Technical efficiency, unions and decentralized labor contracts. New Empirical Evidence

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Abstract

This paper explores the link between the presence of unions in the workplace, the adoption of decentralized labor agreements and technical efficiency, using a relatively new methodology and a large sample of Italian manufacturing firms. We apply the Data Envelopment Analysis, and its robust version based on bootstrap theory, to get reliable estimates of technical efficiency at the firm level in a standard first stage. We devote particular attention to the specific technology adopted, by distinguishing 20 different sector frontiers, as well as to the presence of outliers. The obtained efficiency scores are analyzed in a second stage applying a truncated regression model estimated via Maximum Likelihood, following the Simar and Wilson (2007) methodology. Our results highlight that the presence of workplace unionization decreases the level of technical efficiency, while other aspects limiting unions' power such as a strong exposure to international markets, high debt levels or the prevalence of flexible assets partially reduce the union negative effect. However, when firms adopt decentralized labor contracts agreements, the effect on efficiency is positive and partially compensates the unions' effect. The results are robust to the inclusion of many firm characteristics over which managers have no direct control and to different model specifications.

Keywords: Technical Efficiency, Unions, Decentralized bargaining, Truncated regression model.

1. Introduction

The ongoing debate on the Italian productivity crisis, in particular for the manufacturing industry, has been recently revived by a deep discussion on the alleged beneficial

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consequences of labor market reforms and the role of unions. In particular, the effect of unions on firm's productivity is one of the current hottest topic in Italy, with an increasing attention devoted by media, fostered by the delicate discussion, at institutional level, on the future role of unions. If, on the one hand, the business community, members of the government and policy commentators often include unions among the factors behind the Italian productivity crisis, employees and trade unionists, on the other hand, highlight their fundamental role to protect workers' rights and to promote cooperation and communication.

The debate on these aspects is not new, but the numerous contributions still fail to reach an empirical consensus on the real effects of unions on firm productivity, in line with the theory that identifies the so called *two faces* of unionism (Freeman and Medoff, 1984): the monopoly face and the collective voice/institutional response face (CV/IR). The monopoly face synthesizes the different adverse effects for the firms, based or not on wage aspects. On the one hand, unions can engage in rent-seeking activities, raising labor costs and reducing firms' profitability. As discussed in the hold-up literature, unions' opportunistic behavior may translate into a tax on a firm's capital investment and be detrimental to its innovation activities (see Card *et al.*, 2014, and Cardullo *et al.*, 2015, for recent contributions on the hold-up problem in OECD countries). On the other hand, the unions can take different actions that limit workplace flexibility, encourage restrictive work rules or weaken employees' efforts (Kaufman, 2004). As a consequence, firms appear less flexible and adaptable to environmental shocks, and this impacts negatively on productivity. For instance, the presence of unions may limit a store's *opening hours* and reduce its competitive advantage with respect to non-unionized stores, which are therefore better able to adapt to new market trends. On the contrary, the CV/IR face highlights how the presence of unions increases the communication channels between the workforce and the management, reinforcing the *voice* option for employees[1]. The outcome is a reduction of dissatisfaction at the workplace, absenteeism and turnover, with a general positive effect on productivity. In particular, containing *excess*

[1]The exit-voice dichotomy has been introduced by Hirschman (1970) and represents two sides of social interactions: the voice option suggests how it is possible to discuss and to contribute to a better environment, while the exit option represents a more radical choice of not discussing and exiting the relationship.

worker turnover reduces human capital dispersion and training costs, and avoids the costly expression of the *exit* option by the employees (Ton and Huckman, 2008).

If unions can be considered as promoters and main actors of the voice option, the adoption of decentralized labor contract agreements (DLCAs), which integrate or derogate the national and industry-wide collective agreements, may represent the effective means of voice and imply a smoother conflict among employees and entrepreneurs. A general tendency towards the decentralization of labor contract bargaining has been recently suggested by the European Council[2], for its potential positive effect on productivity. The latter should stem from a better mix of wage settlements and more flexible terms in the organization of labor, which should be able to increase the satisfaction of employees, their effort and firm attachment, reduce turnover, as well as improve firm's adaptability to changing market conditions.

Although there is a widespread interest on the potential effects of increasing decentralized bargaining, the recent scientific literature remains mainly focused on the influence of Performance Related Pay (PRP) schemes, one of the main components of firm local agreements, and investigates in particular their effect on productivity at the individual level (Bandiera *et al.*, 2005). However, the flexibility of wages, still limited in magnitude, is manly accepted and adopted in a collective form, with a modest expected effect on productivity (e.g., Lucifora and Origo, 2015; Gielen *et al.* 2010). In the Italian context, the majority of firms adopting a decentralized contract also introduce a PRP scheme, typically on a collective basis, with a potentially limited effect on the employees' efforts. However, DLCAs can also sustain productivity through other channels not directly linked to wages, like additional flexibility in working hours and labor organization, and other clauses that increase trust and cooperation among employees and managers. The recent case of FIAT (now FCA) that decided to exit Confindustria (the main association representing manufacturing and service companies) and consequently to leave behind the National Labor Contract Agreements (NCLA) in order to apply more flexible (and mainly not wage-based) terms, represents a valid example of the

[2]See for example the recent Country-specific recommendations 2015 (Council recommendation, 14 July 2015; 2015/C 272/16).

issue. Moreover, DLCAs are the direct instrument through which unions make the voice option effective: they contribute to create a better working environment, to increase the employees' commitment with the firm and to favor a cooperative approach with the firms' managers. On top of these aspects, a DLCA can also be considered as an instrument to limit the monopoly face of unions and its opportunistic behavior, in that it formally specifies wage and non-wage claims through a written contract over a relatively long period of time (usually 3 years, and sometimes more). When the firm and the unions jointly discuss and bargain over wages and numerous other aspects of the employment relation or the organization of labor - as is often the case for the DLCAs observed in practice - inefficiencies are more likely to be avoided, compared to the outcomes obtained under a traditional monopoly union setting (e.g., Bennett and Kaufman, 2007). In this respect, the presence of a decentralized contract has a double face: on the one hand, it signals that the voice option has been formally expressed, reducing conflicts and increasing cooperation between the counterparts; on the other hand, it commits the union to a predetermined set of contractual terms (e.g., profit-sharing rules), thereby reducing uncertainty and the union's ex-post opportunistic behavior.

In this paper, we propose to revisit a traditional labor and industrial economics issue using efficiency analysis, a methodology relatively new in these fields. In particular, we compute firms' inefficiency using a Data Envelopment Analysis (DEA) framework, which measures the capacity of obtaining output for any given input bundle with respect to the reference frontier. The bulk of previous literature, better analyzed in the next section, is mainly focused on labor productivity and estimates the effect of unions or performance related pay on measures such as value added per employee or revenues per employees[3]. If the impact of unionization and industrial relations can be straightforward on output obtained per unit of labor, their relationship with the technical efficiency level, which considers a complete input bundle, is more interesting. In fact, efficiency score are computed more coherently with the technology, assuming a production function characterized by many inputs combined to

[3]Papers focusing on standard total factor productivity (TFP) represent an exception, too. See Morikawa (2010) for a recent example.

obtain outputs. The main advantage of the DEA approach is that the shape of this function, which is unknown, is not imposed, but is derived by the observed input and output bundles through linear programming techniques.

Using a large sample of Italian manufacturing firms observed over the years 2010-2012, we study the impact of both unions and decentralized labor agreements on technical efficiency. From a methodological point of view, we use a semi-parametric approach, which minimizes misspecification issues in the technology definition and compensates the limits of purely deterministic models (see Daraio and Simar, 2007 for a thorough reference). Our results show a clear negative effect of workplace unionization on technical efficiency that remains stable across all estimates; however, such a negative impact is roughly counterbalanced by a positive effect related to the presence of decentralized labor contracts. The obtained results are robust to the introduction of additional controls, as well as to the adoption of a propensity score based method, which is aimed at reducing endogeneity concerns between technical efficiency and unions or decentralized contracts. This paper represents one of the first attempts to combine DEA, truncated regression and propensity score based methods. We also show that the corporate strategies pursued by managers to limit the unions' bargaining power substantially affect the overall negative effect on efficiency. In fact, for firms characterized by higher exposure to international markets, higher debt and more flexible assets (all factors limiting the unions' power) the impact of unions is, on average, 40% lower.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature on the role of unions and decentralized bargaining. Section 3 describes the DEA model, the bias correction procedure and the second stage analysis. Section 4 presents the database and section 5 illustrates our main results. Some general considerations and policy implications conclude our work.

2. Literature review and background

The literature on the effect of unions on productivity, vast and mainly dated, identifies two theoretical mechanisms, one leading to an increase of productivity and the other to a productivity drop (Metcalf, 2003). On the one hand, unions can promote cooperation,

monitoring and information sharing between the employees and the management, all factors acting as a stimulus for increasing effort and motivation and contributing to a better workplace environment. On the other hand, they can lead to restrictive work practices, adverse industrial relations, conflicts and rent seeking, factors that contribute to deteriorate trust and cooperation between the employees and the managers, and to reduce investment (hold-up problem) and productivity levels. Despite the wide empirical literature on the relationship between unions and firms' economic performance, a general consensus on the negative impact of unions has been partially reached only as far as profits are concerned[4], while the effect of unions on productivity remains substantially uncertain. Many surveys on this topic (see, for example, Doucouliagos and Laroche, 2003; Kuhn, 1998; Wilson, 1995; Addison and Hirsch, 1989), which mainly collect evidence from the US, fail in finding a common direction on the effect of unions on productivity. The results of the estimates are generally not stable and strongly influenced by the specificity of the sample, by the industrial sectors considered and by the definition of productivity used.[5]

In continental Europe, the recent literature mainly analyzes the effect of work councils, workplace representative bodies characterized by co-determination and bargaining power at the plant level, rather than the generic effect of unionism. Analyzing German firms, Schedlitzki (2002) finds that work councils have a positive, albeit poorly significant, effect on labor productivity. Positive effects are also reported by Muller (2012 and 2015) and Hübler and Jirjahn (2003), who noticed that the impact is more pronounced in German firms not covered by sectoral collective agreements. Instead, Fairris and Askenazy (2010), using a sample of French firms, find a negligible impact on labor productivity from the presence of work councils.

Results are mixed also for the rare works that focus on technical efficiency, rather than labor productivity. Schank *et al.* (2004) estimate technical efficiency via stochastic frontier

[4]See, for some recent reviews, Doucouliagos and Laroche, 2009 and Bennet and Kaufman, 2007.

[5]Contradicting results are also reported in the non-US based literature. For example, Morikawa (2010) analyzes a panel of Japanese firms, finding a 18% labor productivity premium and a 13% TFP premium for unionized firms. Instead, Pencavel (2002) finds that for the UK after the 90' the impact of unions on productivity is negligible.

analysis for a sample of German firms operating in 1993-1996, finding no significant difference between the median efficiency of firms having a work council and their counterparts without it. Chintrakarn and Chen (2010) estimate a parametric production frontier too, but at the aggregate level, using information on manufacturing sectors in US states. They find mixed results for the presence of unions, in that they are shown to increase efficiency, but to reduce technical progress. The most relevant paper in the field of non-parametric technical efficiency analysis is Greer (2009), who focuses on the air transportation sector. After estimating efficiency via DEA, he runs a Tobit regression to analyze the determinants of technical efficiency. While his findings suggest that union density does not affect technical efficiency, the use of a very specific data-set on US airlines, as well as new methodological developments, leave space for further investigations. Doucouliagos and Laroche (2006) propose another application of DEA in the labor field, investigating the effect of human resource practices on technical efficiency in a sample of French firms. Among other control variables, they include a union dummy in a Tobit regression model aimed at explaining efficiency scores, and find a strong negative effect for unionized firms, which appear to be approximately 13% less efficient than non-unionized ones.

The effect of decentralized bargaining on productivity and other economic outcomes has been treated only marginally in the literature, with the exception of the German experience of *pacts*, plant-level agreements characterized by concessions from both bargaining partners, employees and firms, that integrate or partially derogate the collective sectoral agreements. The number of contributions is increasing, but the interest is limited to investigating whether firms adopting the pacts differ in terms of labor productivity and investments in physical capital. Bellmann *et al.* (2015) find an insignificant effect of pacts on investments using firm level data in the period 2001-2010. On the contrary, Addison *et al.* (2015) find a consistent and robust effect (+20%) on labor productivity for firms adopting pacts, using a wide sample of German firms operating in 19 sectors, in the period 2006-2009.

Regarding the empirical evidence from Italy, the most recent and relevant works focus on Flexible Pay Systems (FPS) such as Performance Related Pay (PRP), often foreseen by

decentralized bargaining in order to gain wage flexibility[6]. Origo (2009), analyzing a panel of firms operating in the metalworking sector in the years 1989-1997, finds a positive effect of FPS on labor productivity (7-11%) using diff-in-diff estimators to account for endogenity issues, which seems to be larger for highly unionized firms. Antonietti *et al.* (2014) investigate the adoption of FPS, and find a positive effect on labor productivity, during the years 2009-2011. The authors use a sample of firms located in an Italian region (Emilia Romagna) and control for endogeneity through a two-stage procedure[7]. Damiani *et al.* (2014) analyze the direct link between PRP and labor productivity by applying a quantile regression (and its IV extension) on the RIL-AIDA panel of manufacturing firms in the period 2005-2007-2010, finding a positive effect on labor productivity (9.5%) that is substantially uniform and significant across all the quantiles.[8] Lucifora and Origo (2015), working on a sample of 3000 Italian firms operating in the metal engineering sector during the period 1989-1999, find a positive, but rather limited effect (3-5%) of PRP on labor productivity.

Our paper complements this existing research in two main respects. First, we focus more generally on technical efficiency, rather than on labor productivity. Second, we aim at explicitly separating the productivity impact of workplace unionization *per se*, from the effect of having formally signed a decentralized labor contract agreements.

2.1. Unions and decentralized contracts in Italy

Italy is characterized by a two-tier bargaining system, with a dominant sectoral tier and a supplementary decentralized tier where bargaining is usually carried out at the company/local level.[9] The main objectives of the sectoral agreements (National Collective Labor Agreements, NCLAs) are to protect real wages and to set common economic and normative conditions for sectoral workers nationwide. At the decentralized level, it is possible

[6]In this case, PRP schemes are mainly introduced in collective form, in general linking wages to plant or team performance.

[7]The Probit model in the first stage estimates the probability of being an adopter of FPS, while an OLS regression in the second stage estimates its effect on labor productivity.

[8]Damiani and Ricci (2014) analyze the RIL-AIDA panel of Italian firms operating in manufacturing and service industries in 2005-2007, and find a positive association between unions' presence and the probability of adopting decentralized contracts or PRP schemes.

[9]A territorial level (mostly at the province level) also exists, but is typically confined to particular industries, e.g., construction and agriculture.

to negotiate performance and productivity-related wage increases. In addition, the second level bargaining may address a number of additional matters, such as working hours, tasks, employment training, labor organization and union relations, in order to gain flexibility for organizational changes and competitiveness (Devicienti *et al.* 2015).[10] Application to all workers in the firm of the conditions arrived at through bargaining at the decentralized level is the standard practice. Second-level bargaining is subject to the limits and provisions defined by the specific NCLAs applied in the productive unit.[11]

Italian law gives the workers the right to join a union, engage in union activity and organize a plant-level union representation structure. The main workplace representation body is the so-called unitary workplace union structures (*Rappresentanze Sindacali Unitarie*, RSU). The RSU includes features of works councils (e.g., worker representatives are elected by all the employees) but can also be associated with trade union bodies (e.g., worker representatives are usually elected from competing candidates on trade unions lists). Hence, in Italy, union and employee representation are entrusted to a single body (single-channel representation), as opposed to a dual-channel system, where union delegates operate alongside works councils.[12] Italian labor law makes it clear that setting up such representation bodies is at the initiative of a firm's employees, typically with moderate set-up costs and with an operational support that the territorial structures of the union confederations are always able and willing to provide. Worker representatives are able to negotiate at the plant level on issues delegated from the industry-wide level, and have the right to be informed and consulted. Unions and workers' representatives may be directly involved in the shaping of

[10]There are no official data on the diffusion and content of decentralized bargaining. Survey data suggest that the coverage is at around 60 percent of employees and from 15 to 25 percent of firms (Damiani and Ricci, 2014), with greater incidence in manufacturing and larger firms. A large fraction of second-level agreements (over 60 percent) contain wage increases related to productivity gains, but agreements dealing with workplace organizational changes, performance-based human resource management practices and employment flexibility are not uncommon, and broadly cover the remaining 40 percent of cases.

[11]Decentralized agreements are only supplementary to, and applicative of, the NCLAs. The possibility of opting-out or derogating from NCLAs was formally introduced only recently, beyond the sample period we analyze.

[12]There is also an alternative plant-level union body (*Rappresentanza Sindacale aziendale*, RSA) elected by the members of a particular union. RSUs have tended to replace RSAs, which are usually found in smaller companies and in certain sectors like banking.

the firm's labor organization and hiring policies through participation at firm-level specific agreements on issues not already covered by NCLAs. Union influence may also be exerted through more informal consultation and involvement practices. This channel is likely to be relevant at the productive-unit level, where workers representatives interact with middle level managers (especially for small-medium size firms).

3. Methodology

3.1. Technical efficiency & bias correction

In the present paper, we adopt a semi parametric approach using Data Envelopment Analysis, and its bias corrected version, to compute efficiency scores for a large sample of Italian firms operating in the manufacturing sector. The main advantage of using DEA is that it is not required to specify a form for the technology representing the production process, so that no assumptions are made for the shape of the production frontier. Moreover, DEA allows to compute a simple inefficiency measure also for a technology involving multiple outputs and multiple inputs: the frontier is directly derived from the data and all firms in the sample are evaluated through input or output distance functions[13]. We use an output-oriented approach that maximizes output levels given the present input bundle, because it is more suited for the second stage analysis. Let $x = (x_1, ..., x_N) \in R^N_+$ be inputs and $y = (y_1, ..., y_M) \in R^M_+$ be outputs, and suppose they are both freely disposable. Assuming that the output set $P(x) = \{(y, x) : x \quad \text{can produce} \quad y\}$ is closed and convex, the standard and general DEA efficiency score can be defined as:

$$\lambda_{DEA}(x_0, y_0) = sup\{\lambda \quad | \quad \lambda y_0 \in P(x_0)\}$$

Empirically, it can be estimated via linear programming through $\hat{\lambda}_{DEA}(x_0, y_0)$, by solving K linear programs, one for each firm in the sample. Following the Variable Return to Scale

[13]For a detailed treatment of DEA, see Cooper *et al.*, (2007).

model proposed by Banker *et al.*, (1984):

$$\begin{aligned} \hat{\lambda}_{DEA}(x_0, y_0) &= \max \lambda \\ \text{s. t.} \qquad x_0 &\geq \sum_{k=1}^{K} z_k X_k, \\ \lambda y_0 &\leq \sum_{k=1}^{K} z_k Y_k; \\ z_k &\geq 0; \\ \sum_{k=1}^{K} z_k &= 1, \end{aligned} \tag{1}$$

where k indicates decision making units (DMUs) and X and Y are matrices of inputs and outputs. One of the main disadvantages of this deterministic approach is the absence of a stochastic error component. In fact, $\hat{\lambda}_{DEA}$ are biased by construction and overestimate the true technical efficiency level. Following Simar and Wilson (1998), the BIAS can be defined as:

$$BIAS(\hat{\lambda}_{DEA}(x_0, y_0)) = E(\hat{\lambda}_{DEA}(x_0, y_0)) - \lambda_{DEA}(x_0, y_0) \tag{2}$$

where $\lambda_{DEA}(x_0, y_0)$ represents the true unknown technical efficiency score. An estimate of the BIAS can be obtained using the homogeneous bootstrap method proposed by Simar and Wilson (1998), which assumes that the true production set boundaries lie to the left and above the piecewise linear frontier. The bias corrected DEA scores can therefore be derived as follows:

$$\hat{\hat{\lambda}}_{DEA}(x_0, y_0) = \hat{\lambda}_{DEA}(x_0, y_0) - \hat{BIAS}_B(\hat{\lambda}_{DEA}(x_0, y_0)) \tag{3}$$

The corrected efficiency scores in the output-oriented format are bounded below by 1, a value that cannot be reached due to the correction procedure. Therefore, values near to 1 represent the most efficient firms in the sample, in terms of combining inputs in order to obtain output.

3.2. Truncated regression model and empirical strategy

Explaining efficiency scores trough a classical regression model can be problematic for the unclear nature and the complex data generating process behind such scores. In their

seminal paper, Simar and Wilson (2007) underline a complicated correlation structure for the residuals, and show the bias of the estimates performed using OLS or Tobit models, suggesting an estimation model that takes into account the truncated nature of the DEA scores. In particular, they recommend using a truncated regression model, to be estimated via Maximum Likelihood. In this paper, we use exactly that methodology, so that the empirical specification of the truncated regression is as follows:

$$\hat{\hat{\lambda}}_{DEA}(x_0, y_0) = \gamma w_k + \varepsilon_k \geq 1, \quad k = 1, ...K \tag{4}$$

where w_k represents a set of explanatory variables, and $\hat{\hat{\lambda}}_{DEA}(x_0, y_0)$ is the vector of estimated efficiency scores specific for each year. **The application of Algoritm #2 by Simar and Wilson (2007), to which we refer for any further details, can be resumed in a step by step procedure based on bootstrap and aimed at obtaining more robust and reliable confidence intervals for the estimated coefficients.** Applications of such method on large samples are still scarce. Zelenyuk and Zheka (2006) apply it to a sample of 160 heterogeneous firms operating in different sectors, with the main aim of investigating, in the second stage, the influence of ownership and size on firm technical efficiency. Benito *et al.* (2014) use the truncated regression model to explain inefficiency of a large sample of Spanish municipal firms, while Falavigna and Ippoliti (2012) use it to analyze the efficiency of Italian hospitals over time. Biener *et al.* (2016) investigate the determinants of efficiency in the Swiss insurance sector including many firm's characteristics as covariates, focusing on leverage and international diversification. However, the most recent developments in the field, see for example Simar and Wilson (2011) or Bâdin *et al.* (2012), highlight that the application of the truncated regression is valid only if the separability condition between the input-output space, used in the DEA phase, and the space of environmental variables w (i.e. external factors w that do not influence the shape of the frontier) holds. If the separability does not hold, the interpretation of the coefficients from the truncated regression becomes difficult, and the precision of estimates decreases as well. Since a clear empirical test on the separability condition is currently unavailable (Zschille, 2015), we include variables that, for the most part, are pretty standard in the literature of technical efficiency and for which the

separability assumption appears acceptable. Moreover, these variables can be reasonably considered external to the production process, influencing the inefficiency level but not the technical relationship between inputs and outputs.

3.3. Endogeneity issues

Concerning our two main variables of interest, the relationship of unions or DLCAs with technical efficiency may be potentially endogenous, e.g. if the best performing firms are also those in which unions or decentralized contracts are more likely to be present.

Endogeneity problems may be relevant for DLCA, because it is the firm itself that chooses to sign decentralized contracts, and that choice can be influenced by specific firms' or workforce's characteristics, which may also be related to efficiency performances. We try to solve this problem in two different ways. The first one is through the inclusion of additional control variables in the truncated regression model, to account for firm heterogeneity. The controls used are relatively standard and have already been used in previous works in the field (Bartelsman and Doms, 2000; Latruffe *et al.*, 2008; Zelenyuk and Zheka, 2006; Bruno and Manello, 2015), so that we are relatively confident on the validity of the separability condition. In particular, we include controls for the size and the structure of firms, generally aimed at capturing the effect of scale economies or vertical integration, for the characteristics of the workforce (percentage of young workers, blue-white collars), as well as geographical and sectoral dummies.

The second way is more novel in the field of efficiency analysis. We try to remove any remaining endogeneity bias of the contract status' effect on efficiency by applying the propensity score based method proposed by Card and De La Rica (2006), in turn based on the results by Imbens (2004). In particular, the method is aimed at eliminating, or at least reducing, the bias that may arise if the presence of decentralized contracts is influenced by observed and unobserved firm-specific and worker heterogeneity. The approach requires that a first-stage model for the presence of DLCA is preliminarily estimated on a rich set of observed firm's and workforce's characteristics; a polynomial in the fitted probability (i.e., the propensity score for each firm) is then inserted among the explanatory variables (which

already include the DLCA dummy) in the main regression used to explain the efficiency scores. Accordingly, we estimate the probability of adopting a decentralized contract through a Probit model, and we include the fitted probability, and its squared and cubed terms, as additional regressors in the Simar-Wilson truncated regression model. Essentially, the procedure amounts to controlling for the observed firm-level and workforce heterogeneity in a parsimonious but highly flexible way, thereby also minimizing biases from unobserved heterogeneity.[14]

Endogenity problems for workplace unionization are also relevant in principle; however, they need not be of practical concerns in our application. Indeed, the structure of firm-level representativeness in Italy seems to partially guarantee that union organizations do not systematically select the best firms. As discussed by Breda (2015), the motivation can be traced to the underlying institutional mechanisms for setting up firm-level union representation bodies. In particular, in many countries of continental Europe the presence of unions is typically based upon the initiative of single employees and their willingness to become worker representatives, without the need for large initial investments by the candidate union.[15] As a result, the probability of observing union's representation at the firm level becomes quasi-random, specially after major sources of firm heterogeneity (e.g., size, industry and firm past profitability) are already controlled for.[16] Breda (2015) argues that this is indeed the case for France. Because of the substantial similarities in the Italian and French systems of industrial relations, we believe these arguments can be used to discard concerns of large endogeneity biases in the estimated union effect. Nevertheless, in an attempt to further reducing any such biases, in some of the specifications discussed below we will also rely on the propensity score method for the workplace unionization variable.

[14]This is more likely to happen whenever the omitted unobserved heterogeneity is correlated with the included observed heterogeneity, and points to the importance of using - as we do in section 5.3 - a rich specification for the propensity score.

[15]E.g., unlike the US, a union does not have to obtain the majority of a firm's workforce in a Certification Election to gain firm-level representation and bargaining rights; it only need find a worker who is willing to act as a representative within the firm. This significantly reduces the need to incur in large monetary disbursements and other set-up costs by the candidate union.

[16]These aspects represent a deep difference with respect to other countries, where unions target most profitable and best performing firms (Brown *et al.*, 2009).

4. Data

We use a large and representative sample of Italian firms (both corporations and general partnerships) drawn from the ISFOL's Employer and Employee Survey (RIL)[17]. The survey contains detailed information on each firm's labor force, industrial relations, investment and innovation activities. For our analysis, we focus on a sample of manufacturing firms drawn from the 2010 RIL survey, which contains rich information on the use of decentralized bargaining and of specific PRP schemes. The RIL survey, however, do not include reliable balance sheet data, which had to be recovered from another data sources Since each firm is identified by a tax code, we merged the RIL-ISFOL dataset with the AIDA dataset provided by Bureau Van Dijk, which contains detailed financial and economic data for all Italian corporations[18]. Inputs and outputs used in the DEA model, both derived by direct observation from balance-sheets, can be considered as reliable and representative of the real financial/economic position of the firm, as required by the law, but are less precise than physical quantities.

For this reason, we are particularly aware of the presence of possible outliers, which can cause instability in the solution of linear programs, so that a deep cleaning of the data is required. To be more specific, we firstly separate each two-digit ATECO2007 sector, so as to compare firms with a homogeneous technology (Daraio and Simar, 2005). Secondly, we compute rough indicators of labor productivity (Value of Production/Labor Costs) and of mechanization (Physical Assets/Labor Costs). For each sub-sector, we only keep firms laying between the 1-99 percentiles. This procedure is aimed at eliminating firms with unreliable balance sheet data. Moreover, we follow the method proposed by Simar (2003), to eliminate the remaining additional outliers[19]. The final sample includes 3,450 manufacturing firms which are classified in 20 homogeneous technologies, for which DEA models are computed

[17]ISFOL stands for the Institute for the Development of Vocational Training of Workers, a national research institute that reports directly to the Ministry of Labour and Social Policy and provides support to the central government and local authorities

[18]The cost of the merging is a loss in terms of number of firms, because in Italy only limited liabilities companies (SPA or SRL) are compelled to register balance sheet data.

[19]Outliers are mainly present in two sectors: Printing (code 18) and Repairing and maintenance (code 33).

separately by using a three-inputs and one-output technology. As to the inputs, fixed capital (K) has been proxied by the total assets net of depreciation and amortizations, labor (L) has been proxied by total labor costs (to overcome problems due to the identification of the number of full time equivalent workers and to the difference in the quality of the workforce), while intermediate goods (M), have been proxied by raw material costs net of inventories changes. The latter input, uncommon in this kind of analysis, has been included because the output considered (Y) is the total value of production (revenues net of change in inventories), instead of value added. The motivation relies in the economic and financial crisis, which after 2008 had the effect of reducing value added to small (and sometimes negative) values. All financial variables have been deflated according to specific deflators provided by the national statistics institute (ISTAT). Table 1 reports descriptive statistics for the inputs and output variables.

Table 1: Descriptive statistics for inputs and output (year 2010)

	N. Firms	Inputs (10^3 euros)			Output (10^3 euros)
		Interm. goods	Labor costs	Capital	Value of production
Food	456	17,831	3,537	7,971	32,540
Beverages	71	21,293	3,668	11,201	43,886
Textiles	140	8,713	4,043	5,032	20,030
Clotings	118	11,981	3,572	3,594	28,623
Leather products	93	13,179	3,522	2,888	28,963
Wood	100	2,174	928	2,235	4,641
Paper	78	13,896	3,439	9,143	24,062
Printing	89	1,943	1,148	2,096	5,233
Chemicals and pharmaceuticals	122	67,836	12,371	24,737	115,872
Rubber products	141	18,692	5,338	7,952	32,172
Mineral products	253	5,151	2,615	7,480	13,856
Metallurgy	64	73,873	8,073	24,450	97,892
Metal products	384	3,755	1,806	2,881	8,518
Computers and elctronics	91	9,047	6,478	8,024	22,540
Electrical appliances	122	21,957	6,464	5,445	39,399
Machinery	389	13,349	4,281	3,874	25,477
Automotive and equipments	85	49,809	19,027	16,429	103,098
Furniture	350	3,975	1,496	2,557	8,321
Other manufacturing industries	190	4,727	1,245	1,276	8,443
Repair and maintenance	114	2,616	1,830	1,160	9,348
Total	3450	14,167	3,888	6,151	26,801

Larger firms operate in Chemicals, Automotive and Metallurgy, while smaller firms in Wood and Printing. From a first analysis of the raw data, we notice that different combinations of capital and labor are used in different industries, motivating the computation of technical efficiency scores rather than labor productivity measures. In fact, DEA scores

are computed considering the whole input bundle (capital, labor and intermediate goods) and separating different technologies (sectors), making them more precise than a simple output-input ratio. For example, as expected, the incidence of capital assets on revenues changes from around 15% for the automotive industry to 20% and 25% in the Chemicals and Metallurgy industries, respectively.

Table 2: Number of firms with unions and decentralized contracts

	Unionized	Not Unionized	Total sample
Decentralized LCA	612	87	699
Collective LCA	492	2259	2751
Total sample	1104	2346	3450

Our industrial relation variables of interest, as well other aspects related to the workforce, innovation and firms' internationalization, are obtained from the 2010 RIL Survey. Specifically, we created a dummy variable indicating whether workers have established any form of workers representation at the workplace (RSU or RSA) that is legally entitled to participate in the firm-level bargaining process. As shown in Table 2, such a workplace representation is present in one third of the sample (1,104 firms). We also created a dummy variable indicating whether the firm and the unions have signed a decentralized labor agreement. As reported in Table 2, this occurs in 20% of the cases (699 firms). Among firms characterized by the presence of decentralized labor contracts, more than 90% adopt a PRP scheme, which remains one of the primary clauses discussed and bargained at the firm level. However, as shown in Table 3, its introduction is mainly pursued in a collective form (60% adopt PRP only in collective form, 28% propose a mix of individual and collective PRP, and only 7% declare a wage integration entirely linked to individual performance). This suggests that Italian unions tend to avoid the use of individual incentive schemes or, even more, dislike the individual monitoring of performances.

While our industrial relation variables are obtained from the 2010 RIL, we use firms' balance sheet data for the period 2010-2012 for our DEA computations. We do so for three main reasons. First, by pooling a firm's balance sheet data over a three year period, we aim at increasing the statistical efficiency of our

Table 3: PRP schemes among firms adopting a DLCA

PRP scheme	N. firms
Collective	408
Collective & individual	184
Only individual	50
Firms adopting PRP	642

second stage analysis (truncated regression phase), and minimize the impact of short-term fluctuations and measurement errors in single-year balance sheet entries. Second, we believe that the impact of unions and DLCA on firms' performance is hardly contemporaneous; more likely, it takes time to emerge and has some persistence over time. Notice that the RIL Survey 2010 portrays the firm's situation at the end of 2009; then the 2010 performance (based on data at the end of the year), and subsequent years, should be influenced by the presence of unions/DLCAs. Finally, the fact that union and contracting status are lagged for the period 2010-2012 will further reduce endogeneity concerns that we have already discussed.

5. Results and discussion

5.1. Efficiency results

Efficiency scores have been estimated using both R and the package FEAR (Wilson, 2008). The estimation has been performed separately for each year and for the 20 Ateco 2-digit codes. For each manufacturing activity, the bias correction method (based on the homogenous bootstrap procedure described in Simar and Wilson, 1998) has been applied separately, by running 2000 replications. The results are reported in Table 4. The efficiency scores are bounded below by 1, a value that cannot be reached by fully efficient firms when the bias correction mechanism is implemented. Since the orientation of the DEA model is on outputs, each score can be interpreted as the potential increase in output obtainable if input bundles are combined efficiently. Notice the relatively high values of the average and median scores, which is largely due to the financial nature of data, by definition not so homogeneous also for firms operating in the same industry. Given that the DEA programs

have been run separately for each sectoral sub-sample, the average and median efficiency scores relative to each industry cannot be immediately compared[20]. This is another reason in favor of the estimation of a truncated regression, which is able to eliminate, through the inclusion of sector dummies, the specific effect of each different reference frontier.

Table 4: Bias corrected efficiency scores, computed sector by sector

Industry	2010		2011		2012	
	Mean	Median	Mean	Median	Mean	Median
Food	1.682	1.680	1.637	1.580	1.659	1.592
Beverages	1.535	1.484	1.538	1.513	1.711	1.683
Textiles	1.926	1.919	2.061	1.982	2.042	1.954
Clothing	2.646	2.250	2.170	2.057	2.292	2.071
Leather products	1.677	1.616	1.831	1.715	1.782	1.743
Wood	1.459	1.430	1.520	1.429	1.500	1.470
Paper	1.350	1.300	1.388	1.334	1.330	1.281
Printing	2.643	2.244	2.625	2.173	2.404	2.127
Chemicals and pharmaceuticals	1.935	1.865	1.949	1.869	1.936	1.882
Rubber products	1.396	1.354	1.379	1.350	1.487	1.470
Mineral products	1.944	1.802	2.037	1.968	2.170	1.924
Metallurgy	1.321	1.263	1.297	1.237	1.321	1.267
Metal products	2.242	2.118	2.393	2.178	2.016	1.902
Computers and electronics	1.803	1.701	1.827	1.648	1.837	1.784
Electrical appliances	2.038	1.835	1.709	1.643	1.905	1.813
Machinery	2.046	1.978	1.746	1.711	1.688	1.641
Automotive and equipments	1.546	1.503	1.362	1.309	1.374	1.344
Furniture	1.924	1.790	1.924	1.853	1.931	1.861
Other manufacturing industries	1.792	1.741	1.703	1.633	1.883	1.789
Repair and maintenance	3.251	2.542	2.046	1.983	1.845	1.840
Total	1.940	1.771	1.860	1.723	1.838	1.719

According to the figures reported in Table 4, there appears to be a substantial stability of heterogeneity among firms over time: on average, all firms in the sample remain at a rather constant distance from the specific yearly-estimated frontier. The highest values of inefficiency scores, both in term of mean and median, are recorded in 2010, the worse year in terms of economic cycle. A reducing distance from the frontier suggests that the most disadvantaged firms (i. e. the followers) get closer to the best performers, which are lying on the frontier. Another important aspect is that the efficiency estimates are not much correlated to the number of observations relative to each manufacturing activity, so that our

[20]The indicators collected in Table 4 can only be interpreted as measures of the heterogeneity of the sub-sample in relation to its specific best-practice frontier.

cleaning procedure appears to have been quite effective in eliminating outliers. The relative heterogeneity among firms (i.e. the average distance from their respective frontiers) is lower in Metallurgy, Paper, Rubber, Wood and Automotive, even if in this latter case there is a remarkable difference between 2010 and 2012. The recent crisis has been particularly strong for the automotive sector, substantially reducing the number of cars produced in Europe and particularly in Italy; 2010 was indeed a year of low production with an important share of idle capacity. The inefficiency score recorded for 2010 (1.55) and the improvement in the subsequent years suggests that the situation has become more favorable also for followers firms operating in the automotive supply chain. A similar comment applies to the Machinery sector and to the Repair and Maintenance industry, which are both strictly linked to the economic cycle. The most heterogeneous sectors, where highly efficient firms co-exist with a larger plethora of less efficient units are Clothings, Printings, Metal and Mineral products, traditional activities that typically exhibit lower rates of technological progress.

5.2. Second stage phase

We turn now towards the investigation of the effect of industrial relations and labor contract characteristics on technical efficiency, and apply the truncated regression model depicted in section 3. We use a homogeneous bootstrap procedure, repeating each truncated regression 200 times. In order to increase the robustness of our results, we replicate estimates under 7 different model specifications, including additional control variables. In all the reported estimates, the dependent variable is an efficiency score computed separately for each year and sector; time dummies are included to control for year specificity similarly to Biener *et al.* (2016). The results are reported in Table 6. Given the nature of the efficiency scores, proxing a distance from the reference frontier, a negative sign indicates a positive effect on efficiency. Our empirical strategy is based on the estimation of the truncated regression over the whole sample, where a set of dummies catch the sectoral fixed effect, shifting efficiency estimates according to each specific reference frontier.

The two main aspects of interest are investigated through dummies: the first indicates firms adopting decentralized labor contract agreements (DLCAs), the second identifies firms

Table 5: Descriptive statistics for second stage variables, 2010

Variables	Definition	Mean	SD
Size	Logarithm of employees	3.30	1.32
Size Squared	Square of size	12.62	10.37
Firm's age	Number of years from foundation	25.15	15.53
Vertical Dis-integration	External costs over total costs	0.71	0.14
Graduated employees (%)	Share of graduated employees	0.06	0.10
Young employees (%)	Share of young employees	0.24	0.23
White collar (%)	Share of white collar employees	0.31	0.21
Export (% of revenues)	Share of export over revenues	0.23	0.29
Unionization rate	Share of unionized workers	0.16	0.21
Dummies			
Employees training	1 if the firms offers traning	43%	
Patents	1 if the firm registers patents (2007-2010)	12%	
North-West Italy	1 if the firm is located in North-West	35%	
North-East Italy	1 if the firm is located in North-East	31%	
Center Italy	if the firm is located in Center	18%	
South Italy	if the firm is located in South or in the Islands	16%	

where unions are present. We have included a set of time variant controls from the AIDA dataset (i.e. size, size squared, degree of vertical dis-integration) and a set of time invariant controls (i.e. regional and sectoral dummies, characteristics of managers, export share, labor force composition, innovation). Those variables appear gradually along the estimates in order to test the robustness and the stability of the results. Table 5 lists the full set of explanatory variables.

The impact on efficiency is positive for decentralized contracts and negative for unions, and coefficients are always significant and with a magnitude which remains substantially stable across the different model specifications, even when the most complete set of control variables is included (model 4, our baseline specification). In particular, considering the presence of unions, the average level of inefficiency increases by 0.137-0.162 in magnitude, which corresponds to a 14-16% increase of the average inefficiency level in 2010 (1.940), the baseline year. The effect of adopting a DLCA seems somewhat less stable across model specifications, increasing the efficiency indicator by 0.109-0.171 (11% - 17% of the average inefficiency). The above findings for unions are in line in terms of magnitude (18% for labor productivity and 13% for TFP) with Morikawa (2010), even if the sign is the opposite, while the results for DLCA are similar, in terms of sign and magnitude (20%), to those reported by Addison *et al.* (2015), even if their left hand side variable is labor productivity.

The positive effect of DLCA remains slightly lower than the negative effect of unions,

Table 6: Dependent variable: DEA Inefficiency scores bias corrected using homogeneous bootstrap

	Dependent variable: DEA efficiency scores, bias corrected						
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DLCA	-0.171***	-0.121***	-0.109**	-0.124***		-0.0780**	-0.141***
	(-0.271 - -0.0713)	(-0.203 - -0.0390)	(-0.206 - -0.0126)	(-0.205 - -0.0428)		(-0.155 - -0.00104)	(-0.204 - -0.0775)
Unions	0.162***	0.148***	0.142***	0.137***	0.105**		0.0878**
	(0.0713 - 0.253)	(0.0549 - 0.241)	(0.0552 - 0.228)	(0.0594 - 0.215)	(0.0189 - 0.190)		(0.00654 - 0.169)
Unionization rate							0.227***
							(0.0698 - 0.384)
$Size < 15$	0.0448	0.0634	0.0622	0.0491	0.0413	0.0241	0.0547
	(-0.0460 - 0.136)	(-0.0179 - 0.145)	(-0.0231 - 0.148)	(-0.0267 - 0.125)	(-0.0256 - 0.108)	(-0.0491 - 0.0972)	(-0.0181 - 0.128)
Size	-0.375***	-0.354***	-0.358***	-0.409***	-0.399***	-0.403***	-0.412***
	(-0.528 - -0.223)	(-0.496 - -0.212)	(-0.502 - -0.215)	(-0.557 - -0.261)	(-0.537 - -0.261)	(-0.537 - -0.268)	(-0.555 - -0.269)
Size Squared	0.0175**	0.0162**	0.0185**	0.0309***	0.0278***	0.0323***	0.0318***
	(2.00e-05 - 0.0350)	(0.000698 - 0.0318)	(0.00314 - 0.0340)	(0.0156 - 0.0462)	(0.0147 - 0.0409)	(0.0173 - 0.0473)	(0.0177 - 0.0460)
Firm's age	0.00302***	0.00429***	0.00456***	0.00387***	0.00370***	0.00416***	0.00381***
	(0.00103 - 0.00501)	(0.00209 - 0.00649)	(0.00231 - 0.00682)	(0.00172 - 0.00603)	(0.00164 - 0.00577)	(0.00215 - 0.00617)	(0.00180 - 0.00582)
North - West Italy		-0.370***	-0.356***	-0.285***	-0.295***	-0.291***	-0.287***
		(-0.489 - -0.251)	(-0.469 - -0.243)	(-0.393 - -0.177)	(-0.391 - -0.199)	(-0.392 - -0.190)	(-0.375 - -0.199)
North - East Italy		-0.474***	-0.461***	-0.339***	-0.349***	-0.343***	-0.342***
		(-0.623 - -0.326)	(-0.598 - -0.325)	(-0.458 - -0.221)	(-0.461 - -0.236)	(-0.458 - -0.228)	(-0.453 - -0.232)
Center Italy		-0.402***	-0.397***	-0.296***	-0.302***	-0.297***	-0.301***
		(-0.535 - -0.270)	(-0.532 - -0.262)	(-0.416 - -0.175)	(-0.412 - -0.192)	(-0.415 - -0.179)	(-0.424 - -0.177)
Graduated employees (%)			-0.0350	-0.103	-0.103	-0.0973	-0.0872
			(-0.529 - 0.459)	(-0.568 - 0.362)	(-0.505 - 0.299)	(-0.571 - 0.376)	(-0.528 - 0.353)
Young employees (%)			0.00404	0.0523	0.0549	0.0465	0.0634
			(-0.146 - 0.154)	(-0.0777 - 0.182)	(-0.0997 - 0.210)	(-0.102 - 0.195)	(-0.0868 - 0.214)
Employees training			-0.0750*	-0.0796**	-0.0863**	-0.0814**	-0.0778**
			(-0.151 - 0.00112)	(-0.150 - -0.00878)	(-0.152 - -0.0203)	(-0.145 - -0.0178)	(-0.145 - -0.0103)
White collar (%)			-0.208**	0.0494	0.0503	0.0431	0.0585
			(-0.371 - -0.0447)	(-0.130 - 0.229)	(-0.109 - 0.209)	(-0.0982 - 0.184)	(-0.125 - 0.242)
Export (% of revenues)				-0.101*	-0.101*	-0.0955*	-0.102**
				(-0.216 - 0.0143)	(-0.214 - 0.0109)	(-0.207 - 0.0163)	(-0.200 - -0.00399)
Patents				-0.139***	-0.143***	-0.143***	-0.134***
				(-0.233 - -0.0447)	(-0.228 - -0.0578)	(-0.240 - -0.0457)	(-0.224 - -0.0440)
Vertical Dis-integration				-2.055***	-2.049***	-2.057***	-2.030***
				(-2.534 - -1.575)	(-2.524 - -1.573)	(-2.500 - -1.613)	(-2.467 - -1.592)
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	3.118***	3.336***	3.431***	4.632***	4.640***	4.639***	4.597***
	(2.766 - 3.470)	(2.925 - 3.748)	(3.021 - 3.840)	(4.032 - 5.233)	(4.042 - 5.239)	(4.103 - 5.174)	(4.076 - 5.117)
Sigma	0.955***	0.943***	0.941***	0.895***	0.895***	0.896***	0.894***
	(0.793 - 1.118)	(0.776 - 1.109)	(0.767 - 1.115)	(0.729 - 1.061)	(0.737 - 1.054)	(0.742 - 1.050)	(0.732 - 1.055)
Observations	10,350	10,350	10,350	10,350	10,350	10,350	10,350
Chi-square	144.6	154.3	172.9	260.6	459.4	317.5	1063
Log Lik	-7402	-7343	-7335	-7109	-7112	-7114	-7104

Confidence Interval 0.95% in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

with the exception of model 1. This suggests that, once the collective voice option has been formally recognized, the negative effect of the unions' monopoly face is almost completely compensated. Thanks to a better mix of organizational flexibility, wage incentives and a clearer definition of the union's role, aspects on which both the employees and the managers agree in written form through the stipulation of a DLCA, the drawbacks linked to union activity are largely overcome and minimized. On the contrary, when the unions operating within the firm are unable or unwilling to (pre-)commit on well defined terms on such issues as labor organization, wage claims, cooperation with the management and internal conflicts smoothing, the detrimental effect on efficiency becomes more evident and the monopoly face of unions more likely to prevail, as argued by Kaufman (2004).

In the rest of this section, we briefly discuss the estimates for the remaining control variables, and report on the results of a number of robustness checks. The effect of size has been carefully considered. First, we include a dummy to isolate the effect on efficiency of small sized firms (up to 15 workers), for which the presence of unions and the adoption of DLCA is relatively rare[21]; the effect of such a dummy is, however, never significant across all the specifications. Secondly, we include the logarithm of the number of employees and its square, in order to test for the presence of a non linear effect. As expected, and consistently with previous research dealing with DEA efficiency scores (Latruffe *et al*, 2008; Zelenyuk and Zheka, 2006), the effect of size on efficiency is positive and stable across models, but up to a certain dimensional threshold, after which it becomes negative, as shown by the positive and significant coefficient on the squared term. This suggests that, when their size becomes too large, firms suffer from organizational complexity and coordination inefficiencies. The age of the firm, proxing its stability over time, shows a negative impact on technical efficiency, suggesting that younger firms are more apt to take advantage from technical progress. This evidence is probably linked to the issue of firm's maturity, which reduces the openness to new and risky technological innovation. The geographical location matters and shifts the average level of technical efficiency in favor of northern Italian regions, given that the reference group

[21]Firms employing less than 15 employees are also subject to softened employment protection legislation, as specified by the Italian Workers' Statute stipulated in 1970.

is represented by southern regions and islands.

Time invariant control variables catching workforce characteristics like education (share of graduated), age (share of young employees) and main task (share of white collars), introduced in regressions 3 and 4, show mixed results and do not seem to deeply influence technical efficiency. However, when a firm invests in training activities for employees, the effect on efficiency becomes positive and significant. This last set of variables, based on the RIL survey, refer to the end of 2009, but can be considered as proxies for the long run characteristics of the firm. Firms exporting intensively show better performances in terms of efficiency, as well as firms that patent during the last three years. Both aspects, export and innovation capacity, are two classical features of highly productive firms and this relationship is also confirmed regarding technical efficiency. Finally, the level of vertical dis-integration, measured as the ratio of external costs over total costs, accounts for differences in outsourcing strategies and vertical boundaries and shows a strongly positive impact on technical efficiency. This result suggests that outsourcing represents a valid instrument for increasing productivity levels, and is consistent with the results of Pieri and Zaninotto (2013) and Manello *et al.* (2015).

Additional estimates have been run as robustness checks and the aforementioned evidence, in particular for what concerns the two main variables of interest, is substantially confirmed. Specifically, when we include an interaction term between unions and DLCA, the results are unchanged and the interaction variable remains not significant, highlighting the compensation effect of DLCA on the negative role of unions. Moreover, we run additional regressions, using size-class dummies, without significant changes in the main conclusions. Similarly, when we estimate separated truncated regression models excluding the 2010 year to reduce simultaneity concerns with unions or DLCA, the main findings remain virtually unchanged.[22] Our results are also stable, in terms of sign and statistical significance, when one of the two variable of interest (unions or DLCA) is omitted, but the estimates are deeply downward biased: the single coefficient partially captures the effect on each variable, loosing

[22]These additional results are not reported in the paper, but they are available upon request.

the real trade-off between the two effects, as reported in models 5 and 6.

The last column of table 6 includes the unionization rate, a proxy of the union's power within the firm. The main findings remain the same, with an effect of DLCA substantially stable, and confirm a negative impact of unions on efficiency, but a strong relation between unions' power and technical efficiency emerges. Per se, the presence of unions reduces by 0.09 (8%) the average efficiency score, but the effect becomes even more negative as the percentage of unionized workers in the firm increases. This aspect will be further investigated in the following sections.

Finally, we fully exploit the information on the nature of PRP schemes (collective, individual, or mixed) introduced through the DLCA. The general result is that estimates are substantially robust to the inclusion of dummies accounting for the type of PRP schemes (models 8 through 11), while the new regressors are not found to influence the observed efficiency level, highlighting that, rather than wage settings it is the whole spectrum of contractual clauses that matters for efficiency. Results from those estimates are reported in Appendix A.

5.3. Controlling for the probability of DLCA's adoption

The presence of firm-specific aspects that influence the probability of signing a DLCA can introduce potential bias in the estimated positive effect from such contracts. As previously discussed, we try to solve the problem by introducing a low order polynomial function of the predicted probability of adopting a decentralized contract at firm level, following the methodology proposed by Card and De La Rica (2006). The main advantage is that all the relevant information from additional workforce's and firm's characteristics are condensed in a one-dimensional indicator that flexibly and parsimoniously controls for such additional variables and their interactions. We run a Probit model on the probability of observing DLCA at the firm level using as covariates the fraction of female and temporary workers, the share of educated and young employees, the incidence of white-blue collars, the share of employees trained on the job, firm's size and age, and past average profitability levels [23].

[23]We use Return on Sales averaged for the period 2007-2009 as a proxy of past profitability. If financial data are missing for previous periods, we use the 2010 value.

Finally, we include controls for regions and sectors. The predicted probability, along with its square and its cube, have been included as additional regressors in the Simar-Wilson truncated regression model to partial out the effect on technical efficiency attributed to the potentially higher ex-ante probability of signing DLCA for some firms.

Table 7: Propensity score value added in the Simar-Wilson truncated regression

VARIABLES	p-score on DLCA	p-score on Unions
Unions	0.147***	0.123***
	(0.0672 - 0.227)	(0.0387 - 0.207)
DLCA	-0.102*	-0.101**
	(-0.209 - 0.00432)	(-0.188 - -0.0144)
Propensity score	1.864**	1.446**
	(0.306 - 3.422)	(0.0769 - 2.815)
Propensity score squared	-5.496***	-2.232
	(-9.084 - -1.909)	(-5.052 - 0.587)
Propensity score cubed	4.188***	0.914
	(1.725 - 6.651)	(-0.953 - 2.782)
Observations	10,350	10,350
Chi-square	432.2	436
Log Lik	-7102	-7104

Confidence Interval 0.95% in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Even if not reported, we include the same variables from model 4 of table 6.

The results from table 7 once again confirm the robustness of our main findings. In comparison to our baseline model (table 6, model 4), the estimated coefficient for DLCA obtained with the propensity score based method decreases approximately by 20% (from -0.124 to -0.102), in line with what reported by Card and De La Rica (2006) for their application. The coefficients for the remaining variables[24], as well as for the presence of unions, remain substantially stable when the propensity score terms are included. Therefore, even after controlling for the ex-ante probability of adopting decentralized contracts (which partially solve the endogeneity issues), the effective presence of DLCA shows a positive and significant effect on efficiency (10%). A similar procedure has also been applied for the presence of unions, by estimating a probit model that uses the same covariates listed above. The results of column 3 show that the inclusion of propensity score terms reduces the estimated coefficient on the dummy of interest, that remains positive and significant, with stable results also for other variables. In both the case of DLCAs and unions, therefore, adding the propensity scores terms leaves the main messages unchanged.

[24]Those coefficients are not reported here for simplicity, but are available upon request.

5.4. Extensions: the role of international trade, debt and assets' rigidity

As shown in the previous sections, the presence of unions in the workplace has a significant negative influence on efficiency, which is virtually compensated whenever a decentralized labor contract agreement has been formally stipulated between the managers and the workers' representatives. However, the relative power of unions may be drastically different according to firms' characteristics or to some specific strategies pursued by firms. Previous literature highlights three main channels through which unions can suffer a substantial limitation of their power: exposure to international markets, low degree of capital sunkness/rigidity and high levels of debt. These three aspects have been extensively investigated by empirical papers, also recently, but the main focus has been on labor outcomes (such as wage differentials) or on firms financial outcomes (such as investment or cash flows), rather than on their role in limiting the adverse union effect on firm efficiency.

A higher exposure to international trade is expected to increase managers' bargaining power through the credible threat of de-localizing production activities or via the lower mark-up in the foreign markets. Felbermayr *et al.* (2014) investigate the influence of export intensity on rent-sharing and find lower wages for firms more exposed to international trade, highlighting a lower unions' power, mainly due to the diminishing markups in foreign markets.

Bronars and Deere (1991) argue that increasing the level of debt is a specific strategy pursued by managers to reduce the amount of profits potentially appropriable by employees, as well as the unions' bargaining power before negotiation. Matsa (2010), analyzing data on US firms for the 1970s and the 1990s, finds a significant relation between debt structure and unions' power, confirming that firms increase debt to limit the bargaining power of their employees.

Finally, the so called hold-up theory suggests that, in the presence of large irreversible investments (as in the case of sunk costs or very illiquid assets) and incomplete contracts, the union bargaining power is higher and the firm is more vulnerable to unions' opportunistic behavior in wage negotiations, which may lead to a reduction of future investments. Recently, Cardullo *et al.* (2015) provide evidence on the empirical relevance of this holdup

problem using international sector-level data. They find a negative effect of unions' power on investment per worker, observing a stronger effect in sectors characterized by a higher presence of sunk or rigid capital.

From these previous studies, we can expect a stronger bargaining power of unions when the exposure to international trade is limited, when the invested capital is sunk or rigid and when level of debt is not high. In such cases, the margin of negotiation with the management is wider, so that we expect a higher (negative) impact on efficiency. The empirical strategy is based on a pre-identification of the subset of firms in which the bargaining power of unions should be more limited and a separate estimation of the same truncated regression model across the two groups, comparing the magnitude of the usual union-dummy coefficient. We replicate the same procedure by dividing the sample according to the three aforementioned aspects, and by identifying three groups, sometimes partially overlapped, where union bargaining power is high (low).

Table 8 reports three sets of results, all based on the richest specification of Table 6 (model 4). The first part of Table 8 (columns 2 and 3) analyzes the exposure to international trade. Firms have been divided in two groups on the basis of their export share: the median value (30% in 2010) showed by the subset of firms involved in exporting activities has been used as a threshold for dividing strong versus marginal exporters. The estimated effect of unions' presence across the two groups differ substantially. As expected, for firms intensively (marginally) exposed to international trade, unions reduce efficiency only by 0.09 (0.15). This is consistent with the idea that, when the presence on international markets is marginal, the threat of off-shoring is less credible and mark-ups may be higher, with a stronger bargaining power of unions.

The second part of table 8 (columns 4-5) is focused on firms' debt structure. The whole sample has been divided into two groups on the basis of the leverage index, computed as external debt over equity in 2010. Firms with a leverage higher than 1 are considered as heavily indebted. The results confirm a lower effect of unions on inefficiency for firms with higher leverage, 0.10 versus 0.212 for the low leverage group. Also in this case the result is coherent with previous findings, and confirms that an higher debt exposure reduce unions'

Table 8: Unions' power and differential effect on Technical efficiency

	Exposure to international markets		Debt structure		Degree of capital sunkness	
	Strong exporters	Marginal exporters	High debt level	Low debt level	Flexible assets	Rigid assets
DLCA	-0.0846*	-0.174***	-0.0967*	-0.135	-0.160***	-0.00895
	(-0.179 - 0.00997)	(-0.293 - -0.0548)	(-0.197 - 0.00402)	(-0.324 - 0.0546)	(-0.268 - -0.0525)	(-0.162 - 0.144)
Unions	0.0902**	0.148**	0.100**	0.212**	0.0881*	0.168**
	(0.00600 - 0.174)	(0.0352 - 0.260)	(0.0170 - 0.183)	(0.00596 - 0.419)	(-0.0103 - 0.187)	(0.0247 - 0.312)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,357	6,993	7,518	2,832	7,686	2,664
Chi-square	145.8	334.4	383	87.84	144.1	266.6
Log Lik	-1711	-5261	-4998	-2022	-5050	-1926

Confidence Interval 0.95% in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Notes: we use the richer specification in table 6, model 4, with controls for DLCA, size, location, workforce and managers characteristics as well as sectors and years.

Strong exporters are those who export more than 30% (the median value of exporters' distribution) of their revenues abroad.

Firms with *rigid capital structure* are those showing a ratio of tangible assets over total assets higher than 0.40 (75th percentile).

Firms with an *high level of debt* are those showing leverage (External debt over equity) higher than 1.

bargaining power and limits the negative impact on technical efficiency.

Finally, the last two columns of Table 8 are focused on the role of capital rigidity. We use a firm-level measure of physical capital intensity, the ratio of tangible assets over total assets. The threshold used to identify firms characterized by a rigid capital structure is the 75th percentile value, identifying the 25% of firms with more capital invested in physical goods[25]. Also in the case of physical capital intensity, the effect of unions on inefficiency is higher (0.16 versus 0.08) for the group characterized by higher rigidity.

Despite a direct causal effect of each single aspect influencing unions' power and technical efficiency should be identified with care for the arbitrary divisions of the sample, the substantial coherence of the estimated coefficients across different models increases the interest of our results, and our confidence on their general validity. When the characteristics of the firms or the managerial strategies are such that the bargaining power of unions is limited, the effective presence of unions shows a substantially lower negative impact on technical efficiency, with coefficients that are 40-50% lower in magnitude with respect to the ones reported for the high unions' power sub-samples. The positive effect of DLCA on efficiency is mainly confirmed, even if in some cases (low debt levels and rigid assets), local agreements fail to compensate the stronger negative effect of unions, or, more probably, estimates are less precise due to reduced samples.

Overall, our results suggest that, while workplace unionization decreases efficiency, factors limiting unions' bargaining power, such as higher exposure to international markets, higher debt and flexible assets, reduce this detrimental effect. That evidence is in line with our finding reported in table 6 column 7, which show how unions supported by a small number of members (i.e. the unionization rate within the firm is low) have a more limited effect on technical efficiency.

[25]The 75th percentile corresponds to a ratio equal to 0.4. When using the median of the distribution (0.23) to separate the two groups we obtain very similar results.

6. Concluding remarks

Despite a huge theoretical and empirical literature, the relationship between unions and productivity remains vague, with numerous contributions supporting both positive and negative effects. The conflicting results partly reflect institutional, country and sector specificities, as well as the methodology used to measure productivity and estimate the impact of unions. We contribute to this debate by proposing one of the first applications of efficiency analysis to labor economics issues, investigating the effect of unions and decentralized bargaining on technical efficiency. In particular, we adopt a semi-parametric DEA approach for estimating efficiency scores on a large sample of Italian firms operating in the manufacturing sector. We devote specific attention to compare firms that adopt similar technologies by running 20 separate frontiers and by analyzing efficiency scores through a truncated regression model.

Our main result is that the presence of unions within the firm represents a source of inefficiency that can be reduced or almost neutralized through the adoption of decentralized labor contract agreements. We view these findings as evidence that the negative union effect, which remains significant and stable across all the robustness checks implemented, strongly prevails where unions are present in the firm without a formal commitment (i.e., the adoption of a DLCA) to limit its conflictual/monopoly face with the management. Furthermore, our findings suggest that the relative power of unions plays an important role too. After having classified firms according to their differential exposure to international trade, degree of external debt or rigidity of the capital invested, all factors limiting the unions' bargaining power, we find that the negative effect of unions is much lower for strong exporters, highly leveraged firms and for firms with more flexible assets.

Our findings support the view that the adoption of decentralized bargaining, which once expressed in a formal contract may prove effective in limiting unions' power and its discretionary and opportunistic behavior, acts as an efficiency enhancing factor, as recently argued also by the European Commission. On the one hand, DLCAs counterbalance the presence of unions and reduce the risk of potential appropriations of the firm's returns

by its employees. On the other hand, the additional bargained flexibility introduced by DLCAs increases the possibilities of combining inputs, and sustains technical efficiency not only through performance related pay clauses. Both results receive additional empirical support when a propensity score based method is combined with the truncated regression model to deal with the possible endogeneity of unions and DLCA with respect to technical efficiency. However, despite our attempts to reduce endogeneity issues and to support a causal interpretation of the uncovered relationship between unions, DLCA and efficiency, the results should be interpreted with care. For instance, methodological developments, as well as richer data, are still needed to better deal with the potential estimation biases arising from unobserved heterogeneity. This appears to be a promising avenue for future research in the area of DEA efficiency analysis.

In terms of policy implications, we suspect that the current model of Italian union representation broadly fails in supporting the collective-voice face of unionism, if internal conflicts are not smoothed so as to create the conditions for signing decentralized contracts. In the absence of such agreements, workplace unionization is unlikely to represent an efficiency-enhancing factor, lead to improved industrial relations and contribute to increase reciprocal trust and cooperation between employees and managers. In our view, policies to favor the adoption of DLCAs should be part of the broader set of interventions aimed at reversing the country's long-standing productivity crisis.

References

Addison J. and Hirsch B., 1989. Union effects on productivity, profits, and growth: has the long run arrived?. *Journal of Labor Economics* 7(January): 72 - 105.

Addison J., Textiera P., Evers K. and Bellmann L., 2015. Pacts for employment and competitiveness as a role model? Their effects on firm performance. IZA Discussion Papers No. 9323.

Antonietti R., Pini P. and Antonioli D., 2014. Flexible pay systems and labour productivity: Evidence from Emilia-Romagna manufacturing firms. Working Papers n. 2014143, University of Ferrara, Department of Economics.

Bâdin L., Daraio C. and Simar L., 2012. How to measure the impact of environmental factors in a nonparametric production model. *European Journal of Operational Research*, 223(3): 818 - 833.

Bandiera O., Barankay I. and Rasul I., 2005. Social preferences and the response to incentive: evidence from personnel data. *Quarterly Journal of Economics* 120(3): 917 - 962.

Banker R. D., Charnes A. and Cooper W. W., 1984. Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis. *Management Science*, 30(9): 1078 - 1092.

Bartelsman, E.J. and Doms M., 2000. Understanding productivity: lessons from longitudinal microdata. *Journal of Economic Literature*, XXXVIII: 569 - 594.

Bellmann, L., Gerner H. D., and Hbler O., 2015. Investment under Company-Level Pacts before and during the Great Recession. *Economic and Industrial Democracy* 36(3): 501 - 522.

Benito B., Solana J. and Moreno MR., 2014. Explaining efficiency in municipal service providers. *Journal of Productivity Analysis* 42(3): 225 - 239.

Bennett J. and Kaufman B. (eds), 2007. *What do unions do? A 20-year perspective.* Transaction Publisher, New Brunswick.

Biener C., Eling M. and Wirfs J.H., 2016. The determinants of efficiency and productivity in the Swiss insurance industry. *European Journal of Operational Research* 248(2): 703 - 714.

Breda T., 2015. Firms' rents, workers' bargaining power and the union wage premium. *The Economic Journal* 125: 1616 - 1652.

Bronars S.G. and Deere D.R. 1991. The threat of unionization, the use of debt, and the preservation of shareholder wealth. *The Quarterly Journal of Economics* 106(1): 231 - 254.

Brown W., Bryson A. and Forth J., 2009. *Competition and the retreat from collective bargaining.* Cambridge University Press, Cambridge.

Bruno C. and Manello A., 2015. Benchmarking and effects of reforms in the fixed telecommunications industry: A DDF approach. *Telecommunications Policy* 39(2): 127 - 139.

Card D., Devicienti F. and Maida A., 2014. Rent - sharing, holdup and wages: evidence from matched panel data. *Review of Economic Studies*, 81(1): 84 - 111.

Card D. and De La Rica S., 2006. Firm - level contracting and the structure of wage in Spain. *Industrial and Labor Relation Review* 59 (4): 573 - 592.

Cardullo G., Conti M. and Sulis G., 2015. Sunk capital, unions and the hold-up problem: theory and evidence from cross-county sectoral data. *European Economic Review* 76(C): 253 - 274.

Chintrakarn P. and Chen Y., 2010. Do unions impact efficiency? Evidence from the US manufacturing sector. *Contemporary Economic Policy*, 29(3): 431 - 440.

Cooper W.W., Seidorf L.M. and Tone, K., 2007. Data Envelopment Analysis. *A comprehensive text with models, Application References and DEA-solver Software.* Springer Edition, Berlin.

Damiani, M. and Ricci, A., 2014. Decentralized bargaining, and performance related pay: Evidence from a panel of Italian firms. *International Journal of Manpower*, 35(7): 1038 - 1058.

Damiani M., Pompei F. and Ricci A., 2014. Performance related pay, productivity and wages in Italy: a quantile regression approach. MPRA Paper No. 53341.

Daraio C., Simar L., 2005. Introducing environmental variables in nonparametric frontier models: a probabilistic approach. *Journal of Productivity Analysis* 24(1): 93 - 121.

Daraio, C., Simar, L., 2007. *Advanced robust and nonparametric methods in efficiency analysis.* Methodology and applications. New York: Springer.

Devicienti F., Naticchioni P. and Ricci, A., 2015. Temporary employment, demand volatility and unions: Firm-level evidence. IZA Discussion Paper Series No. 9410.

Doucouliagos H. and Laroche P., 2003. What do unions do to productivity? A meta-analysis. *Industrial Relations* 42(4): 650 - 691.

Doucouliagos H. and Laroche P., 2006. Human resource practices, unionization and the organizational efficiency of French industry, in Lewin D. and Kaufman B. (ed.) Advances in industrial labor relations, Volume 15: 67 - 102, Emerald Group Publishing Ltd, Bingley.

Doucouliagos H. and Laroche P., 2009. Unions and profits: a meta-regression analysis. *Industrial Relations* 48(9): 146 - 183.

Fairris D. and Askenazy P., 2010. Works councils and firm productivity in France. *Journal of Labor Research*, 31(3): 209 - 229.

Falavigna G. and Ippoliti R., 2012. Efficiency of the medical care industry: Evidence from the Italian regional system. *European Journal of Operational Research*, 217(3): 643 - 652.

Felbermayr G., Hauptmann A. and Schmerer H.J. 2014. International trade and collective bargaining outcomes: evidence from German Employer-Employee data. *The Scandinavian Journal of Economics* 116(3):820 - 837.

Freeman R. and Medoff J., 1984. *What do unions do?* Basic Books, New York.

Gielen A., Kerkhofs M. and van Ours J., 2010. How performance related pay affects productivity and employment. *Journal of Population Economics* 23(1): 291 - 301.

Greer M., 2009. Is it the labor unions' fault? Dissecting the cause of the impaired technical efficiencies on the legacy carrier in the United States. *Transportation Research Part A*, 43(9): 779 - 789.

Hirschman A., 1970. Exit, Voice and loyaty. Harvard University Press, Cambridge MA.

Hübler O. and Jirjahn U., 2003. Work councils and collective bargaining in Germany: the impact on productivity and wages. *Scottish Journal of Political Economy*, 50(4): 471 -

491.

Imbens G., 2004. Non parametric estimation of average treatment effect under exogeneity: A review. *Review of Economics and Statistics* 86(4): 4-29.

Kaufman B., 2004. What unions do: insight from economic theory. *Journal of Labor Research* 25(3): 351 - 382.

Kuhn, P. 1998. Unions and the economy: What we know; what we should know. *Canadian Journal of Economics* 31(5): 1033 56.

Latruffe, L., Davidova, S. and Balcombe K., 2008. Application of a double bootstrap to investigation of determinants of technical efficiency of farms in Central Europe. *Journal of Productivity Analysis*, 29(2): 183 - 191.

Lucifora C. and Origo F., 2015. Performance-related pay and firm productivity: evidence from a reform in the structure of collective bargaining. *Industrial and Labor Relations Review*, forthcoming.

Manello A., Calabrese G. and Frigero P., 2015. Technical efficiency and productivity growth along the automotive value chain: evidence from Italy, *Industrial and Corporate Change*, forthcoming.

Matsa A.D., 2010. Capital structure as a strategic variable: evidence from collective bargaining. *Journal of Finance* 65(3), 1197 - 1231.

Metcalf D., 2003. Unioins effect on productivity, profitability and investment, in Addison J. and Schnabel C. (eds), International Handbook of trade unions, Edward Elgar, London.

Morikawa M., 2010. Labor unions and productivity: an empirical investigation using Japanese firm-level data. *Labour Economics* 17(6): 1030 - 1037.

Muller S., 2012. Work council and establishment productivity. *Industrial and Labor Relations Review* 65(4): 880 - 898.

Muller S., 2015. Work council and labour productivity: looking beyond the mean. *British Journal of Industrial Relations* 53(2): 308 - 325.

Origo F., 2009. Flexible pay, firm performance and the role of unions. New evidence from Italy. *Labour Economics*, 16(1): 64 - 78.

Pieri, F. and Zaninotto, E., (2013). Vertical integration and efficiency: an application to the Italian machine tool industry. *Small Business Economics*, 40(2): 397 - 416.

Schank, T., Schnabel, C. and Wagner, J. 2004. Works councils: sand or grease in the operation of German firms. *Applied Economics Letters*, 11: 159 - 161.

Schedlitzki D., 2002. German works councils, employee involvement programs, and their impact on establishment productivity. Centre for Economic Performance Working Paper No. 1191, London School of Economics.

Simar L., 2003. Detecting outliers in frontier models: a simple approach. *Journal of Productivity Analysis* 20(3):391 - 424.

Simar L. and Wilson P.W., 1998. Sensitivity analysis of efficiency scores: how to bootstrap in nonparametric frontier models. *Managerial Science* 44(1):49 - 61.

Simar L. and Wilson P.W., 2007. Estimation and inference in two-stage, semi-parametric models of production process. *Journal of Econometrics* 136 (1): 31 - 64.

Simar L. and Wilson P.W., 2011. Two-stage DEA: caveat emptor. *Journal of Productivity Analysis* 36(2): 205 - 21.

Ton Z. and Huckman R.S., 2008. Managing the impact of employee turnover on performance: The role of process conformance. *Organization Science* 19(1): 55 - 68.

Wilson, K.G. 1995. The impact of unions on United States economy-wide productivity. New York: Garland.

Wilson P.W., 2008. Fear 1.0: a software package for frontier efficiency analysis with R. *Socio Economic Planning Science* 42(4): 247 - 254.

Zelenyuk V. and Zheka V., 2006. Corporate governance and firms efficiency: the case of a transitional country, Ukraine. *Journal of Productivity Analysis* 25 (1-2): 143-157.

Zschille M., 2015. Consolidating the water industry: an analysis of the potential gains from horizontal integration in a conditional efficiency framework. *Journal of Productivity Analysis*, forthcoming.

Appendix A1

Table 9: The interaction of DLCA, PRP schemes and unions

VARIABLES	(8)	(9)	(10)	(11)
DLCA	-0.116**	-0.133**	-0.118**	-0.128***
	(-0.224 - -0.00702)	(-0.234 - -0.0312)	(-0.212 - -0.0232)	(-0.218 - -0.0384)
Unions	0.148***	0.147***	0.137***	0.137***
	(0.0631 - 0.232)	(0.0626 - 0.232)	(0.0502 - 0.223)	(0.0612 - 0.212)
Individual PRP	-0.0182		-0.0211	
	(-0.145 - 0.108)		(-0.130 - 0.0880)	
Collective PRP		0.0209		0.00705
		(-0.104 - 0.146)		(-0.118 - 0.132)
$Size < 15$	0.0636	0.0634	0.0493	0.0491
	(-0.0259 - 0.153)	(-0.0262 - 0.153)	(-0.0319 - 0.131)	(-0.0290 - 0.127)
Size	-0.354***	-0.354***	-0.409***	-0.409***
	(-0.497 - -0.211)	(-0.511 - -0.197)	(-0.557 - -0.261)	(-0.557 - -0.261)
Size Squared	0.0163**	0.0162*	0.0309***	0.0309***
	(0.00133 - 0.0312)	(-0.000325 - 0.0328)	(0.0155 - 0.0463)	(0.0156 - 0.0462)
Firm's age	0.00430***	0.00430***	0.00388***	0.00387***
	(0.00214 - 0.00646)	(0.00206 - 0.00654)	(0.00185 - 0.00592)	(0.00181 - 0.00594)
North - West Italy	-0.370***	-0.370***	-0.285***	-0.285***
	(-0.479 - -0.261)	(-0.483 - -0.257)	(-0.388 - -0.182)	(-0.391 - -0.179)
North - East Italy	-0.475***	-0.475***	-0.340***	-0.339***
	(-0.608 - -0.341)	(-0.618 - -0.331)	(-0.460 - -0.220)	(-0.453 - -0.226)
Center Italy	-0.403***	-0.403***	-0.296***	-0.296***
	(-0.535 - -0.270)	(-0.544 - -0.261)	(-0.416 - -0.176)	(-0.410 - -0.181)
Graduated employees (%)			-0.103	-0.103
			(-0.552 - 0.346)	(-0.571 - 0.365)
Young employees (%)			0.0523	0.0523
			(-0.0986 - 0.203)	(-0.0870 - 0.192)
Employees training			-0.0794**	-0.0795**
			(-0.140 - -0.0185)	(-0.146 - -0.0125)
White collar (%)			0.0495	0.0495
			(-0.120 - 0.219)	(-0.119 - 0.218)
Export (% of revenues)			-0.100*	-0.101*
			(-0.202 - 0.00127)	(-0.211 - 0.0100)
Patents			-0.138***	-0.139***
			(-0.227 - -0.0498)	(-0.228 - -0.0491)
Vertical Dis-integration			-2.055***	-2.055***
			(-2.529 - -1.581)	(-2.530 - -1.579)
Sector dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Constant	3.337***	3.337***	4.633***	4.633***
	(2.943 - 3.731)	(2.902 - 3.772)	(4.052 - 5.214)	(4.050 - 5.215)
Sigma	0.943***	0.943***	0.895***	0.895***
	(0.774 - 1.112)	(0.769 - 1.116)	(0.732 - 1.057)	(0.737 - 1.052)
Observations	10,350	10,350	10,350	10,350
Chi-square	158.6	139.7	170.7	262.8
Log Lik	-7343	-7343	-7109	-7109

Confidence Interval 0.95% in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$