

Collective bargaining and technological innovation in the EU15: An analysis at establishment level

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Abstract

In this paper, we study the relationship between unionisation and workplace innovation in a cross-country and multisectoral approach. This is an important and controversial issue in the industrial relation literature; however, the empirical literature on the links between innovation and unionism is rather scarce and results are mixed and ambiguous, both in theory and in empirical practice. The European Company Survey (Eurofound), with data for establishments in 15 European Union countries, is used employing a probit model. Our results contribute to the debate by showing that the adoption of technology not only increases when the company performs collective bargaining but also when the relationship between wage bargaining and innovation adoption is not linear, being more significant in cases where bargaining occurs at the regional/national level.

KEYWORDS

collective bargaining, establishment level, European Union, technological innovation, trade unions

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1 | INTRODUCTION, MOTIVATION AND CONTRIBUTION

The introduction of technological innovation (TI) in firms is increasing, with more sophisticated technological changes disrupting the labour market and making workers redundant (Brynjolfsson & McAfee, 2011). The unions are concerned about the consequences of that changes, not only in terms of unemployment, wage (Frey & Osborne, 2017) and inequality, but particularly on the labour relations.¹ Related to that, the debate about the union's role on the company adoption of technological advancements and the introduction of TI has returned to gain space in the literature (Bryson & Dale-Olsen, 2020a, 2020b). However, there seems to be no consensus about the direction of this relationship in theoretical and empirical literature so far. More recent works corroborate this lack of consensus, such as those in Bradley et al. (2017), demonstrating negative effects of the presence of trade unions, and in Bryson and Dale-Olsen (2020a, 2020b), who show positive effects.

A strong union can negotiate the nature of TI in the workplace and promote technological and organisational changes that can generate greater positive effects both for its members and for the company in general (Bryson et al., 2009). It can negotiate, for example job guarantees (job security guarantees) and/or wage increases, associated with higher productivity derived from technological change introduced by the company (ensuring high wages in exchange for innovation that improves productivity). Moreover, as an intermediary institution between employer and employees, the union can, as Freeman and Medoff (1984) pointed out, make the changes more acceptable to its members by improving the circulation of information among workers about the benefits of new technologies (labour demand, wage, job tenure and reducing adverse well-being effect from technological innovation—Bryson et al., 2013), even increasing their motivation, their productivity and the competitiveness of the company.

However, on the other hand, unions can exacerbate the rejection of the introduction of TI through the same channels that lead to their improvement, for example highlighting its deficiencies and the effects on workers, increasing rejection and reducing the introduction of new technologies in the production process. Innovation may encounter resistance or hostility from employees who fear change or believe it will be to their detriment. When employees have sufficient bargaining power, they can even block management's attempts at innovation (Cahuc et al., 2014). Some unions were known to impose restrictive labour practices in Britain during the 1960s and 1970s, leading to lower labour productivity in unionised workplaces compared to their non-union counterparts (Metcalf, 1990).

To contribute to this debate, the main objective of this paper is to analyse the relationship between the introduction of technological innovation and collective bargaining in the EU15 countries, at establishment level, using the European Company Survey 2013 database (ECS).²

The research intends to answer two questions: first, from an empirical approach, if there is a relationship between collective bargaining and the introduction of technological innovations in

¹Unions fear about digitalisation, could be summarise in: (a) jobs losses caused by automation; (b) fragmentation of the labour market; (c) worsening of the quality of jobs; (d) reinforcement of the control capacity of management (digital surveillance, data protection...); (e) effects of health and safety; (f) deterioration of industrial relations and new forms of atypical jobs (particularly with the platform economy); and (g) the deepening of societal challenges, like unemployment and rising inequalities (including the gender gaps); deregulation (labour law, wage-setting, collective bargaining...); tax erosion, social protection funding; growing social polarisation (Confederación Sindical de Comisiones Obreras and Unión General de Trabajadores, 2017).

²More information related to the selection of ECS is given in Section 4.



firms and in which cases does it occur; and second, trying to answer, from a more theoretical perspective, if unions could foster innovation.³

The ECS database makes it possible to measure the introduction of innovations and technologies from four binary variables that represent the introduction of product or services innovation, process innovation, organisational innovation and technological change. It also enables to identify the role of unions from two alternative representations: a binary one that represents the participation of the company in a business association that participates in collective bargaining and, the second, the scope of wage bargaining at three levels: wage negotiation of company, superior (sector/regional) and without negotiation.

To drive this main objective, we test three hypotheses. The first one states that collective bargaining affects the introduction of innovation at company level. However, the structure where collective bargaining takes place, produces different results in the firm's innovative decision. Considering Calmfors and Driffill (1988), our second hypothesis is related to the fact that the relationship between collective bargaining and firms' innovative propensity is ambiguous and depends on the structure of collective wage. The third considers the institutional implication to that relationship. Using the Varieties of Capitalism (VoC) literature to categorise different institutional characteristics in each EU15 country, our third hypothesis is that institutions account to that relationship and that companies from Nordic, Central-west and Liberal countries tend to be present with higher propensity to innovate than firms from the South.

As is normal in that type of analysis, the empirical literature identifies a possible simultaneity relationship between these two elements (Menezes-Filho & Van Reenen, 2003; Ruesga et al., 2020). To deal with this issue, the estimated probability models are adapted using the Deb and Trivedi (2006b) estimator that allow the incorporation of instrumental variables to correctly estimate the impacts of collective bargaining on the probability of introducing innovations by firms. In this sense, our methodology could be considered as a novelty.

Compared to most studies at the country level or comparing two countries (Bryson & Dale-Olsen, 2020a, 2020b; Menezes-Filho & Van Reenen, 2003), this study contributes to the analysis of the phenomenon by presenting new evidence for companies in the EU15. Besides, we have explored the implications of our findings considering the importance of the manufacturing sector as an engine of growth and structural change.

Furthermore, our results shed new light on the perception that is commonly held about the role of trade unions in the introduction of innovation and technologies, by showing that not only the adoption of technology increases when the company performs collective bargaining but also the relationship between wage bargaining and innovation adoption is not linear, being more significant when bargaining occurs at the regional/national level. In this sense, our analysis shows that collective bargaining increases the probability of innovating of those establishments less likely to innovate.

In order to achieve our goals, the paper starts with a theoretical and empirical literature review and the formulation of the hypothesis (Sections 2 and 3). Section 4 shows our methodological framework. In Section 5, the results are presented and discussed. Finally, in the Conclusions section, we summarise our findings.

³However, it is not the purpose of this work to explain how this process happens within each firm, nor to explore the union—formal or informal—internal tools, methods or practices, to boost innovation within the firm.

2 | LITERATURE REVIEW

The role of trade unions in the economy has always been the subject of intensive debate. Traditionally, the theoretical literature related to monopoly union model (Dunlop, 1944) and right-to-manage model (Nickell & Andrews, 1983), emphasised the role of unions in distorting relative prices and the effects of that distortion on employment, unemployment and wage. Moreover, the empirical studies focus on looking for evidence of that relationship, which is, the effect of unions on wages, employment, unemployment and profitability and, on the other side, the determinants of union membership. Soskice (1990) analysed the crucial role of collective bargaining coordination on economic and firm performance, specifically regarding wages, unemployment and inflation.⁴ However, more recently economic theory has focused on the impact of union on the design of efficient contracts (Cahuc et al., 2014), whereas applied economists shifted their attention to the long-term effects of unions, that is on investment, technology and productivity growth (Hirsch, 2004).

Both models assume that the effect of collective bargaining will be negative on employment and, therefore, on company investment and to the adoption of new technologies, since this is a company unilateral decision based on the wage defined in collective bargaining. The higher the wage, the higher the cost of production, the less employment and investment. However, following Cahuc et al. (2014) and Menezes-Filho and Van Reenen (2003), they point out that the final effect can also be ambiguous, since investment can be increased because of wage increases, by favouring capital–labour substitution; however, the wage increase also has a cost effect, which would reduce investment in new technologies. The result will depend on the relative prices and benefits of the capital–labour substitution.

This theoretical approach also admits that collective bargaining, due to the ‘hold-up’ hypothesis, can lead to a reduction in investment. In a bargaining game, admitting the possibility of wage renegotiation, companies may have incentives to under-invest. Given the irreversible nature of the investment, when the union cannot make a credible commitment to avoid renegotiation of wages, the company has an incentive to invest less even to outsourcing. The fact is that, once installed, equipment generally cannot be modified without incurring in costs, and if not used, companies may face the risk of substantial losses (Cahuc et al., 2014).

Despite the hold-up hypothesis, Bhuller et al. (2022) argue that firms’ investment decisions may be determined by the degree of centralization of collective bargaining. Centralised bargaining processes seem to favour innovative firms by setting labour costs common to all firms, benefiting those that manage to increase productivity. On the other hand, local bargaining allows unions greater ability to negotiate wages according to the value added of firms, increasing labour costs and reducing the incentive to innovate. ‘Collective industry bargaining is expected to lead to a modernized industry with high average productivity and an egalitarian wage distribution across firms. Local bargaining should lead to a less modernized industry with a somewhat lower average productivity and with a more inegalitarian wage distribution’ (Bhuller et al., 2022: 40).

⁴Coordination of collective bargaining can have the same effect as centralisation (Soskice, 1990). Brandl (2022) reviews the current academic and public policy debates on the effects of collective bargaining, highlighting the role of coordination and detailing the differences that may exist between the effects of horizontal versus vertical coordination: ‘...the logics of horizontal and vertical coordination are different and therefore need to be investigated separately’ (Brandl, 2022: 12).



Nevertheless, this result changes if both parties behave like the McDonald and Solow (1981) 'efficient innovation' model and the 'companies' strategic investment' games models (Bond & Van Reenen, 2002), in which companies invest to maintain or gain market shares, faced with the threat of entry by new competitors and a potential loss of market power and profits (efficiency effect). These models of strategic games of company behaviour highlight the importance of the market structure in the investment decision, particularly in R&D (Menezes-Filho & Van Reenen, 2003). In these models, the effect of the unions on investment depends on its preference between employment and wages. A risk-averse union will prefer employment to wages and, in such a situation, the effect of an increase in union power is to increase employment and, therefore, company investment. This gain in market share encourages investment, including in R&D, due to the threat of new entries. Empirical literature has found support for this prediction (Menezes-Filho et al., 1998).

Moreover, considering that (i) innovative companies are those showing higher productivity and (ii) collective bargaining could increase productivity and investment in new technology (Brandl & Braakmann, 2021; Cahuc et al., 2014), by promoting voice and participation, unions can also stimulate companies to invest in TI- and firm-specific human capital (Bryson et al., 2005; Freeman & Medoff, 1984). Unions can also play an essential role in the effects of the introduction of innovative practices in companies. This effect will depend on the bargaining capacity of the unions and also on their ability to negotiate. Following the analysis taken by Bryson et al. (2005), a strong union can bargain the nature of investment and innovation in the workplace, blocking those attempts that may have the most negative effects for its members or may even make them more acceptable to both the company and its affiliates. They can bargain, for example initiatives like job security guarantors and high wages in return for productivity-enhancing innovation (Freeman & Medoff, 1984).

In this way, Freeman and Medoff (1984) show that the search for benefits for workers by unions also benefits companies and, therefore, stimulates their growth, investment and competitiveness. In the process of generating benefits for workers, they favour job retention, reducing search and training costs. On the contrary, they also provide incentives for employers to invest in the company and in the workers (company-specific human capital).

Bhuller et al. (2022) and Haucap and Wey (2004) show theoretically that top-level bargaining favours investment in innovative firms by generating lower relative production costs compared to non-innovative firms; on the contrary, individual bargaining eliminates this relative cost advantage by setting wages according to the value added of firms (as the wage differential between firms increases, the profit of the innovative firm decreases). In other words: 'Industry bargaining, in contrast, works as a tax on the least productive units and as a subsidy on the most productive. In this case, firms have incentives to invest more in modern technologies and in scrapping the old ones at an earlier stage' (Bhuller et al., 2022: 40).

Brandl (2022) refers to it as a cartelizing effect, where the homogenisation of wages and working conditions prevents companies from using wage reduction or working conditions as a competitive strategy. Therefore, higher level collective agreements and coordination encourage companies to increase their competitiveness through innovation or adoption of new technologies, rather than reducing labour costs. This argument matches in part with that of duopoly models. Duopoly models generally conclude that centralization of collective bargaining favours innovation by more innovative, or more competitive, firms; as opposed to individual bargaining (Basak & Mukherjee, 2018). The innovation decision of the collectively bargained firm is related to market structure. Individual bargaining introduces higher transaction costs (Willman et al., 2004), and confirms the hypothesis of Bhuller et al. (2022). On the other hand, Haucap and

Wey (2004) show that the benefits of innovation are higher for a highly productive firm when bargaining is centralised versus individual; both for process innovation and for job creation and employment.

As shown by Willman et al. (2004), following transaction cost theory (Williamson, 1981), unions reduce transaction costs in two ways, by providing an agency role for the employer, enforcing and monitoring contracts and improving information flows; by reducing the transaction costs faced by employers by assisting them in their management functions.

However, unions can also resist or instigate demonstrations against investment and new TI if they believe it will be detrimental for their purposes. Where employees have sufficient bargaining power, they may even be able to block management attempts to innovate (Metcalf, 1990). On the other side, trade unions can also exacerbate the negative effects of the introduction of innovative practices on investments through the same channels that lead to their improvement, for example information about the introduction of innovative practices may highlight the deficiencies of the same and the effects on workers, increased rejection and labour conflict and reducing investments (Bryson et al., 2005; Menezes-Filho & Van Reenen, 2003).

To sum up, the effect of the unions on the firm's investment and adoption on new technology depends on several factors related to the market structure, the industrial relations institutions, the union bargaining centralization and coordination and, above all, the unions behaviour, the interaction between unions and employers (Freeman & Medoff, 1984) and the direction of technological change (Doucouliagos et al., 2017), and none of these factors can be neglected. In this research, we seek to contribute to this debate by presenting evidence of this relationship for the EU countries and focusing on the effect of collective bargaining centralization.

The empirical literature on the relationship between technological change and unionism is rather scarce and results are mixed. Menezes-Filho and Van Reenen (2003) found mixed results: unions reducing R&D expenditure in the United States but not in Western Europe. Tan et al. (1992) suggest that the presence of a union is favourable to investment in the human capital of firms in the United States, the United Kingdom and Australia. Dustmann and Shoenberg (2009) support that union recognition increases training in apprenticeship programmes in Germany. And Addison et al. (2013) show that collective bargaining can foster innovation at the sectoral level in Germany and, more recently, Bryson and Dale-Olsen (2021) show a positive relationship between innovation and unionisation for the United Kingdom and Norway; showing that individual negotiation also boost both product and process innovation together, or just product innovation. In the latter, Rocha (2010) proves that shop stewards lead to employee-driven innovation processes, within the companies, enabling manufacturers to become more competitive.

An analysis of over 2000 establishments from the British Workplace Industrial Relations Survey (WIRS) concluded that the general reaction of the workers affected by the introduction of technology change at the workplace was favourable; cases where either shop stewards or full-time officers [i.e. union officials] became involved, they tended to support the change even more strongly than their members' (Daniel, 1987: 264). Keefe (1991), using establishment-level data on union status and of seven advanced manufacturing, finds that unionised plants were more likely than non-union plants to be using advanced technology.

However, the predominant approach is that collective bargaining and technological advance have a negative relationship so far. The meta-analysis of Doucouliagos and Laroche (2013), using different union measures, innovation measures, and empirical strategies, indicated that unions and innovations are negatively related. Bradley et al. (2017) found that a reduction in

R&D expenditures, productivity and departures of innovative inventors appear to be plausible underlying mechanisms through which unionisation impedes firm innovation. In response to unionisation, firms move their innovation activities away from States where union elections win.

In this sense, considering the lack of consensus about the role of collective bargaining in the TI at company or establishment level, this paper contributes to that debate showing new evidence to EU countries.

3 | HYPOTHESIS

The academic literature has demonstrated that collective bargaining impact on the company decision to introduce new technology (Bryson & Dale-Olsen, 2020a, 2020b; Cahuc et al., 2014; Doucouliagos et al., 2017) and its effect could be ambiguous (Laroche, 2020; Menezes-Filho & Van Reenen, 2003). In addition, the union's behaviour model and Efficiency Contract Model, and the structure of collective bargaining and the union power (Calmfors & Driffill, 1988), could delineate the type of that relationship in a positive, negative or no lineal way. For this reason, to estimate that relationship, we include in the model two different forms to measure collective bargaining.

The first one represents the company situation facing collective bargaining that is if the company is a member of an employer organisation which participates in collective bargaining. Bargaining, in our model, takes value 1 for those companies that have collective bargaining. It allows us to present our first hypothesis.

H1. Collective bargaining affects the introduction of innovation at company level.

However, the structure that collective bargaining takes place produces different results in the firm's innovative decision. Considering Calmfors and Driffill (1988) hypothesis and that our study focus on the EU-15 countries, where collective bargaining account for productions costs and industrial relations throughout different wage bargaining systems, the relationship may assume a U-shape inverted form and the sign will reflect a perspective of the union behaviour on innovative firms. So that, our second hypothesis is:

H2. The relationship between collective bargaining and firms' innovative propensity is ambiguous and depends on the structure of collective wage.

In order to measure the structure of collective bargaining at establishment level we use dummies for the level at which wage bargaining takes place at each establishment; the first dummy represents wage bargaining at company level (company) and the second one represents collective bargaining at sectoral or regional or national level (superior).

The industrial relations institutions also demonstrate to affect company strategy (Bhaumik et al., 2012; Commander & Svejnar, 2011). However, it is necessary to consider that North (1991) defines institutions as 'the humanly devised constraints that structure political, economic, and social interaction. They consist of both informal constraints and formal rules', many including a wide variety of elements that can be considered as a potential institution. Despite this, the definition of institutions and their measurement has not achieved universal consensus among researchers (Nunn & Trefler, 2014; Rodríguez-Pose, 2013). We also find no consensus on the

effect of institutions on the economic performance at macro or micro level (Betcherman, 2012), while at the labour market an identical problem is documented with institutions (European Commission, 2008). Hence, controlling by industrial relations arrangement by country as an indicator of labour market institutions may allow us to capture the impact on company decisions of innovation. In other words, not only the centralization of collective bargaining is important to assess the effect on innovation, as previously highlighted in the theoretical review, other variables such as coordination and bargaining strength, the members' preference between wage and employment, the market structure, and the direction of technological change, are also relevant.

In our model, to capture all that complexity in a summary variable which represents labour market relations, and following Bechter et al. (2020), we use the European Commission's classification (European Commission, 2008: 49), based on industrial relations arrangements, 'such as union and employer organizations, the power relations between them, levels and styles of bargaining, the space for social partner intervention in public policy and for state intervention in union–employer relations'. On that basis, the European Commission (2008) have distinguished four arrangements or regimes of industrial relations:

1. The Nordic countries: organised corporativism, formed by Sweden, Finland and Denmark, with exceptionally high union density and collective bargaining coverage.
2. The Central-west countries: Germany, Austria, Belgium, Luxemburg and the Netherlands, with institutionalised social partnership, and a dual system of employment representative and high coverage of collective bargaining.
3. The South countries, compose by France, Italy, Spain, Portugal and Greece, with a polarised/ state-centred industrial relations regime.
4. The liberal model economies are the United Kingdom and Ireland, with collective bargaining basically at company level.

So that, our third hypothesis is:

H3. Institutions are important to company innovation performance and its relationship with collective bargaining depends on the behaviour between union and employer organisation, which is characterised by the different industrial relations arrangement.

Using the VoC literature, we expect that companies from Nordic countries and Central-west countries, which could configured the Coordinated market economies (CME)—due to the existence of greater collaboration with unions—, and companies from Liberal market economies (LME)—due to the incentive role of market relations—, will facilitated the firm introduction of TI and, as a consequence, will promote a better performance than companies from the South countries, where the lack of coordination and coherence between unions and employers reduces the innovative capacity of companies relative to other groups of countries.

The VoC model (Hall & Soskice, 2001: 7) explains the technological performance of firms and, therefore, of countries, based on the coherence/complementarity of the institutions that characterise the countries' model of capitalism. These fundamental institutions are (a) corporate governance, (b) corporate financing, (c) industrial relations (labour market) and (d) inter-firm relationships.



There will be coherence/complementarity between these institutions when the efficiency of one institution increases the efficiency of the other; therefore, the innovative performance will be better among all of them: 'national institutional coherence is seen to precede national innovation performance' (Malik, 2017).

Related to the industrial relation institution, the liberal model (LME) is characterised by flexible labour market and collective bargaining at company level and low coordination⁵; the Nordic and Central-west countries (Hall & Soskice, 2001) are characterised by mutual cooperation between employees and employers and a collective agreement based on long-term stability and coordination.⁶ Both VoC produce comparative advantages in the introduction of new technology because of the internal coherence in each institution.

Because the South countries, called Mediterranean countries by VoC literature (Hall & Soskice, 2001: 21), referred as South mixed market economies—SME—(by European Commission, 2008), adopt only partially the institutions of LME and CME, the lack of institutional coherence/complementarities (less cooperation between unions and companies, lack of confidence active the theoretical mechanism related to 'hold up hypotheses' and increase transactional costs) makes them less innovative countries.

In fact, the findings of Hall and Soskice (2001: 39–41) indicate that LME countries are more prone to radical innovations, while CME countries are more prone to incremental innovations. This has caused a great debate in the literature, including comparison with the other SME countries.⁷ Related to that, we present a sub-hypothesis:

H3.1. Companies from Nordic, Central-west and Liberal countries tend to present a higher propensity to innovate than firms from the South.

So, separately, institutions characteristics and collective bargaining structure account by firm innovation; together they could produce important different effects. Also, it is reasonable to suppose that the set of specific institutions that characterises each group of countries regarding their industrial relations arrangement, plays an important role determining how unions face companies' productive, process or organisational change.

As Balsmeier (2017) argues, 'the power that unions can exert on firms' decision making is mainly determined by the degree of workforce unionization' and 'their bargaining power granted by collective relations laws. Hence, a high degree of unionization might influence R&D investments strongly in one country but exert no or dissimilar influence in another. Irrespective of whether unions influence R&D expenditures positively or negatively, their marginal impact should increase the stronger the rights they are granted by law'. In other words, institutional differences in terms of the collective bargaining power change the way unions affect firms' investment behaviour. So that, our H3.2 is:

H3.2. Institutions characteristics and collective bargaining structure account by firm innovation (H1*H3 and H2*H3).

⁵'Because trade unions and business organizations in LMEs are less cohesive and encompassing, economy wide-wage coordination is generally difficult to secure' (Hall & Soskice, 2001: 29–30).

⁶Hall and Soskice (2001: 25) point out that collective bargaining coordination in CMEs is crucial to macroeconomic stability and, among other positive results, to reducing the risk of sunk investment.

⁷For further review of this literature, see, among others, Malik (2017) and Schmidt (2002).

4 | METHODOLOGY

The analysis uses the European Company Survey's microdata (ECS),⁸ carried out in 2013 on a sample of establishments with more than 10 employees in all sectors of activity, excepting agriculture. The survey included variables that identify the structure of the firm (size, number of employees, sector, etc.), the characteristics of wage negotiation, the introduction of innovations and changes in technology, among other aspects. This analysis uses data for the EU15 countries, with a total of 16,165 observations. However, the number of valid observations may change among the dependent variables used in the econometric models, because of the presence of missing values in some of the definitions of innovation.

To analyse the introduction of innovations within firms, we use the variables that represent whether the establishment has introduced—or not—product or services innovations, process innovations, organisational innovations or technological changes, in the last 3 years.⁹

To test the three hypotheses, as empirical strategy, probit-type models are defined to estimate the probability that a company performs each of these four types of innovation, based on a set of explanatory variables. The main vector of explanatory factors represents the way in which wages and collective bargaining are implemented. The first factor is a dummy of value 1 in the case of the company being part of an employer organisation that participates in collective bargaining agreements and of zero value otherwise. The second component takes into consideration the level at which wage bargaining occurs, if higher (carried out on a sectoral or regional or national level) or if it develops at the company level (in the company itself or for a certain occupation), using two dummies.

The set of models to be estimated can be represented by the equation:

$$\text{prob}(y_{ji} = 1) = f(\text{bargaining}_i; X_i) \quad j = 1, \dots, 4; i = 1, \dots, n \quad (1)$$

where y_{ji} is a dichotomical variable of value 1 if company i has introduced the j types of innovation considered, and zero if it has not implemented significant changes and X_i a set of control variables. They are estimated separate models for each innovation type. Bargaining (i) represents the set of dummies representative of the company's participation i in an employers' organisation and the level of wage bargaining.

Multiplicative variables of the groups are also added, with the previously defined wage and collective bargaining factors. These interactions contribute to evaluating the role of collective bargaining on innovation, according to the type of unionism experienced in the country.

However, as Menezes-Filho and Van Reenen (2003) highlighted, the Equation (1) may present some endogeneity and unobservable heterogeneity problems, based on the relationship between collective bargaining and the firm decision to implement innovations. For instance, expectations of economic expansion can incentivise both investment decisions in

⁸The focus of ECS was 'on work organization, workplace innovation, HR practices, employee participation and social dialogue' (Eurofound, 2013), while in the ECS-2019, the objective is to 'collect data in over 20,000 establishments on workplace practices with regards to work organization, human resource management, skills use, skills strategies, digitalization, direct employee participation and social dialogue' (Eurofound, 2019). Considering the objective of this paper, the ECS-2013 is more appropriate than the ECS-2019, and it is reflected in the set of variables that are used. Variables like women, 50 years of age, University degree and Technology are not available in the latest version of the ECS (for more information on variable definition, see Appendix 1: Table A1).

⁹See Appendix 1: Table A1, for a better definition of these variables.



R&D in the firm as well as union activity. These phenomena generate a correlation between the regressors and the residuals of the model, causing the estimation of biased regression coefficients and making it difficult to correctly identify the effect of collective bargaining on the innovative attitude.

Given the lack of panel data to control fixed effects, an alternative strategy commonly used is the utilisation of estimators with instrumental variables to control the correlation of the residuals with the regressors. Nevertheless, the identification of a suitable instrument is a recognised complex task in the literature, since it means finding a factor correlated with the level of collective bargaining or union activity and, at the same time, not sufficiently correlated with investment in innovation decisions within the firms. Menezes-Filho et al. (1998) suggested the union level in the sector considering the year when the firm was born, and the proportion of women, as instruments of the union density. Addison and Wagner (1994) used the rate of unionism of the same industrial segment existing in another country (Germany), as an identification of the relationship between unions and innovation in Great Britain. Balsmeier (2017) proposed as an instrument, the number of days per year that the company spends with inspections and meetings with employees related to safety issues, such as fire prevention, under the hypothesis that these are issues of central interest to workers.

Given the binary nature of the dependent variables and the factors with potential for endogeneity, linear models do not seem to be adequate for the current situation. So, a conditional mixed-process estimator (CMP) is used to accommodate a multilevel logistic model with endogenous variables, including a multinomial case, proposed in Roodman (2011). These models with endogeneity control, according to these authors, are robust and seem to adequately correct the biases highlighted by Menezes-Filho and Van Reenen (2003).

The new set of models to be estimated can be represented by the equation:

$$\text{prob}(y_{ji} = 1) = f(\text{bargaining}_i; X_i; h_i) \quad j = 1, \dots, 4; i = 1, \dots, n \quad (2)$$

$$\text{prob}(\text{bargaining}_i = 1) = f(z_i; h_i) \quad i = 1, \dots, n \quad (3)$$

In which y_{ji} and X_i are defined as before; z_i is a set of instruments to explain the levels of collective bargaining. Although in this work the explanatory variable of interest is the participation in wage collective bargaining and not directly the union density, as in other previous studies, the problems of potential endogeneity and choice of instruments are still present. The adequate selection of control methods and instruments is essentially theoretical and dependent on the characteristics of the databases, since there is no perfect variable for empirical use (see, for instance, Hill et al., 2021). As an identification strategy, a first instrument is included based on the choice of Menezes-Filho et al. (1998): the use of the unionised rate in the sector, obtained in the 2004 round of the same survey. This option is based on the hypothesis that the historical level of union presence is a good predictor of the present power of the unions, and, at the same time there are no significant reasons to believe in the existence of a correlation with current decisions in R&D. In addition, and following these authors, the current proportion of female employees in the firm is used as an additional instrument. h_i is a set of controls common to the two dependent variables of the system of equations.

To control different establishment characteristics, we use a set of control variables (vector X_i). First, the share of university degree workers in firms' workforce is added, since it is expected that high-skilled employees contribute positively to the innovation output (Fonseca

TABLE 1 Estimated marginal effects on the probability of innovation and collective bargaining (employer organisational member: member of an employer organisation that participates in collective bargaining).

	Product and services			Processes			Organisational			Technology		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Member of any employers' organisation	0.435* (0.08)	0.471* (0.09)	0.476* (0.07)	0.545* (0.07)	0.392* (0.08)	0.489* (0.09)	0.514* (0.07)	0.543* (0.07)				
Nordic	0.024 (0.02)	0.111* (0.03)	0.096* (0.02)	0.180* (0.03)	0.254* (0.02)	0.315* (0.03)	0.128* (0.02)	0.158* (0.03)				
Central	0.076* (0.02)	0.084* (0.02)	0.087* (0.02)	0.099* (0.02)	0.064* (0.02)	0.077* (0.02)	0.028 (0.02)	0.023 (0.02)				
South	0.132* (0.02)	0.125* (0.02)	0.148* (0.02)	0.151* (0.02)	0.133* (0.02)	0.157* (0.02)	0.046* (0.02)	0.057* (0.02)				
LME (reference)												
Member* Nordic		-0.144* (0.05)		-0.160* (0.04)		-0.161* (0.05)		-0.068 (0.05)				
Member* Central		-0.038 (0.04)		-0.061 (0.04)		-0.096** (0.04)		-0.017 (0.04)				
Member* South		-0.003 (0.04)		-0.040 (0.04)		-0.118* (0.04)		-0.049 (0.04)				
% University degree	0.099* (0.01)	0.098* (0.01)	0.058* (0.01)	0.057* (0.01)	0.066* (0.01)	0.066* (0.01)	0.017 (0.01)	0.017 (0.01)				
Private sector	0.043** (0.02)	0.042** (0.02)	0.018 (0.02)	0.017 (0.02)	-0.036*** (0.02)	-0.036*** (0.02)	-0.004 (0.02)	-0.004 (0.02)				
Single company (reference)												
Headquarters	0.097* (0.01)	0.097* (0.01)	0.111* (0.01)	0.111* (0.01)	0.162* (0.01)	0.163* (0.01)	0.087* (0.01)	0.087* (0.01)				

TABLE 1 (Continued)

	Product and services		Processes		Organisational		Technology	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Subsidiary site	0.079* (0.02)	0.081* (0.02)	0.128* (0.01)	0.129* (0.01)	0.140* (0.02)	0.141* (0.02)	0.037** (0.01)	0.037** (0.01)
10/49 employees (reference)								
50/249 employees	0.008 (0.02)	0.009 (0.02)	0.029 (0.02)	0.028 (0.02)	0.084* (0.02)	0.087* (0.02)	-0.011 (0.02)	-0.009 (0.02)
250+ employees	0.006 (0.04)	0.006 (0.04)	0.043 (0.03)	0.040 (0.03)	0.137* (0.03)	0.141* (0.03)	-0.045 (0.03)	-0.042 (0.03)
Industry (reference)								
Construction	-0.194* (0.02)	-0.194* (0.02)	-0.148* (0.02)	-0.147* (0.02)	-0.047** (0.02)	-0.047** (0.02)	-0.041** (0.02)	-0.042** (0.02)
Commerce and hospitality	0.074* (0.01)	0.074* (0.01)	-0.025 (0.02)	-0.024 (0.02)	0.033** (0.02)	0.032** (0.02)	0.043* (0.02)	0.042* (0.02)
Transport and communication	-0.175* (0.02)	-0.175* (0.02)	-0.123* (0.02)	-0.123* (0.02)	-0.100* (0.02)	-0.100* (0.02)	-0.015 (0.02)	-0.015 (0.02)
Financial services and real estate	-0.099* (0.03)	-0.099* (0.03)	-0.031 (0.02)	-0.031 (0.02)	0.075* (0.03)	0.078* (0.03)	-0.025 (0.03)	-0.025 (0.03)
Other services	0.009 (0.02)	0.007 (0.02)	-0.003 (0.02)	-0.004 (0.02)	0.063* (0.02)	0.062* (0.02)	0.075* (0.02)	0.074* (0.02)
Obs.	14,305	14,305	14,305	14,305	14,305	14,305	14,305	14,305
χ^2	2072.50	2095.79	2197.25	2218.81	2621.30	2633.55	1868.58	1873.10
Prob > χ^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Standard deviation in bracket.
*** $p < .10$, ** $p < .05$, * $p < .01$.

et al., 2019; Grimpe & Kaiser, 2010). It is also controlled by the firm's ownership and headquarter, and subsidiary establishment, since they affect the innovation outcomes. Firms' ownership and innovation outcome at firm level is far from being conclusive (Clò et al., 2020), the expected relationship it is not a consensus in the literature: some account for the inferior innovation capability of public firms due to their internal governance structure, lack of adequate monitoring and market incentives and risk of political capture. On the other hand, one may argue that public enterprises might have a better attitude towards innovation. The importance of subsidiaries contributing to innovation activities (Gölgeci et al., 2019) and different companies units, HQ and subsidiaries, possess different innovation capabilities (Zeng et al., 2018), even subsidiaries' innovation through knowledge inflows from headquarters and peer subsidiaries (Crespo et al., 2020).

We also include firms' size, since larger firms perform more R&D and are more likely to recognise unions, a failure to control for size would leave a spurious positive association of unions and R&D (Menezes-Filho & Van Reenen, 2003). The sector controls are included in response to the substantial heterogeneity found between industries not only in collective bargaining, but also in innovative performance. Lastly, dummies for the group of countries under the VoC literature.¹⁰ The grouping of countries, according to VoC (Table A2), also allows to partially control the role of institutions in the effects of collective bargaining, given the different behaviours that unions present, as shown, for example by Hall and Soskice (2001).

As the ECS sample uses a stratification by firm size and sector, following the strategy of Williams and Horodnic (2016), dummies for establishment size by number of employees and for the sectors of the NACE classification are added as a control variable (Table A3).

5 | RESULTS AND DEBATE

As mentioned above, the models with the simple binary instrument are estimated by means of a binomial probit, while the results of the model with multinomial instruments are obtained with the mixed estimator of Deb and Trivedi (2006b).¹¹ For the first estimation (Table 1),¹² the results, without and with interaction, show that to be a member of a business organisation that participates in collective bargaining, increases the likelihood of introducing technological innovation in product and service and process as well as organisational changes (Table A2), a result that matches the works developed by Keefe (1991), Addison et al. (2013) and Bryson and Dale-Olsen (2020a, 2020b) (confirming our Hypothesis H1).

Moreover, although, usually, the establishments of the group of countries with liberal labour relations (LMEs), which constitute the reference in the model show a lower probability of

¹⁰In attention to the problem of standard deviations detailed in Bryan and Jenkins (2016) for models with reduced number of countries, alternative versions have been estimated, with and without the country controls, with no significant changes in the main results.

¹¹Following these Deb and Trivedi (2006a), 200 simulations are used for the Halton sequence, compatible with the sample size.

¹²Tables A4 and A5, in the Annex, present the estimated coefficient of the Equation (3), the probability of bargaining type, and the correction variables (ATANHRHO), from the CMP model. Tables A6 and A7, also in the annexes, present the results of the marginal effects without the use of the conditional estimators of instrumental variables, for comparison. As can be seen, the results are similar in the signs of the main coefficients, although not in their respective significance, which seems to indicate consistency of the results obtained by the conditional estimators.



innovation,¹³ the interactions between collective bargaining and varieties of unionism reveal that the role of unions in the introduction of changes is relatively more important in these LME countries (Table 1, columns 2, 4, 6 and 8). In other words, collective bargaining is crucial for influencing innovation in countries with the least probability of change, which leads us to the first important conclusion of this paper: collective bargaining has a non-linear effect on innovation, and its effect is more important in those establishments with liberal industrial relations than the others industrial arrangement, which suppose is more cooperative and unions have more bargaining power (confirming our Hypothesis H3.2).

In summary, the interaction variables demonstrate that participation in collective bargaining has a different impact on innovation according to the type of unionism of the country. Negative and significant values, especially in organisational innovation, reveal that participation in collective bargaining has a higher impact in countries with a liberal union model, although this group shows a lower probability to innovate in all four estimated models.

Our results means that LME firms have, in average, less probability to innovate; however, the interaction show that LME firms with the presence of collective bargaining have more probability to innovate than Nordic firms in product and services, process and managerial; and more than Central in managerial innovation; however, there is no relationship with the variable technological innovation. Although the database from the ECS survey does not enable to analyse in more detail the coordination aspects of collective bargaining within each firm, these results seem to demonstrate the existence of different behaviours towards innovation according to the VoC groups.

Considering now the level of negotiation (Table 2), the results indicate that wage negotiation at a higher level increases the likelihood of innovation (in all types) and that bargaining at the company level reduces the probability of innovation, except for products and services innovation (confirming our Hypothesis H2). Individually, establishments in LMEs are less likely to introduce technological changes than other union models in the EU15. This is the second important conclusion of this research: collective bargaining at the company level reduces the probability of introducing innovation, although when collective bargaining occurs at superior level, it boosts changes in product and service, process, organisational and technological change.

These findings could indicate that collective bargaining at superior (sector/regional) level enhances cooperative and coordinated solutions, between employers and workers, with a long-term perspective. On the contrary, negotiation at company level seems to lead to a competitive strategy between workers and employers, with short-term strategies, focused on wages and profits, and reducing the space for firms to adopt product and services, process, organisational and technological changes. This outcome supports, although in general terms, the mixed results found by Menezes-Filho and Van Reenen (2003): unions reducing R&D expenditure in the United States (in which prevail collective bargaining at company level) but not in Western Europe (where a superior level of collective bargaining is preminent). It is also a result that corroborates the hypothesis of Calmfors and Driffill (1988) that shows a non-linear relationship between collective bargaining and macroeconomic performance (the same is observed in relation to innovation). These results also find support in the recent publication of Bhuller et al. (2022), as explained above in the theoretical review, and with the perspective of Haucap and Wey (2004) and Basak and Mukherjee (2018), who show that incentives to introduce innovation are relatively higher for firms when bargaining is centralised versus individual, including process innovation.

¹³Which calls into question the H3 and H3.1 based on the VoC. However, other studies, such as the one by Malik (2017), show evidence against the hypothesis that LMEs and CMEs are more innovative than Southern countries.

TABLE 2 Estimated marginal effects on the probability of innovation and collective bargaining level.

	Product and services		Processes		Organisational		Technology	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1-Superior	0.100 (0.13)	0.131 (0.13)	0.410* (0.08)	0.441* (0.08)	0.052 (0.12)	0.142 (0.13)	0.325* (0.11)	0.349* (0.12)
2-Company	-0.269* (0.10)	-0.247** (0.10)	-0.127** (0.05)	-0.119** (0.06)	-0.366* (0.09)	-0.342* (0.09)	-0.202* (0.08)	-0.223* (0.08)
3-No bargaining (reference)								
Nordic	0.058* (0.02)	0.219* (0.03)	0.104* (0.02)	0.155* (0.03)	0.284* (0.02)	0.304* (0.03)	0.125* (0.02)	0.128* (0.03)
Central	0.085* (0.02)	0.104* (0.02)	0.096* (0.02)	0.085* (0.02)	0.083* (0.02)	0.056** (0.02)	0.007 (0.02)	-0.006 (0.02)
South	0.142* (0.02)	0.139* (0.03)	0.147* (0.02)	0.145* (0.02)	0.136* (0.02)	0.152* (0.03)	0.024 (0.02)	0.028 (0.02)
LME (reference)								
Superior*Nordic		-0.230* (0.05)		-0.095** (0.04)		-0.091*** (0.05)		-0.052 (0.05)
Superior*Central		-0.057 (0.04)		-0.016 (0.04)		-0.022 (0.04)		-0.034 (0.04)
Superior*South		-0.019 (0.04)		-0.025 (0.04)		-0.098** (0.04)		-0.049 (0.04)
Company*Nordic		-0.194* (0.06)		-0.001 (0.06)		0.049 (0.07)		0.061 (0.07)
Company*Central		-0.036 (0.05)		0.052 (0.04)		0.093** (0.05)		0.098** (0.04)

TABLE 2 (Continued)

	Product and services		Processes		Organisational		Technology	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Company*South		−0.065 (0.05)		0.026 (0.04)		0.112** (0.05)		0.047 (0.04)
% University degree	0.098* (0.01)	0.100* (0.01)	0.050* (0.01)	0.051* (0.01)	0.063* (0.01)	0.062* (0.01)	0.018 (0.01)	0.018 (0.01)
Private sector	0.040** (0.02)	0.036*** (0.02)	0.017 (0.02)	0.016 (0.02)	−0.043** (0.02)	−0.041** (0.02)	−0.005 (0.02)	−0.004 (0.02)
Single company (reference)								
Headquarters	0.104* (0.01)	0.106* (0.01)	0.106* (0.01)	0.109* (0.01)	0.160* (0.01)	0.160* (0.01)	0.093* (0.01)	0.094* (0.01)
Subsidiary site	0.092* (0.02)	0.095* (0.02)	0.128* (0.01)	0.131* (0.01)	0.154* (0.01)	0.152* (0.02)	0.045* (0.01)	0.044* (0.01)
10/49 employees (reference)								
50/249 employees	0.087* (0.02)	0.091* (0.01)	0.087* (0.02)	0.088* (0.02)	0.156* (0.01)	0.155* (0.01)	0.072* (0.02)	0.074* (0.02)
250+ employees	0.160* (0.02)	0.167* (0.02)	0.154* (0.03)	0.154* (0.03)	0.281* (0.02)	0.278* (0.02)	0.112* (0.03)	0.116* (0.03)
Industry (reference)								
Construction	−0.224* (0.02)	−0.223* (0.02)	−0.178* (0.02)	−0.178* (0.02)	−0.079* (0.02)	−0.081* (0.02)	−0.075* (0.02)	−0.078* (0.02)
Commerce and hospitality	0.032** (0.02)	0.028*** (0.02)	−0.050* (0.02)	−0.051* (0.02)	−0.011 (0.02)	−0.011 (0.02)	−0.003 (0.02)	−0.005 (0.02)
Transport and communication	−0.170* (0.02)	−0.168* (0.02)	−0.109* (0.02)	−0.111* (0.02)	−0.094* (0.02)	−0.096* (0.02)	−0.005 (0.02)	−0.005 (0.02)

(Continues)

TABLE 2 (Continued)

	Product and services		Processes		Organisational		Technology	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Financial services and real estate	−0.083* (0.03)	−0.085* (0.03)	−0.002 (0.02)	−0.002 (0.02)	0.082* (0.03)	0.083* (0.03)	−0.003 (0.03)	−0.004 (0.03)
Other services	−0.034*** (0.02)	−0.041** (0.02)	−0.018 (0.02)	−0.019 (0.02)	0.015 (0.02)	0.018 (0.02)	0.041** (0.02)	0.038** (0.02)
Obs.	14,654	14,654	14,654	14,654	14,654	14,654	14,654	14,654
χ^2	1504.72	1547.22	3307.48	3169.37	2807.71	2816.49	1809.69	1878.20
Prob > χ^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Standard deviation in bracket.
*** $p < .10$, ** $p < .05$, * $p < .01$.



The interactions (Table 2, columns 2, 4, 6 and 8), taking the LMEs as a reference, corroborate the results of the previous model. The relationship between innovation and collective bargaining is not linear, showing that collective bargaining is more efficient in those countries with the least tendency to introduce innovations; although it is less evident due to the significance of the coefficients estimated in some models. Thus, although establishments in liberal unionism models are less likely to innovate, the existence of wage bargaining at sectoral/regional level favours the introduction of technological changes in those establishments, located in LME, that have a superior collective bargaining tool. Precisely, collective bargaining in the liberal model seems to contribute a greater proportion to innovation and technological changes than the Nordic model (in product and services and process innovations) and a greater probability of organisational innovation than the unionism model in the South countries.

The introduction of control variables can lead to a deeper analysis. For instance, regarding the characteristics of labour conditions, precarious contracts seem to be crucial only in the introduction of technological changes, indicating that job quality fosters new technologies in the establishments within the EU15. These results match with the works carried out by Wachsen and Blindb (2016) and Franceschi and Mariani (2016), who claimed that excessive labour flexibility has negative effects on innovation in German and Italian companies, respectively.

On the other hand, the younger and more educated the workers, the greater the likelihood of TI introduction by companies. The same is observed by size of the establishment in the case of medium and large companies. Furthermore, no significant differences are perceived in the probability of TI introduction between public and private firms, except for organisational innovation, in which the private ones seem to have more difficulties than the public ones. Nevertheless, it is outside the scope of this paper the explanation of the control variables in the model. Regarding unionism and collective bargaining within the VoC approach, further research is required to analyse the role of working conditions, educational level and age range, ownership of the establishment, size, sector of activity and establishment type.

Summarising, the purpose of this paper is to contribute to the debate on the role of trade unions and collective bargaining in introducing innovations in the EU15 countries. Mainly, two important outcomes are reached. The first one confirms that collective bargaining has a non-linear effect on innovation and, besides, its impact is more relevant in those establishments with less tendency to innovate. This implies that in LME countries' establishments, although they have a lower level of innovation, when collective bargaining exists, it has a greater impact on the likelihood of introducing innovations than in countries with a higher union presence, such as Nordics. The second important conclusion of this research confirms this nonlinearity by showing evidence that collective bargaining at the company level reduces the probability of introducing changes. In addition, collective bargaining at a higher level encourages improvements in products and services, processes and in organisational and technological areas within firms.

6 | CONCLUSIONS

In this paper, we analyse the impact of collective bargaining in the introduction of innovation at establishment level in the EU15. For that purpose, we used the ECS-2013 database and estimated, using a biprobit model, and correcting by instrumental variables the possible bias related to endogeneity and no observed heterogeneity between both variables. In line with one part of the previous academic literature, our results confirm that when a firm is engaged in collective bargaining, the probability that the firm will introduce new technologies increases.

Our results also indicate that the introduction of TI not only varies according to the membership of any employers' organisation which participates in collective bargaining, but also depends on the level of wage bargaining adopted by firms. In particular, and, as expected, the results obtained for wage bargaining are positive and significant and are also higher for superior levels than collective wage agreement negotiated at the establishment or company level. More specifically, the results indicate a probability of about 30 percentage points higher for technological innovation among firms that engage in centralised or higher collective bargaining, compared to firms that do not. On the other hand, negotiation at establishment level may compromise the propensity to innovate by between 11 and 36 percentage points, depending on the type of innovation. The interaction components allow observing a smoothing of about nine points in the negative impact produced by decentralised negotiation in the CME.

Concerning the impact of different types of industrial relations classified by the European Commission (2008), our results show that companies in Nordic industrial relations model countries have a higher likelihood to introduce TI than companies in South, Centre-West and Liberal industrial relations model countries. However, when we interact this variable with collective bargaining, we find out that the impact of unions is relatively higher in less innovative companies. In other words, unions in low innovative companies are more committed to contributing to firms' introduction of new technology than in higher innovative companies. To the best of our knowledge, this particular result might be considered an original contribution to the previous literature.

However, the economic literature tends to consider unions as a source of relative price distortions as well as an institution that captures firm profits. The positive association between collective bargaining and TI for EU companies point out to their role as an important pillar to help firms triggering competitiveness. This result is close to the findings of the efficiency bargaining model, in which both unions and companies focus on the long-term effects of collective bargaining in terms of productivity growth, investments and employment.

We also examine the impact of the different types of labour contracts and the workers characteristics on the probability of TI. The outcomes reveal that labour flexibility has a negative impact on TI and that younger and university degree workers increase the company probability to introduce TI.

But the paper shows certain limitations. As a major shortcoming, ECS-2013 database does not contain information on employment, firms' productivity, R&D expenditure and other ways to measure innovation and technology. In addition, the cross-section nature of the data makes it difficult to assess whether collective bargaining results in a greater likelihood to introduce TI over time. In fact, the period considered should be large enough to assess the effects of the asymmetric collective bargaining systems on the adoption of new technologies over time. Besides, the results should be read with caution. ECS-2013 database does contain data on a firm's relative position within a certain range, but does not offer information on absolute values for strategic variables (i.e. sales volume, wages, productivity, R&D expenditure) nor about the individual level and characteristics of collective bargaining coordination. Further research may consider these drawbacks.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.



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APPENDIX 1

TABLE A1 Variables.

Variable	Definition
Product or services innovation	Since beginning of 2010 has this establishment introduced any new or significantly changed products or services?
Process innovation	Since beginning of 2010, has this establishment introduced any new or significantly changed processes?
Organisational innovation	Since the beginning of 2010, has this establishment introduced any organisational change?
Technological change	Changes in the use of technology—changes made since the beginning of 2010?
Member	Member of any employers' organisation which participates in collective bargaining
Company	Dummy for a collective wage agreement negotiated at the establishment or company level
Superior	Dummy for a collective wage agreement negotiated at the sectoral or regional level or national cross-sectoral
Nordic	Denmark, Sweden and Finland
Liberal	United Kingdom and Ireland
Central-west	Germany, Austria, Netherland, Belgium and Luxemburg
South	France, Spain, Portugal, Italy and Greece
Open end contract	Percentage of open-ended employment contracts: dummy of value 1 if the company has more than 40% of employees with this type of contract
Part-time	Percentage of part-time contracts: dummy of value 1 if more than 40% of the employees have this type of contract
Women	Percentage of women: dummy of value 1 if more than 40% of the employees are women
50years of age	Percentage of workers over 50years old: dichotomous variable of value 1 if more than 40% of the workers are in this condition
University degree	Percentage of workers with a university degree: dummy of value 1 if more than 40% of the employees have a university degree
Private company	Private sector: variable of value 1 if the company is private in nature and zero value if it is public (a public sector organisation is either wholly owned by the public authorities or they have own more than 50%)
Size	Establishment size: small (10–49 employees); medium (50–249); and large (250 or more)
Sector	Sectors: industry; construction; commerce and hospitality; transport and communication; financial services and real estate; y other services
Establishment	Types: single establishment company; headquarters; subsidiary site

TABLE A 2 Statistic of types of innovative practices changed since 2010 and collective bargaining by establishment (%) and number of establishments.

	Innovative practices changed since 2010				Level of collective bargaining ³		
	Products or services (%) ¹	Processes (%) ¹	Organisational (%) ¹	Technology (%) ¹	Member (%) ²	Superior (%)	Company (%)
Belgium	45.20	39.70	46.00	43.90	56.9	72.8	5.9
Denmark	58.30	60.10	69.60	62.60	68.4	55.9	12.6
Germany	37.40	37.50	25.80	39.40	31.6	44.2	16.5
Ireland	43.60	38.50	42.90	49.30	30.2	37.8	11.7
Greece	56.50	54.30	48.30	49.30	27.0	68.5	13.7
Spain	51.40	51.00	46.70	53.80	41.7	76.5	12.9
France	46.70	37.20	43.00	31.20	42.0	51.7	19.9
Italy	49.80	46.60	46.40	47.30	51.5	88.7	3.8
Luxembourg	54.80	45.30	36.10	42.80	56.1	39.3	18.0
Netherlands	46.00	41.00	49.00	48.20	62.7	43.3	18.3
Austria	51.20	51.20	54.90	54.40	73.7	82.0	2.8
Portugal	54.30	53.70	41.60	59.90	34.6	53.7	5.5
Finland	40.60	55.70	62.40	60.90	74.9	88.3	4.3
Sweden	44.20	42.30	65.40	62.80	85.0	86.4	2.0
United Kingdom	42.00	36.50	35.10	46.40	13.8	16.6	16.5
EU15	47.70	45.70	46.80	49.40	48.50	61.00	11.20
Nordic	47.7	52.7	65.8	62.2	76.2	77.0	6.3
Central-west	45.2	42.2	41.2	45.3	53.6	56.7	12.2
Liberal	42.4	36.9	36.8	46.9	17.9	21.8	15.3
South	51.2	47.8	45.4	47.3	40.8	69.0	11.3

Note: Obs: 1 = Changed since 2010; 2 = member of any employers' organisation which participates in collective bargaining; 3 = collective wage agreement negotiated at the establishment or company level; 4 = collective wage agreement negotiated at the sectoral or regional level or national cross-sectoral; 5 = sample size.

Source: ECS-2013.

TABLE A3 Correlation matrix.

Product and service	Processes	Organizational	Technology	Member	Superior	Company	% Open contract	% part-time	% 50 years of age	% University degree	Private sector	50/249 employees	250+ employees	Construction	Commerce and hospitality	Transport and communication	Financial services and real estate	Other services	Headquarters	Subsidiary site	Nordic	Central	South		
1	0.5047	1																							
Processes	0.3078	0.3902																							
Organizational	0.2389	0.2594	1																						
Technology	0.0688	0.0776	0.6771	1																					
Member	0.0198	0.0994	0.0671	0.3166	1																				
Superior	0.0163	-0.0351	-0.0315	-0.0715	-0.4493	1																			
Company	0.0006	0.0192	-0.02	0.0306	0.0124	0.0211	1																		
% Open contract	0.0014																								
% part-time	-0.0039	-0.0254	-0.023	-0.0196	-0.0223	-0.0043	-0.1081	1																	
% 50 years of age	-0.0331	-0.0134	-0.0016	-0.0065	0.0791	0.0229	0.0175	0.0069	0.0146	1															
% University degree	0.0789	0.0645	0.0903	0.043	-0.0413	-0.0636	0.0175	0.0544	-0.0262	-0.0192	1														
Private sector	0.0098	-0.0123	-0.0502	-0.0248	-0.0556	-0.0166	-0.0028	0.017	-0.1022	-0.1109	-0.0773	1													
50/249 employees	0.0503	0.0791	0.0952	0.0599	0.1011	0.0356	0.02	0.0012	0.0051	0.0569	0.018	-0.0428	1												
250+ employees	0.0852	0.1288	0.1424	0.0695	0.1913	0.0689	0.0705	0.0139	-0.0055	0.0463	0.0433	-0.0543	-0.2856	1											
Construction	-0.1033	-0.0741	-0.0516	-0.0361	0.0067	0.0345	-0.0411	-0.0079	-0.0852	-0.0237	-0.0811	0.0276	-0.0499	-0.0535	1										
Commerce and hospitality	0.0464	-0.0471	-0.036	-0.023	-0.0914	-0.0503	-0.0199	-0.0887	0.1315	-0.0976	-0.0948	0.1032	-0.0595	-0.1336	-0.1716	1									
Transport and communication	-0.0643	-0.0299	-0.0396	-0.0088	0.0339	0.0204	0.0104	0.017	-0.0358	0.0312	-0.0756	-0.0223	0.0214	0.0191	-0.0797	-0.1551	1								
Financial services and real estate	-0.0025	0.035	0.0615	0.0174	0.065	0.0102	0.0001	0.0203	-0.0177	0.0101	0.111	-0.068	0.0125	0.0518	-0.0631	-0.1228	-0.0571	1							
Other services	0.017	0.015	0.0551	0.0415	-0.0487	-0.0641	-0.0042	-0.0231	0.1257	0.0142	0.3078	-0.1409	0.0176	0.0083	-0.1679	-0.3267	-0.1518	-0.1202	1						
Headquarters	0.0599	0.1144	0.1647	0.1008	0.1216	0.0659	-0.0042	0.0528	-0.0311	0.0221	0.1204	-0.0319	0.0905	0.1364	-0.0482	-0.0127	0.0011	0.0685	0.0743	1					
Subsidiary site	0.042	0.0702	0.0748	0.0253	0.1033	0.0075	0.0328	-0.0042	0.0459	-0.0015	0.0168	-0.0044	0.0494	0.0336	-0.0478	0.0454	0.0182	0.0051	-0.0304	-0.2115	1				
Nordic	0.0128	0.0642	0.1735	0.1206	0.2465	0.1257	-0.0667	-0.0162	-0.0349	0.1033	0.0959	-0.0675	0.0425	-0.0075	-0.0234	-0.0193	-0.0234	0.0549	0.0662	0.1036	0.0768	1			
Central	-0.0397	-0.049	-0.077	-0.0496	0.0097	-0.0617	0.0197	0.0484	0.0344	-0.0142	-0.119	-0.084	-0.0016	0.0607	-0.0557	0.0088	0.015	0.0068	-0.0236	-0.0739	-0.3086	-0.0291	-0.5629	1	
South	0.05	0.0351	-0.0167	-0.0329	-0.1279	0.1374	-0.0021	-0.0332	-0.0578	-0.064	-0.0221	0.0816	-0.0379	-0.0325	0.0079	0.033	0.0091	-0.0598	-0.0673	-0.0511	-0.3831	-0.5629	-0.0291	-0.5629	1

TABLE A4 First-stage estimated coefficients—Employer organisational member.

	(1)		(2)		(3)		(4)	
	Product and services		Processes		Organisational		Technology	
50/249 employees	0.445* (0.02)	0.445* (0.02)	0.444* (0.02)	0.444* (0.02)	0.446* (0.02)	0.446* (0.02)	0.445* (0.02)	0.445* (0.02)
250+ employees	0.844* (0.03)	0.844* (0.03)	0.843* (0.03)	0.844* (0.03)	0.846* (0.03)	0.846* (0.03)	0.843* (0.03)	0.844* (0.03)
Construction	0.054 (0.04)	0.054 (0.04)	0.055 (0.04)	0.055 (0.04)	0.052 (0.04)	0.052 (0.04)	0.050 (0.04)	0.050 (0.04)
Commerce and hospitality	−0.183* (0.03)	−0.183* (0.03)	−0.176* (0.03)	−0.176* (0.03)	−0.174* (0.03)	−0.174* (0.03)	−0.178* (0.03)	−0.179* (0.03)
Transport and communication	0.063 (0.04)	0.063 (0.04)	0.066 (0.04)	0.066 (0.04)	0.066 (0.04)	0.066 (0.04)	0.067 (0.04)	0.067 (0.04)
Financial services and real estate	0.135** (0.05)	0.135** (0.05)	0.137** (0.05)	0.136** (0.05)	0.145* (0.05)	0.145* (0.05)	0.137* (0.05)	0.137* (0.05)
Other services	−0.196* (0.03)	−0.196* (0.03)	−0.191* (0.03)	−0.191* (0.03)	−0.184* (0.03)	−0.184* (0.03)	−0.187* (0.03)	−0.188* (0.03)
% Women	0.049** (0.02)	0.049** (0.02)	0.046** (0.02)	0.046** (0.02)	0.029 (0.02)	0.029 (0.02)	0.036*** (0.02)	0.036*** (0.02)
% Union 2004	0.511* (0.03)	0.511* (0.03)	0.521* (0.03)	0.520* (0.03)	0.519* (0.03)	0.518* (0.03)	0.523* (0.03)	0.522* (0.03)
Intercept	−0.487* (0.03)	−0.487* (0.03)	−0.492* (0.03)	−0.492* (0.03)	−0.488* (0.03)	−0.487* (0.03)	−0.489* (0.03)	−0.489* (0.03)
atanrho_12	−0.564* (0.15)	−0.564* (0.15)	−0.658* (0.14)	−0.672* (0.14)	−0.421* (0.12)	−0.403* (0.13)	−0.724* (0.14)	−0.707* (0.14)

Note: Standard deviation in bracket.
*** $p < .10$, ** $p < .05$, * $p < .01$.

TABLE A 5 First-stage estimated coefficients—collective bargaining level.

	(1)	(2)	(3)	(4)
	Product and services	Processes	Organisational	Technology
_outcome_2_3				
50/249 employees	0.295* (0.03)	0.294* (0.03)	0.295* (0.03)	0.296* (0.03)
250+ employees	0.685* (0.05)	0.683* (0.05)	0.687* (0.05)	0.685* (0.05)
Construction	0.059 (0.06)	0.067 (0.06)	0.052 (0.06)	0.063 (0.06)
Commerce and hospitality	-0.218* (0.04)	-0.216* (0.04)	-0.217* (0.04)	-0.214* (0.04)
Transport and communication	0.009 (0.06)	0.012 (0.06)	0.001 (0.06)	0.008 (0.06)
Financial services and real estate	-0.178** (0.08)	-0.181** (0.08)	-0.174** (0.08)	-0.179** (0.08)
Other services	-0.332* (0.04)	-0.331* (0.04)	-0.330* (0.04)	-0.330* (0.04)
% Women	0.039 (0.03)	0.053*** (0.03)	0.028 (0.03)	0.035 (0.03)
(mean) ix_sindicato04	0.378* (0.05)	0.385* (0.05)	0.379* (0.05)	0.391* (0.05)
Intercept	0.438* (0.04)	0.428* (0.04)	0.442* (0.04)	0.432* (0.04)

TABLE A5 (Continued)

	(1)	(2)	(3)	(4)
	Product and services	Processes	Organisational	Technology
_outcome_2_4				
50/249 employees	0.351* (0.04)	0.348* (0.04)	0.350* (0.04)	0.352* (0.04)
250+ employees	0.809* (0.06)	0.801* (0.06)	0.815* (0.06)	0.808* (0.06)
Construction	-0.406* (0.09)	-0.378* (0.08)	-0.399* (0.08)	-0.348* (0.08)
Commerce and hospitality	-0.312* (0.05)	-0.312* (0.05)	-0.332* (0.05)	-0.320* (0.05)
Transport and communication	-0.055 (0.08)	-0.050 (0.08)	-0.084 (0.08)	-0.078 (0.08)
Financial services and real estate	-0.182*** (0.10)	-0.178*** (0.10)	-0.183*** (0.10)	-0.213*** (0.10)
Other services	-0.363* (0.05)	-0.359* (0.05)	-0.376* (0.05)	-0.376* (0.05)
% Women	-0.068 (0.04)	-0.056 (0.04)	-0.064 (0.04)	-0.044 (0.04)
(mean) tx_sindicato04	-0.399* (0.06)	-0.396* (0.06)	-0.393* (0.06)	-0.418* (0.06)
Intercept	-0.475* (0.05)	-0.482* (0.05)	-0.469* (0.05)	-0.472* (0.05)
atanhrho_13	-0.137 (0.15)	-0.608* (0.18)	-0.028 (0.14)	-0.377** (0.17)

(Continues)

TABLE A5 (Continued)

	(1)	(2)	(3)	(4)
	Product and services	Processes	Organisational	Technology
atanrho_14	0.435** (0.17)	0.296*** (0.15)	0.705* (0.19)	0.388** (0.17)
	0.480** (0.19)	0.257 (0.18)	0.661* (0.21)	0.447** (0.21)

Note: Standard deviation in bracket.
*** $p < .10$, ** $p < .05$, * $p < .01$.

TABLE A 6 Estimated marginal effects on the probability of innovation and collective bargaining—without instruments model (employer organisational member: member of an employer organisation that participates in collective bargaining).

	Product and services		Processes		Organisational		Technology	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Member of any employers' organisation	0.038*	0.077**	0.045*	0.111*	0.082*	0.182*	0.025*	0.067***
	(0.01)	(0.03)	(0.01)	(0.03)	(0.01)	(0.03)	(0.01)	(0.03)
% University degree	0.089*	0.088*	0.055*	0.054*	0.059*	0.059*	0.015	0.015
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Private sector	0.037**	0.037**	0.015	0.015	−0.033***	−0.032***	−0.005	−0.004
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Headquarters	0.089*	0.090*	0.108*	0.109*	0.146*	0.145*	0.082*	0.081*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Subsidiary site	0.072*	0.073*	0.122*	0.123*	0.125*	0.125*	0.033**	0.033**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Nordic	0.044**	0.125*	0.118*	0.199*	0.240*	0.289*	0.145*	0.175*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Central	0.043*	0.050*	0.053*	0.064*	0.037**	0.050*	−0.008	−0.012
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
South	0.101*	0.097*	0.119*	0.124*	0.105*	0.128*	0.018	0.031***
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)
50/249 employees	0.069*	0.070*	0.099*	0.100*	0.121*	0.121*	0.069*	0.069*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
250+ employees	0.119*	0.119*	0.172*	0.172*	0.205*	0.204*	0.103*	0.103*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Construction	−0.166*	−0.166*	−0.133*	−0.132*	−0.039**	−0.039**	−0.033**	−0.034**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)

(Continues)

TABLE A6 (Continued)

	Product and services		Processes		Organisational		Technology	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Commerce and hospitality	0.036* (0.01)	0.036* (0.01)	−0.059* (0.01)	−0.058* (0.01)	0.006 (0.01)	0.007 (0.01)	−0.000 (0.01)	−0.000 (0.01)
Transport and communication	−0.150* (0.02)	−0.151* (0.02)	−0.112* (0.02)	−0.112* (0.02)	−0.086* (0.02)	−0.086* (0.02)	−0.011 (0.02)	−0.011 (0.02)
Financial services and real estate	−0.071* (0.02)	−0.071* (0.02)	−0.010 (0.02)	−0.009 (0.02)	0.080* (0.02)	0.081* (0.02)	−0.002 (0.02)	−0.002 (0.02)
Other services	−0.025** (0.01)	−0.027** (0.01)	−0.042* (0.01)	−0.043* (0.01)	0.031** (0.01)	0.031** (0.01)	0.026** (0.01)	0.026** (0.01)
Member* Nordic		−0.136* (0.04)		−0.155* (0.04)		−0.144* (0.04)		−0.073*** (0.04)
Member* Central		−0.040 (0.04)		−0.064*** (0.04)		−0.089** (0.04)		−0.022 (0.04)
Member* South		−0.012 (0.04)		−0.048 (0.04)		−0.110* (0.04)		−0.055 (0.04)
Pseudo—R ²	.0338	.0349	.0454	.0465	.0795	.0802	.0244	.0247
Obs.	14,247	14,247	14,210	14,210	14,269	14,269	14,260	14,260
χ ²	653.44	674.79	862.10	883.96	1489.93	1505.93	471.32	478.47
Prob > χ ²	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Standard deviation in bracket.
****p* < .10, ***p* < .05, **p* < .01.

TABLE A 7 Estimated marginal effects on the probability of innovation and collective bargaining level—without instruments model.

	Product and services		Processes		Organisational		Technology	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
level = 1-Superior	−0.001 (0.01)	−0.005 (0.01)	0.025** (0.01)	0.019*** (0.01)	0.040* (0.01)	0.026** (0.01)	0.038* (0.01)	0.035* (0.01)
level = 2-Company	0.007 (0.02)	0.007 (0.02)	−0.020 (0.02)	−0.023 (0.02)	−0.037** (0.02)	−0.041* (0.02)	−0.024 (0.02)	−0.026*** (0.02)
% University degree	0.085* (0.01)	0.088* (0.01)	0.052* (0.01)	0.055* (0.01)	0.057* (0.01)	0.060* (0.01)	0.015 (0.01)	0.017 (0.01)
Private sector	0.035*** (0.02)	0.035*** (0.02)	0.016 (0.02)	0.013 (0.02)	−0.039*** (0.02)	−0.035*** (0.02)	−0.004 (0.02)	−0.005 (0.02)
Headquarters	0.093* (0.01)	0.090* (0.01)	0.112* (0.01)	0.109* (0.01)	0.148* (0.01)	0.146* (0.01)	0.084* (0.01)	0.081* (0.01)
Subsidiary site	0.081* (0.01)	0.074* (0.01)	0.131* (0.01)	0.126* (0.01)	0.141* (0.01)	0.130* (0.01)	0.040* (0.01)	0.036* (0.01)
Nordic	0.063* (0.02)	0.113* (0.02)	0.127* (0.02)	0.174* (0.02)	0.260* (0.02)	0.252* (0.02)	0.123* (0.02)	0.155* (0.02)
Central	0.055* (0.02)	0.037*** (0.02)	0.058* (0.02)	0.041*** (0.02)	0.052* (0.02)	0.012 (0.02)	−0.028*** (0.02)	−0.029*** (0.02)
South	0.110* (0.02)	0.085* (0.02)	0.121* (0.02)	0.095* (0.02)	0.105* (0.02)	0.082* (0.02)	−0.004 (0.02)	0.004 (0.02)
50/249 employees	0.071* (0.01)	0.071* (0.01)	0.103* (0.01)	0.102* (0.01)	0.128* (0.01)	0.124* (0.01)	0.068* (0.01)	0.070* (0.01)
250+ employees	0.128* (0.01)	0.120* (0.01)	0.182* (0.01)	0.175* (0.01)	0.223* (0.01)	0.211* (0.01)	0.105* (0.01)	0.105* (0.01)

(Continues)

TABLE A 7 (Continued)

	Product and services		Processes		Organisational		Technology	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Construction	−0.166* (0.02)	−0.166* (0.02)	−0.139* (0.02)	−0.134* (0.02)	−0.043** (0.02)	−0.042** (0.02)	−0.037** (0.02)	−0.037** (0.02)
Commerce and hospitality	0.031* (0.01)	0.035* (0.01)	−0.063* (0.01)	−0.060* (0.01)	0.001 (0.01)	0.004 (0.01)	−0.007 (0.01)	−0.002 (0.01)
Transport and communication	−0.147* (0.02)	−0.151* (0.02)	−0.112* (0.02)	−0.113* (0.02)	−0.086* (0.02)	−0.087* (0.02)	−0.007 (0.02)	−0.012 (0.02)
Financial services and real estate	−0.070* (0.02)	−0.072* (0.02)	−0.012 (0.02)	−0.011 (0.02)	0.082* (0.02)	0.078* (0.02)	−0.005 (0.02)	−0.003 (0.02)
Other services	−0.030** (0.01)	−0.028** (0.01)	−0.046* (0.01)	−0.045* (0.01)	0.023*** (0.01)	0.028** (0.01)	0.024** (0.01)	0.025** (0.01)
Member* <i>Nordic</i>		−0.060** (0.02)		−0.059** (0.02)		0.021 (0.02)		−0.023 (0.02)
Member* <i>Central</i>		0.039** (0.02)		0.038** (0.02)		0.080* (0.02)		0.030*** (0.02)
Member* <i>South</i>		0.066* (0.01)		0.059* (0.01)		0.065* (0.01)		0.005 (0.01)
Pseudo- <i>R</i> ²	.0325	.0347	.0450	.0465	.0764	.0800	.0247	.0257
Obs.	14,586	14,247	14,545	14,210	14,602	14,269	14,604	14,260
χ^2	646.06	671.34	876.03	885.54	1463.69	1500.53	488.65	496.57
Prob > χ^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Standard deviation in bracket.
****p* < .10, ***p* < .05, **p* < .01.