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Are unions detrimental to innovation?

Theory and evidence*

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ABSTRACT. In this paper we study the effect of unions on product and process innovation both theoretically and empirically. We propose a Cournot duopoly model where labor productivity is allowed to differ across unionized and non-unionized sectors due to collective voice mechanism. Our findings suggest that the traditional hold-up view whereby unions discourage innovation does not necessarily survive. When the voice effect is neither too strong nor too low, the unionized sector outperforms the market in terms of process innovation, while the effect on product innovation is strictly increasing in the voice power. Our empirical analysis of a large representative sample of Italian firms supports the model's predictions in both pooled OLS, fixed effects and IV.

KEYWORDS: Innovation · labor-unions

JEL CLASSIFICATIONS: J51 · O31 · 032

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1. Introduction

Innovation is a highly idiosyncratic process (Holmstrom, 1989) that results from the combination of multiple factors that include, but are not limited to, the exogenous conditions of the outside economic environment, the firm's investment decisions and the effort of the employees who work in the organization, including those who are not directly involved in R&D. At first blush, one may think that production workers have little to do with the firms' innovation performance. And yet, the resource-based theory of the firm (Barney, 1991) suggests otherwise. Acknowledging organizations as loci of competence accumulation, in fact, ultimately leads to recognize the role of worker effort in the generation of tacit knowledge, that in turn, stands as a key antecedent for the codification of new organizational and technical knowledge (Foss, 1997, 1998; Penrose, 1959). In this framework, innovation depends on the combination of formalized R&D and unformalized on-the-job learning. Grinza and Quatraro (2019: 7) find support to this hypothesis by showing that workers' replacements have a negative effect on the number of patent applications, consistently with the idea whereby "when workers leave, they take with them firm-specific knowledge about competencies and routines, as well as about the potential for resource combination for the creation of novelty."

From here to postulating that workers' organizations may affect innovation – the focus of this article – the step is short, although not devoid of ambiguities. When unions and work councils enhance worker well-being, provide better employment protection or secure higher wages, in fact, workers may either reciprocate and increase their labor effort or leverage on their insiders' benefits and decrease the latter, thus affecting productivity and by extension, innovation. These sharply different outcomes are related to the ambivalent role of unions, that may either behave as rent-seekers as originally postulated by Grout (1984) or enhance voice mechanisms that boost organizational performance (Freeman and Medoff, 1984). Given this unsolved puzzle, it comes as no surprise that the effect of workers' organizations on innovation is still an open issue.

In this paper, we study the effect of unions on innovation both theoretically and empirically. Our contribution to this stream of literature is threefold. First, we follow Bryson and Olsen (2020) to incorporate a voice effect in the Cournot duopoly model of Haucap and Wey (2005), where we relax the assumption that unions have no effects upon productivity. Differently from Bryson and Olsen, however, we allow the model to distinguish between process and product innovation. Second, we focus – both theoretically and empirically – on coordinated systems of collective bargaining, i.e. those that according to Haucap and Wey

(2005) are the least conducive to innovation, as well as the least studied in the literature. Third, studying Italy – a typically coordinated wage bargaining country – and using a large and representative sample of private non-agricultural firms, we test the main predictions of the model.

Our key theoretical findings are that, in the case of product innovation, unionization will provide greater innovation incentives than a market where wages are determined competitively if the productivity gains due to voice mechanisms are large enough. Conversely, when it comes to process innovation incentives, the effect of union voice is more ambiguous, as unions have a positive effect on innovation if the latter is not too low but neither too high.[1] Empirically, we take advantage of the variability across firms and over time of formal workers' representative bodies – by means of which they channel their voice towards employers – and estimate OLS, fixed-effect and IV models of the theoretical hypotheses put forward above. Consistently with the theory, we find that product innovation is doubtlessly growing in the presence of such representative bodies, while process innovation display a less clear-cut relationship with firm-level union representations. In addition, we also show that the voice effect is likely to be heterogeneous across firms of different size.

The remainder of the paper is organized as follows. In section 2, we overview the different theories and associated evidence on the relationship between unions and innovation. In section 3, we depart from Haucap and Wey (2005) and develop our theoretical model. Section 4 outlines the data used for the estimations, along with some descriptive statistics, presents the econometric strategy and the main results. Section 5 comments and concludes.

2. Related literature

2.1. Theory

Theoretically, the effect of unions on innovation is ambiguous – see Table 1 for a summary. A first strand of research sees unions as monopolist institutions that distort market outcomes through rent-seeking behaviors. The classic reference in this case is Grout (1984).[2] In this view, wage-bargaining reduces the gains from innovation by imposing a sort of a tax on sunk capital, therefore discouraging R&D investments ex-ante. Key to this hold-up mechanism are the degree of asset specificity, the elasticity of substitution between capital and labor and the time horizon

[1] That innovation incentives can be larger in unionized that in non-unionized industries is something already put forward from the literature on strategic R&D – see for instance, Beath et al. (1989) and Ulph and Ulph (1994). For further discussion, see section 2.2.

[2] For empirical support see Addison et. al (2007) and Card et al. (2014) and the references therein.

of the industrial relations.[3] However, when unions and firms bargain over wages and employment levels as in efficient bargaining models (Oswald and Turnbull, 1985; Layard et al., 1991; and Booth, 1995), the negative relationship between unionization and innovation may be weakened or even disappear, depending on the unions' preferences for wage and employment.[4]

Table 1: Theory summary

Theoretical view	Effect on innovation	Mechanism
Monopoly power	↓	↑ wages = ↓ innovation gains (e.g., Grout, 1984)
Collective voice	↑	↓ worker grievances/turnover = ↑ productivity (e.g., Freeman and Medoff, 1984)
Strategic R&D	↑	↑ market share = ↑ R&D investments (e.g., Beath et al., 1989)
Employment protection	↓	↑ long-term commitment = ↑ greater worker effort (e.g., Acharya et al., 2014)
Employment protection	↑	↓ dismissal probability = ↓ labor effort (e.g., Bassanini and Ernst, 2002)

In a second line of research that traces back to Freeman and Medoff (1984), unions are seen as collective voice institutions that boost labor productivity (and by extension, innovation) through a variety of different channels. First, by reducing worker grievances, they may have a positive and direct effect on the supply of labor effort. Second, by encouraging workers to voice their ideas, they may increase the flow of intuitions from production to R&D departments and thus facilitate the codification of new organizational and technical knowledge. Third, by lowering labor turnover, they may promote the accumulation of firm-specific human capital. Fourth, by easing the introduction of organizational innovations, they may increase job satisfaction and improve learning achievements, with positive spillovers on labor productivity and innovation.

A third strand of research studies the effect of unions on innovation in oligopolistic markets (Beath et al., 1989; Ulph and Ulph, 1994). In this framework, when unions bargain

[3] When players engage in repeated interactions and abstract from end-game scenarios, the incentives to act uncooperatively weaken or even disappear (Van Der Ploeg, 1987).
[4] Mukherjee and Pennings (2011), for instance, study a Cournot oligopoly where innovation incentives depend on the union's preferences for wage and employment and on the degree of wage centralization.

higher employment levels, firms are incentivized to invest in R&D to protect their market shares.[5] Along similar lines, Haucap and Wey (2005) develop a Cournot duopoly model that studies how different unionization regimes (centralized, coordinated and decentralized) lead to different innovation incentives. Their key results is that the relationship between unions and innovation is non-monotonic in the degree of wage centralization, as innovation incentives are large under "centralization" – when an industry union bargains a single wage for the entire industry – intermediate under "decentralization" – where firm-level unions set their wages uncooperatively – and low under "coordination" – where a single union maximizes the industry wage bill by adjusting firm-level wages to the firms' relative competitiveness. Under some circumstances, they also show that "centralization" is the only regime that may perform better than a market where wage determination is competitive when it comes to innovation incentives. However, this result follows from the assumption that unions have no effect on productivity. The model developed in section 3 relaxes this assumption and shows that, under some circumstances, innovation incentives are lager also under "coordination".

Finally, the "employee protectionism" hypothesis generates controversial predictions. On the one hand, providing workers with better employment protection may nurture innovation by ensuring tolerance for early failures. On the other hand, union presence could encourage shirking by lowering the probability of being dismissed, thereby reducing the negative consequences for supplying less effort. Manso (2011) develops a principal-agent model where the optimal contract to motivate innovation shows rewards for long-term success and tolerance for short-term failure, while Acharya et al. (2014) proposes a theoretical framework where wrongful discharge laws – i.e., laws which prevent employees to be fired in "bad faith" – boost innovation and new-firms creation. In contrast, Bassanini and Ernst (2002) and Scarpetta and Tressel (2004) find that the difficult or expensive firing of redundant personnel can frustrate labor-saving innovations at the firm level.

2.2. Empirical evidence

Given the array of possible effects that unions may have on innovation, it comes as no surprise that the empirical findings in the field are yet to be conclusive. In their review, Menezes-Filho and Van Reenen (2003) highlight a sort of "Atlantic divide", as the available evidence seems to suggest that unions depress innovation in the US but not in Western Europe. This is consistent with the findings of Addison et al. (2013) and Bradley et al. (2016), who show,

[5] See Menezes-Filho et al. (1998) for empirical support.

respectively, that the effect of unions on innovation is almost null in Germany, while is negative and statistically significant in the US. Finally, Doucouliagos and Laroche (2013) apply a meta-regression analysis to twenty-seven studies on four different countries (UK, US, Canada, Germany) and find a negative correlation between unionization and innovation in all four countries analyzed, despite the effect is declining over time and increasing in the flexibilization of labor markets, which is loosely consistent with the conclusions of Menezes-Filho and Van Reenen (2003). However, all these results seem to suffer from a geographical shortcoming, as " the samples of countries under study […] are still very Anglo-Saxon biased" (ivi: 329). Hence, our study goes in the direction of expanding the samples of countries analyzed and overcome the above limitation.

From a broader perspective, Bryson et al. (2013) find that union presence mitigates the increase in job-related anxiety due to the introduction of process innovations, thus providing suggestive support to the idea whereby the costs of implementing an innovation are larger in non-unionized than in unionized firms, perhaps, due to voice mechanisms. Holman and Raferty (2018), in turn, show that the introduction of organizational innovations is greater in more unionized systems of industrial relations (socio-democratic and Nordic systems vis-à-vis liberal and Mediterranean systems), while Antonioli et al. (2011) identify a positive relationship between on-the-job well-being (as dependent variable) and organizational innovation and cooperative industrial relations (as covariates). Finally, Bryson et al. (2005) use British data on the introduction of HRM practices at the firm-level and find that the positive effect of organizational changes on labor productivity is confined to unionized firms. All these pieces of evidence seem somewhat supportive to the view that sees unions as collective voice institutions

The "employee protectionism" hypothesis, in turn, has been tested by Acharya et al. (2014) using US data. Their findings show that the States adopting wrongful discharge laws as an exception to the employment-at-will doctrine experienced an increase in the annual number of patents and citations by 12.2% and 18.8% respectively. In a companion paper (Acharya et al. 2013), the same authors extend the analysis to other three countries, Germany, UK and France, and provide further evidence to the view whereby more stringent dismissal laws foster innovation, particularly, in knowledge-intensive industries. Finally, Ederer and Manso (2013) find support to Manso's (2011) principal-agent model by revealing that innovation-motivating contracts ensure rewards for long-term success but also tolerance for early failures.

A concluding remark on the role of monopoly power is worth drawing. Schnabel and Wagner (1994) find that union density impact positively on R&D only if the union's monopoly power is not too high, while Fang and Ge (2012) suggest that the positive association between union presence and innovation in China can be explained by the poor bargaining power of Chinese trade unions. Menezes-Filho and Van Reenen (2003), in turn, justify the presence of non-linearities in the relationship between unions and innovation in Europe by claiming that unions have a positive impact on innovation when their bargaining power is low and a negative impact on innovation when their bargaining power is high.

3. The model

In this section, we follow Bryson and Olsen (2020) and incorporate a voice effect in the Cournot duopoly model of Haucap and Wey (2005: 153) that studies how different unionization regimes (centralized, coordinated and decentralized) lead to different innovation incentives. In addition, and always in line with Bryson and Olsen (2020), we extend Haucap's and Wey's (2005) original framework to account for product innovation. Hence, we consider two different types of R&D tournament: in the first, the innovation winner acquires the exclusive right over a labor-saving technique that reduces its labor cost; in the second, it gets to introduce a quality-enhancing innovation that vertically differentiates the product market and directly increases its market share.

Our study differs from that of Bryson and Olsen (2020) in two important ways. First, while they consider the case where non-unionized firms directly compete with locally-unionized firms – a situation which seems to be common in both Norway and the UK – we compare the incentives to participate in R&D tournaments across unionized and non-unionized industries. As our empirical analysis is based on Italian data, we focus on the unionization regime in Haucap's and Wey's (2005) classification that best describes the Italian system of industrial relations. In this setting – that Haucap and Wey (2005: 153) call "coordination" – "there is an industry union that coordinates the wage demands so as to maximize the industry wage bill, […so that] labor supply is completely monopolized, […] while firm-level wages are adjustable to the firms' relative competitiveness".[6] In Haucap's and Wey's original model, this regime is the least conductive to innovation and under no circumstances it can perform better than a market where wage determination is competitive. Conversely, when voice mechanisms are

[6] Consistently, Haucap and Wey (2005: 153-154) recalls that the coordinated regime reflects "recent trends in continental Europe towards flexible wage setting, while the union's monopoly power remains largely intact".

allowed into the picture, we find that this may no longer be true, depending on the magnitude of the labor productivity gains conveyed by union voice. Second, while Bryson and Olsen (2020) do not allow for the possibility that firms may invest differentially in product and process innovation, we treat the two as separate strategies, as to show how innovation incentives vary across the latter. Our key finding, with this respect, is that union voice has a clear and positive effect on product innovation, while such effect is more ambiguous when it comes to process innovation.

3.1. Assumptions

Consider a model economy with four firms and two duopolistic sectors. While the labor market is competitive in one of the two sectors, it is monopolized by an industry union in the other. Denote as U (resp., N) the unionized (resp., non-unionized) sector, as 1 and 2 the firms competing in the U-sector, and as 3 and 4 those competing in the N-sector. As we stick to Haucap's and Wey's (2005) original setting, we do not allow for the possibility of intersectoral competition, so that firm 1 competes exclusively with firm 2 and firm 3 competes exclusively with firm 4.

In each sector, firms operate under constant returns to scale, with labor as the sole factor of production. To produce one unit of the final good, firm i requires $\beta \leq 1$ units of homogeneous labor, so that firm i's marginal cost is given by βw_i, where w_i denotes the wage rate in firm i and β depends on the sector-specific labor productivity. Production quantity of firm i, q_i, is related to its labor demand, l_i, so that $l_i = \beta q_i$.

To model the idea that union presence may increase labor productivity through voice mechanisms, we follow Bryson and Olsen (2020) and assume that $\beta = 1$ in the N-sector, while $\beta = \alpha \leq 1$ in the U-sector. As labor productivity increases, α goes down, and fewer workers are needed to produce one unit of the final good.[7]

Given this, we consider the following extended form game: at stage 1, firms decide whether to participate in an innovation race. Differently from Haucap and Wey (2005), we consider both process and product innovation. In the first case, the R&D tournament provides the innovation winner with the exclusive right over a technique that reduces its labor

[7] The assumption that unions increase productivity may appear rather a strong one. However, more exactly we assume that *through the voice mechanism*, unions increase labor productivity. In this more specific sense, the quasi-experimental evidence provided by Jäger et al. (2020) is reassuring. Taking advantage of a German reform, they find that in firms with a more voice-oriented governance (namely *codetermination*) the hold-up mechanism disappears, and productivity (value added per worker) is higher by 2 to 8%.

requirement by $\Delta \in (0,1)$. In the second case, the R&D tournament bestows the exclusive right over a patent that vertically differentiates the product market, thus increasing the demand of the innovation winner of a factor $\Theta \in (0,1)$. We assume that firms have the same chance of winning both races and face the same implementation cost, given by $I(\Delta) > 0$ in the case of process innovation and by $I(\Theta) > 0$ in the case of product innovation.

At stage 2, wages are determined, either competitively in the N-sector – where the equilibrium-wage is driven down to the opportunity cost of labor, given by $w_0 > 0$ – or by the union, which takes employment levels as given according to a classical right-to-manage rule.[8] In the "coordinated" wage setting regime, firm-level wages are adjusted to the firm's relative competitiveness according to the following rule: $w_i = \text{argmax} \sum_{i=1}^{2} l_i(w_i - w_0)$.

At stage 3, firms compete in quantities on the product market and choose their employment levels. In the case of process innovation, we assume that the goods supplied by the duopolists in both the U and the N-sector are perfect substitutes, which implies that firms in both sectors face an inverse demand function of the form $p = A - q_1 - q_2$, with $q_1 + q_2 \leq A$. Conversely, we assume that product innovation generates a quality difference between the good supplied by the innovation winner and that supplied by the innovation loser that creates a demand asymmetry that vertically differentiates the product market – see section 3.3.1.

To make sure that all firms have positive output levels in equilibrium – so that innovation losers are not driven out of the market – we impose the following restriction upon the set of parameters' value[9]:

Assumption 1—*The opportunity cost of labor is not so high to drive innovation losers out of the market, so that* $w_0 < \overline{w}_0 \equiv \frac{A}{1+\Delta}$

3.2.1. Equilibrium quantities and wages

We derive the subgame perfect equilibrium quantities and wages by backward induction, supposing, without loss of generality, that firm 1 is the innovation-winner in the U-sector and

[8] As recalled by Haucap and Wey (2005: 153) "While unions usually neither have perfect monopoly power nor do they exclusively care about their members' wage bill, these simplifying assumptions allow us to concentrate exclusively on the effects of wage setting rigidities". The same simplification is used, for instance, in Basak and Mukherjee (2018) and in Calabuig and Gonzalez-Maestre (2002).

[9] Assumption 1 is sufficient to make sure that all the arguments in equations (6), (10), (19) and (23) are > 0.

firm 3 is the innovation winner in the N-sector. Given the above discussion, the firms' problem in the U-sector is given by:

$$\max_{q_i} \Pi_i = \left(A - q_i - q_j\right)q_i - \beta w_i(1-\Delta)q_i \tag{1}$$

$$\max_{q_j} \Pi_j = \left(A - q_i - q_j\right)q_j - \beta w_j q_j \tag{2}$$

where $i = 1, j = 2$ and $\beta = \alpha \leq 1$ in the U-sector and $i = 3, j = 4$ and $\beta = 1$ in the N-sector. From equations (1) and (2) we have that:

$$q_i = \frac{A + \beta\left[w_j - 2w_i(1-\Delta)\right]}{3} \tag{3}$$

$$q_j = \frac{A + \beta\left[w_i(1-\Delta) - 2w_j\right]}{3} \tag{4}$$

Recalling that $l_k = \beta q_k, k = i, j$, we now turn to wage determination occurring at stage 2. In the N-sector, workers are paid their reservation wage, so that $w_3 = w_4 = w_0$. Making use of this and the fact that $\beta = 1$, the equilibrium quantities of firm 2 and 3 in the case of process innovation are given, respectively, by:

$$q_3^* = \frac{A - w_0(1-2\Delta)}{3} \tag{5}$$

$$q_4^* = \frac{A - w_0(1+\Delta)}{3} \tag{6}$$

Conversely, the industry-union in the U-sector adjusts the firms' wages to their relative competitiveness, so that the equilibrium wages in firms 1 and 2 are given, respectively, by:

$$w_1^* = \frac{A/\alpha + w_0(1-\Delta)}{2(1-\Delta)} \tag{7}$$

$$w_2^* = \frac{A/\alpha + w_0}{2} \tag{8}$$

Inserting equations (7) and (8) in equations (3) and (4) and recalling that $\alpha \leq 1$ by assumption, we derive the equilibrium quantities of firm 1 and 2 in the case of process innovation, which are given, respectively, by:

$$q_1^* = \frac{A - \alpha w_0(1 - 2\Delta)}{6} \quad (9)$$

$$q_2^* = \frac{A - \alpha w_0(1 + \Delta)}{6} \quad (10)$$

With this, we have completed the analysis of the first two stages of the game in the case of process innovation. The next step is to compare the incentives to innovate across sectors.

3.2.2. Innovation incentives

Since we have assumed that both firms have an equal probability $= 1/2$ of winning the R&D tournament and that firms 1 and 3 are the innovation winners in the *U*-sector and *N*-sector respectively, we can proceed by referring to $\Pi_i(\Delta)$ as the profit of the innovation winner in the and to $\Pi_j(\Delta)$ as the profit of the innovation loser, where $i = 1$ and $j = 2$ in the *U*-sector and $i = 3$ and $j = 4$ in the *N*-sector. Hence, a firm will participate in the race as long as $\frac{1}{2}\left[\Pi_i(\Delta) + \Pi_j(\Delta)\right] - I(\Delta) \geq \Pi_j(\Delta)$, that is, as long as the expected profit from participating is higher than the certain profit from unilaterally abstaining – in which case the rival firm obtains the labor-saving technique for sure. Assuming that $\frac{1}{2}\left[\Pi_i(\Delta) - \Pi_j(\Delta)\right] \geq I(\Delta)$ is always satisfied – so that innovation incentives do exist – we can follow Haucap and Wey (2005) and use the profit differential $\Psi_\rho = \Pi_i(\Delta) - \Pi_j(\Delta), \rho = N, U,$ to measure the magnitude of process innovation incentives across sectors.

Before proceeding, it will be instructive to draw some preliminary remarks on the implications of allowing for voice mechanism when firms compete to acquire the right over a labor-saving technique. Observing that $\Pi_k = q_k^2 k = i, j,,$ holds in equilibrium, we can use equations (3) and (4) and rewrite the profits of the innovation winner and loser in the *U*-sector as:

$$\Pi_1^* = \frac{[A + \alpha(-d_w - w_1 + 2\Delta w_1)]^2}{9} \quad (11)$$

$$\Pi_2^* = \frac{[A + \alpha(d_w - w_2 - \Delta w_1)]^2}{9} \quad (12)$$

where $w_1 - w_2 = d_w$ measures the wage differential that results from the competitiveness-driven adjustment imposed by the union. The second term on the r.h.s. of equation (11) measures what Haucap and Wey call the "wage differential" hold-up, which enters equation

(12) with a positive sign: hence, the larger d_w, the smaller the incentives to innovate. The third terms on the r.h.s. of equations (11) and (12), in turn, measure labor costs, and hence, they turn out to be a measure of the classic "wage hold up" postulated by Grout (1984). Finally, the fourth and final term in equations (11) and (12) capture, respectively, the gains and losses of implementing the labor-saving innovation under the coordinated wage setting regime, where both are increasing in the wage set by the union in firm 1.

As all these terms are increasing in α, we can shed light upon the implications of introducing a voice mechanism in the model. In particular, we distinguish two effects. First, as α decreases, the severity of both the wage and wage-differential hold-up decreases as well, with positive effects on innovation incentives. Second, as α decreases, the gains from introducing a labor-saving innovation decreases as well, and so do the losses from losing the R&D tournament. Perhaps counterintuitively thus, the effect of union voice on innovation is ambiguous and depend on the combination of these two channels.

We now turn to the explicit comparison of innovation incentives across the different wage setting regimes. To do so, we analyze the maximum willingness to pay for implementing the labor-saving innovation in the two regimes. Formally, this is given by:

$$\Psi_U - \Psi_N = -\frac{\Delta w_0}{12}\left[B\alpha^2 - 2A\alpha + 4(2A - B)\right] \tag{13}$$

where we have defined $B \equiv w_0(2 - \Delta)$. We are now in the position to advance the following Proposition, which summarizes our main findings:

Proposition 1— *When the productivity gains conveyed through union voice are not too large nor too small, the incentives to introduce a labor-saving innovation (process innovation) are larger in a market where wages are coordinated by an industry union than when they are set competitively.*

Proof: First, we prove that when union voice is absent, Ψ_N is always greater than Ψ_U. When $\alpha = 1$, we have that $\Pi_1 = \frac{1}{4}\Pi_3$ and $\Pi_2 = \frac{1}{4}\Pi_4$. Hence, $\Omega_U - \Omega_N|_{\alpha=1} = -\frac{1}{4}(\Pi_3 - \Pi_4) < 0$. Second, we need to find the critical α for which $\Psi_U - \Psi_N > 0$ when $\alpha < 1$. Solving equation (13) for α, we see that this is satisfied if $\frac{A-\left(A^2+4B^2-8AB\right)^{1/2}}{B} < \alpha < \frac{A+\left(A^2+4B^2-8AB\right)^{1/2}}{B}$ ■

In the absence of productivity gains due to voice mechanisms, our Proposition 1 replicates the original finding of Haucap and Wey (2005), who postulate that a market where wages are determined competitively performs better than one where wages are coordinated when it comes to process innovation incentives. When union voice exists, however, we get at a newer conclusion, resulting from the combination of the two mechanisms highlighted above. Despite higher productivity conveyed through union voice decreases the gains from introducing a labor-saving innovation, it also decreases the severity of both the wage and the wage differential hold-up. Hence, our findings suggest that voice mechanisms are a necessary but not sufficient condition for unions to have a positive effect on innovation. While similar non-linearities have been found in the unions' monopoly power (Menezes-Filho and Van Reenen, 2003), to our knowledge, ours is the first study that analyzes the issue.

3.3. Product innovation

3.3.1. Equilibrium quantities and wages

As for the case of process innovation, we derive the subgame perfect equilibrium quantities and wages by backward induction, supposing, as before, that firm 1 is the innovation-winner in the U-sector and the firm 3 is the innovation winner in the N-sector. As anticipated, we assume that product innovation creates a quality difference between the products supplied by the innovation winner that vertically differentiates the market, thus creating a demand asymmetry. Therefore, we assume that innovation winners face an inverse demand function of the form $p_i = A(1+\Theta) - q_i - q_j$, while the inverse demand function of innovation losers is given by $p_j = A - q_i - q_j$, where $\Theta \in (0,1)$ is the degree of vertical differentiation following the innovation race and $i = 1$ and $j = 2$ in the U-sector, while $i = 3$ and $j = 4$ in the N-sector.[10] Given the above discussion, the firms' problem is given by:

$$\max_{q_i} \Pi_i = \left[A(1+\Theta) - q_i - q_j\right]q_i - \beta w_i \tag{14}$$

$$\max_{q_j} \Pi_j = \left(A - q_i - q_j\right)q_j - \beta w_j q_j \tag{15}$$

[10] We derive these inverse demands functions from a simplified version of Singh's and Vives's original model (1984), which is commonly taken as representing a micro-founded demand system of differentiated products. The derivation is as follows. The representative consumer's utility is a quadratic function of the purchased quantities of two vertically differentiated products. Due to the innovation race, product i is of high-quality, while product j is of low-quality. Formally, the demand function is given by $U(q_i, q_j) = A(1+\Theta)q_i + Aq_j - q_i q_j - (q_i^2 + q_j^2)/2$. Utility maximization yields the inverse demand functions $p_k = \partial U/\partial q_k$, $k = i, j$ and and $i = 1$ and $j = 2$ in the U-sector, while $i = 3$ and $j = 4$ in the N-sector.

From equations (14) and (15) we have that:

$$q_i = \frac{A(1+\Theta) + \beta(w_j - 2w_i)}{3} \tag{16}$$

$$q_j = \frac{A + \beta(w_i - 2w_j)}{3} \tag{17}$$

Recalling that $l_k = \beta q_k, k = i, j$, and that $w_3 = w_4 = w_0$ and $\beta = 1$ in the N-sector, the equilibrium quantities of firm 3 and 4 in the case of product innovation are given, respectively, by:

$$q_3^* = \frac{A(1+\Theta) - w_0}{3} \tag{18}$$

$$q_4^* = \frac{A - w_0}{3} \tag{19}$$

while the equilibrium wages in firms 1 and 2 are given, respectively, by:

$$w_1^* = \frac{A(3+2\Theta)/\alpha + 3w_0}{6} \tag{20}$$

$$w_2^* = \frac{A(3+\Theta)/\alpha + 3w_0}{6} \tag{21}$$

Hence, the equilibrium quantities of firm 1 and 2 in the case of product innovation are given, respectively, by:

$$q_1^* = \frac{A(1+\Theta) - \alpha w_0}{6} \tag{22}$$

$$q_2^* = \frac{A - \alpha w_0}{6} \tag{23}$$

We can now move to the comparison of innovation incentives across sectors.

3.3.2. Innovation incentives

To form ideas on the difference between product and process innovation in this model, we follow steps identical to those in section 3.2.2. and write the profit of the innovation winner and loser in the U-sector as:

$$\Pi_1 = \frac{[A(1+\Theta) + \alpha(-d_w - w_1)]^2}{9} \tag{24}$$

$$\Pi_2 = \frac{[A + \alpha(d_w - w_2)]^2}{9} \tag{25}$$

From equations (24) and (25), we see that the key difference between the acquirement of a labor-saving or a quality-enhancing patent is that, while the gains (and losses) from process innovation must be weighted for the sector-specific labor productivity – see equations (11) and (12) and the discussion therein – the benefits of product innovation are unrelated to the voice face of unions. Indeed, while both the wage and the wage differential hold-up are decreasing in α when it comes to both process and product innovation – see equations (11), (12), (24) and (25) – union voice has no mediating effect on product innovation, as can be seen from the fact that $A\Theta$ – which measures the gain from the acquisition of a quality-enhancing patent – does not depend on α in equation (24). Intuitively, this seems to suggest that union presence should have a less ambiguous effect on product innovation.

To verify this intuition, we follow steps identical to those in the case of process innovation and compute the incentives differential across the two wage setting regimes, which is given by:

$$\Omega_U - \Omega_N = \frac{\Theta A[2(4-\alpha)w_0 - 3A(2+\Theta)]}{36} \tag{26}$$

The effects of union voice on process innovation incentives are summarized in the following Proposition:

Proposition 2—*When the productivity gains conveyed through union voice are large enough, the incentives to introduce a quality-enhancing innovation (product innovation) are greater in a market where wages are coordinated by an industry union than when they are set competitively.*

Proof: First, we prove that that when union voice is absent, Ω_N is always greater than Ω_U. When $\alpha = 1$, we have that $\Pi_1 = \frac{1}{4}\Pi_3$ and $\Pi_2 = \frac{1}{4}\Pi_4$. Hence, $\Omega_U - \Omega_N|_{\alpha=1} = -\frac{1}{4}(\Pi_3 - \Pi_4) < 0$. Second, we need to find the critical α for which $\Omega_U - \Omega_N > 0$. Solving equation (24) for α, we see that this is satisfied if $\alpha < \frac{8w_0 - 3A(2+\Theta)}{2w_0}$ ■

As expected, the key difference between process and product innovation is that union voice has a clear and positive effect upon the latter, and an ambiguous effect upon the former.

This does not mean, however, that unionization is more conducive to process innovation *tout court*. To verify this, we need to restrict our attention to quality-enhancing patents and labor-saving techniques that yield comparable productivity gains. To do so, we proceed by assuming that $\Delta = \Theta$. Straightforwardly, and quite uninterestingly, in fact, when either of the two parameters is larger than the other, the ordering of innovation incentives chiefly depends on the relative efficiency of the two types of innovation. Hence, we can advance the following Proposition:

Proposition 3—*When process and product innovation are similar in terms of productivity gains – $\Delta = \Theta$ – we have that:*

(i) *If $w_0 < A/3$ or $A/3 < w_0 < A$ and $\Delta < \widetilde{\Delta}$, process innovation incentives are greater than product innovation incentives in both the U and the N-sector ($\Psi_U > \Omega_U$ and $\Psi_N > \Omega_N$)*

(ii) *If $A/3 < w_0 < A$ and $\Delta > \widehat{\Delta}$, product innovation incentives are greater than process innovation incentives in both the U and the N-sector ($\Omega_U > \Psi_U$ and $\Omega_N > \Psi_N$)*

(iii) *If $A/3 < w_0 < A$ and $\widetilde{\Delta} < \Delta < \widehat{\Delta}$, product innovation incentives are greater than process innovation incentives in the U-sector ($\Omega_U > \Psi_U$), while process innovation incentives are greater than product innovation incentives in the N-sector ($\Psi_N > \Omega_N$).*

Proof: Making use of equations (13) and (24), we see that $\Omega_U > \Psi_U$ if $\Delta > \frac{2(3w_0-A)(A-\alpha w_0)}{A^2-\alpha w_0^2} \equiv \widetilde{\Delta}$, or, alternatively, if $\frac{A}{3w_0} > \frac{2(A-\alpha w_0)+\Delta\alpha w_0}{2(A-\alpha w_0)+\Delta A}$. Since $A - \alpha w_0 > 0$ according to Assumption 1, $\frac{2(A-\alpha w_0)+\Delta\alpha w_0}{2(A-\alpha w_0)+\Delta A}$ is strictly smaller than 1. This entails that a necessary condition for $\Omega_U > \Psi_U$ is that $w_0 > \frac{A}{3}$. Similarly, making use of equations (13) and (24), we see that $\Omega_N > \Psi_N$ if $\Delta > \frac{2(3w_0-A)(A-w_0)}{A^2-3w_0^2} \equiv \widehat{\Delta}$, or, alternatively, if $\frac{A}{3w_0} > \frac{2(A-w_0)+\Delta w_0}{2(A-w_0)+\Delta A}$. As before, since $A - w_0 > 0$ according to Assumption 1, $\frac{2(A-w_0)+\Delta w_0}{2(A-w_0)+\Delta A}$ is strictly smaller than 1. This entails that a necessary condition for $\Omega_N > \Psi_N$ is that $w_0 > \frac{A}{3}$. The rest of the proof follows from the fact that $\widehat{\Delta} > \widetilde{\Delta}$ ■

All in all, the results from Propositions 1, 2 and 3 corroborates the idea whereby the relationship between unions and innovation is still an open issue. Even within the boundaries of our very simple model, in fact, the effect of union presence on the firms' innovation performance chiefly depends on the model's parametrization, and no closing theoretical statement can be advanced. In the next section, we inquire empirically into our data to assess whether unionization promotes or discourage innovation in Italy.

4. Empirical analysis

Our theoretical model makes two broad testable predictions about the relationship between unions and innovation. On the one hand, within coordinated systems of wage bargaining, the impact of unions on *product* innovation is expected to be increasingly positive in the voice capacity of the former, while that on *process* innovation appears less predictable as it is inverse U-shaped with respect to the voice capacity. On the other hand, we expect collectively coordinated wages to be more inducive of product innovation with respect to market wages when the voice performance of unions is high. Conversely, the same holds for process innovation at intermediate levels of the voice capacity of unions.

Testing the second prediction requires comparing different wage bargaining systems – i.e. different countries – at similar levels of the voice performance of unions. Disentangling the effect of a specific labor market institution through international comparisons is anyway often unfeasible, as these institutions, within each country, are strictly related one to the others (Bentolila et al., 2020). Instead, we study a single country – hence conditioning on the overarching institutional system – to test formally the first prediction. Our case-study is Italy, for three reasons mainly. First, its system of wage bargaining is coordinated in the sense assumed by our theoretical model. Second, the existence of formal union bodies at the establishment level creates variability at the micro level in space and over time in the voice capacity of unions. Third, the available data allows to keep track of the existence of such union bodies, and to distinguish between product and process innovation. In the remainder of this empirical section, we first describe the data and outline some descriptive statistics, then we introduce the econometric strategy, and at last we comment our results.

4.1. Data and descriptive statistics

The empirical analysis is based on the last three waves of the *Rilevazione su Imprese e Lavoro* (RIL) conducted by INAPP (the Italian National Institute for Public Policy Analysis) in 2010, 2015 and 2018 on a large representative sample of partnerships and limited liability firms operating in Italy.[11] Each wave of the survey covers over 25,000 firms from the non-

[11] Ideally, we could also include in the data the first wave of RIL, collected in 2007. However, this first wave is much smaller than the others, and is known to be of lower data quality. For more details on sample design,

agricultural private sector. A subsample of the included firms (over 35%) is followed over time, making the RIL dataset partially panel over the period under study.

Each wave of the RIL questionnaire provides a rich set of information. Most important to our purposes, RIL data allows to separate information on whether during the current year or in the past two years before the interview the firm introduced product or process innovation.[12] Moreover, we know whether in the workplace there is an elected workers' representative body (RSU or RSA).[13] This last piece of information is tracked as a dummy, which is not neutral with respect to our capability to test the theoretical predictions under scrutiny here. Indeed, as in our model the impact of unions on product innovation is strictly growing in its voice capacity, we still expect the empirical impact of the presence of workers' representative bodies on product innovation to be positive. On the contrary, as theory suggests that the impact on process innovation is inverse U-shaped, we cannot put forward clear-cut predictions by operationalizing the voice power through a dummy. However, as Italy is usually understood as a country with very powerful unions, we may expect their voice capacity to be very high, and hence to have a nearly null effect on process innovation, and a largely positive effect on product innovation.

As for the explanatory variables we take advantage from the rich set of information provided by the RIL survey on management and corporate governance, workforce characteristics and firms productive specialization. In particular, we have data on the demographic profile of the entrepreneurs, on the ownership structure and on external or dynastic recruitment of the management. This information offers the great advantage of controlling for important sources of firm heterogeneity, as emphasized in the previous literature (Bloom and van Reenen, 2011). Further we add information about workforce structure (education, age, professional status, gender, contractual arrangements, citizenship, hiring), firm characteristics (size, sales per employees, foreign trade, multinational, private funded training investment, start-up status) and other categorical variables describing economic activities (Nace Rev.2 aggregations of 2 digit sectors) and regions (NUTS1). Table A1 in the Appendix shows more detailed definitions of all variables used in the empirical analysis.

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methodological issues and procedures for requesting data related to RIL, see: http://www.inapp.org/it/ril

[12] See the Community Innovation Survey: https://ec.europa.eu/eurostat/web/microdata/community-innovation-survey.

[13] The *Company Union Representation* (RSA, in Italian) protects all workers members of a specific trade union within a company, not participating in firm level bargaining. The *Unitary Representation Bodies* (RSU), on the other hand, involves all the workers of a company, regardless of whether they are members of a trade union or not.

Out of the overall data source, we excluded firms with less than 10 employees, where both union and innovation activities are relatively unstructured.

Table 1: descriptive statistics

	2010		2015		2018	
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
Product inn. (0/1)	0.475	0.499	0.387	0.487	0.388	0.487
Process inn. (0/1)	0.410	0.492	0.355	0.479	0.364	0.481
Union (0/1)	0.182	0.386	0.187	0.390	0.213	0.409
Strike density	0.060	0.431	1.098	9.259	0.008	0.093
			Management characteristics			
Tertiary edu.	0.255	0.436	0.254	0.436	0.284	0.451
Upper sec. edu.	0.531	0.499	0.546	0.498	0.516	0.500
Lower sec. edu.	0.214	0.410	0.200	0.400	0.200	0.400
Female (0/1)	0.119	0.324	0.129	0.335	0.139	0.346
Age > 54	0.320	0.466	0.346	0.476	0.321	0.467
34 < age < 55	0.292	0.455	0.236	0.425	0.199	0.399
Family ownership (0/1)	0.870	0.337	0.846	0.361	0.843	0.364
External manag. (0/1)	0.031	0.174	0.043	0.202	0.039	0.193
			Workforce characteristics			
Share w. tertiary edu.	0.080	0.153	0.101	0.168	0.139	0.217
Share w. upper sec. edu.	0.435	0.281	0.466	0.272	0.476	0.287
Share w. lower sec. edu.	0.485	0.318	0.433	0.306	0.385	0.318
Share of female	0.338	0.264	0.332	0.257	0.338	0.253
Share aged > 54	0.177	0.154	0.239	0.179	0.293	0.207
34 < share aged <55	0.491	0.204	0.491	0.194	0.448	0.200
Share aged <34	0.332	0.229	0.270	0.206	0.259	0.215
Share of executives	0.037	0.077	0.035	0.079	0.040	0.091
Share of white collars	0.345	0.292	0.374	0.295	0.364	0.295
Share of blue collars	0.618	0.313	0.591	0.313	0.596	0.319
Share of temporary workers	0.129	0.192	0.097	0.162	0.158	0.220
Share of immigrants	0.059	0.119	0.054	0.114	0.062	0.123
Hiring (0/1)	0.599	0.490	0.566	0.496	0.693	0.461
			Firms' characteristics			
Foreign trade (0/1)	0.322	0.467	0.383	0.486	0.356	0.479
Multinational (0/1)	0.024	0.152	0.022	0.146	0.029	0.167
Training from own funds (0/1)	0.320	0.467	0.373	0.484	0.448	0.497
Start up (0/1)	0.145	0.353	0.095	0.293	0.035	0.184
Log of sales per empl. (€)	11.676	1.226	11.810	1.229	11.793	1.246
Log of no. of employees	2.974	0.739	3.022	0.804	3.065	0.813
North-West	0.325	0.468	0.403	0.491	0.365	0.481
North-East	0.279	0.449	0.286	0.452	0.293	0.455
Center	0.208	0.406	0.168	0.374	0.173	0.379
South	0.188	0.391	0.143	0.350	0.168	0.374
Number of observations	4,077		6,509		6,047	

Source: own computations on RIL data. Notes: sampling weights applied. Statistics by 2-digit NACE sector are available upon request.

After excluding also firms with missing information for our key variables, we obtain an unbalanced panel with more than 5,000 firms appearing at least twice over the triple 2010-2015-2018.[14]

Table 1 reports some descriptive statistics. For the sake of conciseness, we focus here on our variables of interest, and some main firms' characteristics. Both product and process innovation show a rather remarkable downward trend between 2010 (over 40% of firms reporting they underwent some innovation) and 2015 (38.7% and 35.5% respectively) – not surprising during an economic downturn – while afterwards they both appear stabler. In 2010 18% of firms report hosting a union representation body, either an RSA or RSU; this share looks stable in 2015 and grows to more than 21% in 2018. Over the observed period, the average firm employs twenty workers and produces a per-employee value of sales of around 120,000€. The share of blue-collar workers is decreasing over time and around 60%, while that of white collars slightly grows to more than 36%. Females represent more than 33% of the employed workforce, while immigrants are 6%. The share of temporary workers first falls from 13% to 10%, then grows again to almost 16%. The large majority of firms is located in the North of the country.

4.2. The econometric analysis

The extremely wide set of information available in the RIL-AIDA data downplays the possibility that the presence of unobserved heterogeneity plays a crucial role. We begin with the estimation of a simple pooled OLS model of the following type:

$$Y_{it} = \beta U_{it} + \alpha M_{it} + \delta F_{it} + \gamma X_{it} + t + \sigma \mathrm{s} + \lambda \mathrm{r} + \varepsilon_{it} \tag{27}$$

- where i and $t = \{2010, 2015, 2018\}$ are the indexes for firms and years respectively, Y_{it} is a dummy for product or process innovation, U_{it} is a dummy taking the value of one if firm i in wave t is recorded as having a formal union representation (RSA or RSU) at the workplace level. Vectors $M_{i,t}$, $F_{i,t}$ and $X_{i,t}$ formalize controls for corporate governance and management characteristics, workforce composition and firm productive specialization, respectively (see Table 1 and Table A.1 in the Appendix). All these covariates should minimize the main concerns about spurious correlation bias, for instance because higher profits allow, on the one hand, to

[14] Our RIL unbalanced sample maximizes the number of observations and hence increases the external validity of our results. However similar evidence is found when the analysis is performed on the balanced panel – available upon request.

invest more in innovation and, on the other, may stimulate the formation of workers' representative bodies attracted by rent sharing (see Berton et al., 2017, for a review). Furthermore, t is a time dummy indicator, σs captures sector specific effects, while λr formalizes regional (NUTS1 level) effects. Finally, $\varepsilon_{i,t}$ is the error term capturing the idiosyncratic component of the dependent variable.

Of course, we cannot rule out endogeneity concerns completely. For this reason, we take advantage of the panel structure of the RIL data to estimate a fixed-effect model of the following type:

$$Y_{it} = \beta U_{it} + \alpha M_{it} + \delta F_{it} + \gamma X_{it} + t + \sigma \mathrm{s} + \lambda \mathrm{r} + \mu_i + \theta_{it} \quad (28)$$

where μ_i controls also for time-invariant firm-specific observed and unobserved components. The main limitation of the strategy under (28) is that identification of our parameter of interest – namely β – relies on within-firm variability only which, when it comes to the presence of a union representation – appears rather limited (see Table 1). In addition, we still cannot prevent that reverse causality issues are driving our results, for instance because the introduction of innovative processes or products may require organizational changes that in turn stimulate workers to organize themselves into unions at the local level. This potential is in our data increased by the retrospective nature of questions in the RIL questionnaire, where respondents are often interviewed about the last years, and information about innovation is in this perspective no exception (see data description above). We therefore follow Devicienti et al. (2017) and use the lagged (2010) union incidence averaged at the two-digit sector by four classes of firm size as an instrument for current presence of union's representatives at the firm level. We hence estimate:

$$U_{it} = \theta \overline{U}_{s,2010} + \alpha M_{it} + \delta F_{it} + \gamma X_{it} + t + \sigma \mathrm{s} + \lambda \mathrm{r} + \epsilon_{it} \quad (29)$$

where s stands for NACE two-digit sectors and $\overline{U}_{s,2010}$ is the average incidence of the presence of union's representatives at the workplace level in 2010 and $t = \{2015, 2018\}$. As standard in two-stage least squares procedure, the predicted values of U_{it} from equation (29) – call them $\widehat{U}_{it}$ – replace U_{it} in equation (27). Through lags and sector- and size-class level averages, we grant (higher) exogeneity of the presence of union's representatives to the individual firm's specific dynamics, and hence also to workplace innovative investments. The price to pay is a shorter panel length, as the first year of the series is used to build our instrument.

4.3 Estimate results

Table 2 reports our main results. The left panel shows those on product innovation, the right one those on process innovation. Estimates from model (27) are in first columns, from model (28) in second columns, from model (29) in third ones. All the models are linear, hence coefficients must be read as the variation in the probability to undergo a product or process innovation at the establishment level as a consequence of having established a formal workers' representative body. Standard errors are clustered at the firm level. For the sake of simplicity, we only report the parameters of interest.[15]

Table 2: main results

	Product innovation			**Process innovation**		
	Pooled OLS	*FE*	*IV-2SLS*	*Pooled OLS*	*FE*	*IV-2SLS*
$\hat{\beta}$	0.015*	0.035**	0.228**	0.019**	0.017	0.010
	(0.009)	(0.017)	(0.102)	(0.009)	(0.017)	(0.095)
# obs.	19,988	19,988	15,523	19,988	19,988	15,523
R^2	0.161	0.025	0.117	0.171	0.022	0.170
First-stage F	-	-	115.1	-	-	115.1
$\hat{\theta}$	-	-	0.031***	-	-	0.031***

Source: own computations on RIL data. Notes: clustered standard errors in second lines; ***: 1% significant; **: 5% significant; *: 10% significant.

Let us first focus on product innovation. According to pooled OLS estimates, the presence of a voice mechanism, as captured by formal workers' representative bodies, increases the establishment's propensity to innovate their products by 1.5 percentage points. By further controlling for other unobserved establishment-specific time-invariant determinants of innovation, the estimated effect grows to 3.5 percentage points. Eventually, IV estimates, that also remove potential reverse-causality biases, suggest a much larger impact of 23 percentage points, i.e. around a half of the average propensity to invest in new products (Table 1). A very sizeable effect indeed. All results are statistically significant at conventional levels, and the estimated $\hat{\theta}$ and the first-stage F-statistics are reassuring of the relevance of our instrument.

Two comments are in order. First, consistently with our theoretical model, the presence of a voice mechanism raises the firm's propensity to innovate in products; neglecting for the moment on the magnitude of the effect, it is reassuring to find that this result is robust to different estimation strategies, and hence identification hypotheses. Second, one may argue that the very sizeable effect we find with IV is suspect. We can explain this "jump" with three

[15] Full parameter estimates remain available upon request to the authors.

arguments: (i) pooled OLS and FE may actually suffer from a negative reverse causality bias, as workers employed in firms with a high propensity to product (typically labor-augmenting) innovations are less keen to establish formal representation bodies. (ii) Our instrument – i.e. the lagged presence of voice mechanisms at the local and sectoral level – may partially capture the independent effect on product innovation of being in a well-established context of industrial relations; if, on the one hand, this formally represents a violation of the exclusion restriction, on the other – and from a more economic point of view – it still suggests that one of the messages from our model holds true: within a context of coordinated wage bargaining, a well-functioning voice mechanism enhances – rather than hindering – the positive effect of unions on product innovation. (iii) Since Italy, as anticipated above, is usually represented as a country where unions are powerful institutions, a sizeable effect on product innovation is exactly what the model predicts. If this is actually the case, the effect on process innovation should be instead much weaker. The right panel of Table 2 suggests exactly so. According to pooled OLS estimates, the presence of workers' representation body increases also process innovation, namely by 1.9 percentage points. However, this result does not survive to more robust approaches, as both fixed-effects and two-stages least squares suggest that the effect is statistically negligible. This is again consistent with what our theoretical model predicts where unions play a crucial role.

Table 3: results by firm size

	Product innovation			**Process innovation**		
	Pooled OLS	*FE*	*IV-2SLS*	*Pooled OLS*	*FE*	*IV-2SLS*
			Less than 250 workers			
$\hat{\beta}$	0.016*	0.034**	0.236**	0.017*	0.010	-0.025
	(0.009)	(0.017)	(0.105)	(0.009)	(0.017)	(0.096)
# obs.	18,420	18,420	14,255	18,420	18,420	14,255
R^2	0.143	0.024	0.094	0.152	0.024	0.146
First-stage F	-	-	103.6	-	-	103.6
$\hat{\theta}$	-	-	0.352***	-	-	0.352***
			250 workers or more			
$\hat{\beta}$	0.022	0.052	-0.561	0.064*	0.147*	0.289
	(0.037)	(0.087)	(0.576)	(0.037)	(0.081)	(0.582)
# obs.	1,568	1,568	1,268	1,568	1,568	1,268
R^2	0.278	0.082	0.126	0.288	0.076	0.268
First-stage F	-	-	6.5	-	-	6.5
$\hat{\theta}$	-	-	0.160**	-	-	0.160**

Source: own computations on RIL data. Notes: clustered standard errors in second lines; ***: 1% significant; **: 5% significant; *: 10% significant.

To further dig into the causal mechanism put forward by our model, we deem useful to admit that the actual voice capacity of a workers' representation body might not be constant across firms' characteristics and might vary with them. In this perspective, a prominent candidate to affect voice capacity is firm size (O'Toole and Lawler, 2006). In Table 3 we replicate our analysis after splitting the sample in SMEs (sized less than 250: upper panel) and large firms (250 or more: lower panel). Results for SMEs almost perfectly mirror those reported in Table 2 on the aggregate sample. The picture changes rather dramatically, however, when large firms are considered. The positive effect on product innovation disappears, while that on process innovation emerges in pooled OLS and fixed-effects, but not when we use an IV approach where, also due to smaller sample size, the first-stage F-statistics does not pass the critical value of 10 suggested by Staiger and Stock (1997) to avoid the weak instrument bias. Assuming our theoretical model is a good representation of the relationship between unions and innovation, the results in the lower panel of Table 3 suggest that workers' representative bodies have a low-to-moderate voice capacity in large firms. This is consistent with O'Toole and Lawler (2006). A possible explanation is that when firm size is beyond a certain threshold, workers may feel that the distance to the firm's governing body is too wide, and their chance to speak up – even in the presence of a formal union representation – too low, with a negative feedback in terms of productivity (Machin, 1991). We are now in a position to draw some concluding remarks.

5. Conclusions

In this article, we study the relationship between unions and innovation, from both a theoretical and an empirical point of view. From the theoretical standpoint, we propose a model capable of providing a rationale for the possibly ambiguous effect – confirmed by the international empirical literature – of unions on innovation. The intuition is that the traditional rent sharing/hold-up view can be more than compensated by the cooperative state of industrial relations and by the incentive to commit that unions may provide to the workers through their voice capacity. More specifically, our model predicts that a cooperative wage bargaining system – i.e. one in which a single union maximizes the industry wage bill by adjusting firm-level wages to the firm's relative competitiveness – is more inducive of product innovations than a system in which wages are set at their competitive level, the larger is the voice capacity of workers' representative bodies. The same effect on process innovation appears instead inverse U-shaped, with intermediate levels of voice capacity that maximize the probability of cooperative wage bargaining systems to outperform the pure market.

To test the model's main predictions, we use a large representative sample of Italian firms and take advantage of the existence of establishment-level workers' representative bodies to capture the variability of workers' voice capacity across firms and over time. Consistently with the theory, we find that the presence of a workers' representation within the firm enhances the propensity to innovate the products by up to 23 percentage points when we use an IV approach. This suggests that workers' voice instruments are on average very effective, what in turn – as suggested by the theory – depresses the propensity to process innovation. Heterogeneity analysis suggests that – beyond formal representation – the actual voice power of workers varies across firms, and that tends to vanish beyond a certain firm size.

Our analysis has strong policy implications. Deregulation has been a hallmark of labor market policies since the early nineties, thereby including industrial relations (IMF, 1999; OECD, 1994). The general advice was that collective bargaining should be moved from the national/sectoral level to the local/firm one, to better match productivity. In other words, industrial relations should mimic the market more closely. With this article, we suggest that this is not necessarily beneficial to innovation. Indeed, we show that a system where bargaining occurs at the sectoral level and an intermediate voice capacity of unions is preserved outperforms the market with respect to both product and process innovation. Local or firm agreements should therefore combine rather than substitute a more overarching bargaining system.

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Appendix A: definition of variables

Table A1: Definition of variables

Variables	Description
	Innovation and industrial relations
Product innovation	Dummy variable that equals to 1 if the firm has invested in product innovation in the current year and/or during the past two years before the survey, 0 otherwise
Process innovation	Dummy variable that equals to 1 if the firm has invested in process innovation in the current year and/or during the past two years before the survey, 0 otherwise
Union	Dummy variable that equals to 1 if a trade union association (both RSA or RSU employees rapresentation) are found at workplace, 0 otherwise
Strike density	Share of total hours striked on the total number of firms' employees
	Management and corporate governance
Education	Three dummy variables that equals to 1 whether the educational level of the employers/managers who run the firm is, respectively: i) tertiary; ii) upper secondary iii) lower secondary or no education (0 otherwise)
Age	Three dummy variables that equals to 1 whether the age coorth to which the employer/managers who run the firm belong to is respectively: i) <35 years ii) 34< years<55 iii) >54 years
Female	Dummy variable that equals to 1 if the manager/employer who run the firm is female, 0 otherwise
Family ownership	Dummy variable that equals to 1 if the ownership of the firm is held by a family, 0 otherwise
external managment	Dummy variable that equals to 1 if firm is run by an external manager which has beed recruited on the labor market, i.e outside dynastic ties with firms ownership, 0 otherwise
	Workforce characteristics
Educational composition	Three variables indicating the share of employees (on the firms' total number of employees) with: i- tertiary education; ii- upper secondary education; iii- lower secondary, primary or no education
Age composition	Three variables indicating the share of employees (on the firms' total number of employees) with: i- less than 35 years old; ii- between 34 and 50 years old; iii- more than 49 years old
Professional composition	Three variables indicating the share of employees (on the firms' total number of employees) who are : i- executives; ii- white collars; iii- blue collars
Share of temporary workers	Share of employees with fixed tem contract (on the firms total number of employees)
Share of female workers	Share of female employees (on the firms' total number of employees)
Share of immigrants	Share of immigrant employee on the firms total number of employees)
	Firms' characteristics
Log of sales per employee	(log of) the sales on the total number of employees. The amount of the sales is deflated relying on sectoral (2-digit NACE) deflators of production prices.
Log of size	(log of) total number of employees. Alternatively we use four dummy variables

Privately funded training	Dummy variable that equals to 1 if firms financed workplace training with their own funds, 0 otherwise (i.e public financed training)
Foreign trade	Dummy variable that equals to 1 if firm operates (selling or buying products or services) on international trade markets, 0 otherwise
Multinational	Dummy variable that equals to 1 if firm is a multinational, 0 otherwise
Start-up	Dummy variable that equals to 1 if firm has less than 10 years since its entry on the market, 0 otherwise
Geographical localization	20 dummies variables indicating Italian Nuts 2 regions
Sector of activity	45 dummies variables indicating the 2-digit NACE sectors: Electricity, Gas water distribution, Food, textile, tobacco; chemistry, metallurgy mechanics and other manufacturing goods; Construction; retail and wholesale, tourism, hotels and restaurants transportation; insurance and financial intermediation, information and communication; other business services; healthcare, educational and social services, others.

Source: RIL data