes ❑ No

Q4: Were the union representatives involved in the following issues?

Issues	Not involved	Informed	Consulted	Bargained with
1. Organisational Innovations	❑	❑	❑	❑
2. Training	❑	❑	❑	❑
3. Technological Innovation	❑	❑	❑	❑
4. ICT implementation	❑	❑	❑	❑
5. Environmental Innovation	❑	❑	❑	❑
6. Internationalisation Strategies	❑	❑	❑	❑

For each firm UNIONINV = Mean of $\sum_i(J_i)$ where $J_i = \frac{\sum_i(Innovation-strategies-ticked)}{\sum(All-possible-innovation-strategies)}$ with i = Information, Consultation, Bargaining respectively

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Appendix B

Table B1
Distribution by sector, size and geographical location of population and sample firms.

Sectors	Freq.	Percent	***Size***	Freq.	Percent	*Province*	Freq.	Percent
Population								
CokeChemical	130	3.2	20–49	2720	66,86	Out region	91	2.24
Food	382	9.39	50–99	726	17,85	BO	904	22.22
Machinery	1387	34.1	100–249	414	10,18	FC	346	8.51
Metallurgy	883	21.71	250+	208	5,11	FE	196	4.82
NonMetallic	285	7.01				MO	891	21.9
PaperPrinting	197	4.84				PC	200	4.92
Shoes	236	5.8				PR	381	9.37
Textile	119	2.93				RA	229	5.63
WoodRubberPlasticOther	449	11.04				RE	667	16.4
						RN	163	4.01
Total	4068	100		4068	100		4068	100
Sample								
CokeChemical	28	5.05	20–49	208	37,48	Out region	20	3.6
Food	49	8.83	50–99	193	34,77	BO	115	20.72
Machinery	232	41.8	100–249	96	17,30	FC	40	7.21
Metallurgy	94	16.94	250+	58	10,45	FE	30	5.41
NonMetallic	42	7.57				MO	124	22.34
PaperPrinting	19	3.42				PC	25	4.5
Shoes	12	2.16				PR	49	8.83
Textile	23	4.14				RA	32	5.77
WoodRubberPlasticOther	56	10.09				RE	96	17.3
						RN	24	4.32
Total	555	100		555	100		555	100

Table B2
Unionisation by size and sector

	Union		
Size	0	1	Total
0: 20–49	101	102	203
1: 50–99	40	137	177
2: 100–249	11	95	106
3: ≥250	1	68	69
Total	153	402	555
Sectors	0	1	Total
Food	8	41	49
Textile	11	12	23
Shoes	2	10	12
WoodRubberPlasticOther	13	43	56
PaperPrinting	7	12	19
CokeChemical	6	22	28
NonMetallic	6	36	42
Metallurgy	33	61	94
Machinery	67	165	232
Total	153	402	555

Table B3
Unions involvement modalities on EIs.

	UnionBargEI		
UnionInfoEI	0	1	Total
0	151	27	178
1	224	0	224
Total	375	27	402

	UnionConsEI		
UnionInfoEI	0	1	Total
0	101	77	178
1	224	0	224
Total	325	77	402

	UnionConsEI		
UnionBargEI	0	1	Total
0	298	77	375
1	27	0	27
Total	325	77	402

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