Teamwork and Delegation of Decisions Within the Firm

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August 2015

Abstract

This paper analyzes the interaction between teamwork and decentralization of decision rights. Being two of the most popular instruments on how to manage workers, it is important to better understand their relationship, most notably as they both rely on the cooperative behavior of workers. In particular, we develop a simple model allowing for different organizational structures, according to whether or not firm strategic decisions and production decisions are delegated. We find that *overall delegation* of decision making has a positive effect on teamwork. However, when we distinguish between *delegation of firm strategic decisions* and *delegation production decisions*, we obtain that it is just the delegation of firm strategic decisions that induces teamwork. The positive correlation between teamwork and overall delegation - and particularly, delegation of firm strategic decisions - is confirmed empirically for a unique dataset of Spanish small and medium size firms that contains information on worker self-reported importance of teamwork. The empirical analysis also corroborates the findings in the previous literature regarding the positive correlation between cooperation and pay incentives.

Keywords: teamwork, delegation, firm strategic decisions, production decisions.

JEL classification: D23; L23; M54.

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1 Introduction

An important aspect of organizational design is the allocation of decision-making rights (authority) and, especially, their distribution between managers and employees. Traditionally, managers have been considered 'monitors' controlling the performance of subordinates under the premise that they have a better knowledge on the tasks employees should do. This believe is currently being challenged by practitioners and academics alike, as a reaction to an increasing uncertainty and complexity in corporate decisions brought about by longstanding technological, social, and economic changes.

Referring to the famous and successful 'just-in-time' method of stock control implemented by Toyota in Japan, The Economist (2006) points out that the company realized that the best way to make this system work was to allow the workers on the factory floor to control the flow of supplies, because they had the information that would keep stocks at their lowest. This forced Toyota to delegate decision-making and empower its shop-floor workers (unlike most Japanese companies). In fact, there is a progressive declining interest in top-down 'command and control' management based on the notion that the boss has all the answers.

From a different perspective, there is evidence that associates teamwork with higher firm productivity and other indicators of firm performance. For instance, Boning *et al.* (2007) find that teamwork is associated with 6% higher firm productivity in their study of steel mills and Hamilton *et al.* (2003) find that the introduction of teamwork in a garment factory led to an average increase in productivity of 18%.

Thus, it seems important to shed light on the link between the delegation of decision making and teamwork. This is the main purpose of our paper.

More precisely, we explore the organizational aspects of the firm that are associated with teamwork. The literature to date has mainly focused on the impact of incentives on worker cooperation. By contrast, we take a broader look to analyze the extent to which the firm's vertical organizational design can shape the inter-worker horizontal relationships to produce higher levels of teamwork. We differentiate between *firm strategic decisions* and *production decisions*. The former refer to the ones that affect corporate inputs and performance in the medium and long run (e.g., production technology decisions, hiring, and training), while the latter concern everyday operations such as planning activities, supplies and purchases, etc. Is delegation a good corporate strategy in producing teamwork? Should managers distinguish between firm strategic decisions and production decisions when implementing decentralized mechanisms? As far as we are aware of, this is the first paper that makes a theoretical and empirical analysis of the interaction between teams and decentralization of decision rights.

Being two of the most popular instruments on how to manage workers, it is important to better understand their relationship, most notably as they both rely on the cooperative behavior of workers.

In particular, we develop a simple model in which the allocation of decision rights play an important role in inducing teamwork. More precisely, each worker produces an exclusive output (which depends on his exclusive effort) and a teamwork output (which depends on the degree of collaboration from coworkers in the firm along with the recipient's absorptive capacity) under different organizational structures according to whether or not firm strategic decisions and production decisions are delegated. Our theoretical results can be summarized as follows. First, overall delegation of decision making has a positive effect on worker cooperation and teamwork. Second, when we distinguish between delegation of firm strategic decisions and delegation production decisions, we obtain that only the delegation of firm strategic decisions influences positively worker cooperation and teamwork.

These theoretical results constitute testable predictions that we examine empirically using a unique survey database of Spanish firms. Among other variables, the survey includes worker self-reported importance of teamwork, which is our dependent variable.[1] Our empirical analysis confirms our theoretical predictions on the relationship between teamwork and delegation, and it also corroborates the findings in the previous literature regarding the use of pay incentives.

The paper is organized as follows. Section 2 reviews the existing literature and highlights our main contributions. Section 3 presents the theoretical model and describes the three different organizational structures for the allocation of decision rights within the firm (Subsections 3.1, 3.2, and 3.3) comparing them against each other (Subsection 3.4). The model yields testable hypotheses concerning teamwork and the firm organizational design that we empirically analyze in Section 4. Section 4 also describes the data and the variables used in the empirical model. Finally, Section 5 concludes.

[1]Worker cooperation and teamwork are not really the same thing. Teamwork usually refers to the firm-chosen practice by which workers are assigned to work in a joint project as opposed to separate individual tasks, whereas cooperation is a worker choice. Thus, the fact that teamwork is used by a firm does not guarantee per se that workers actually cooperate with each other. However, in our empirical exercise, we consider workers' self-assessed importance of teamwork as a proxy for actual worker cooperation since both measures should be strongly correlated. Therefore, throughout the paper, we take liberty to use the terms teamwork, worker cooperation, and collaboration, interchangeably.

2 Related literature

The study of teamwork can be traced back to the theoretical works of Alchian and Demsetz (1972) and Holmstrom (1982), which focused on free-riding and competition in teams. Since then, an important strand of the literature has focused on the relationship between teamwork and firm productivity. Besides the studies by Boning *et al.* (2007) and Hamilton *et al.* (2003) that have been mentioned before, Gant *et al.* (2002) argue that the productivity benefits of teamwork stem mainly from faster problem-solving because of tighter horizontal interactions between workers. It has also been argued that teams complement certain work practices - such as flexible job assignments, skill training, and communication procedures (Milgrom and Roberts, 1995) - as well as the adoption of information technologies (Bartel *et al.*, 2007) that enhance firm productivity. Teamwork may also affect firm productivity indirectly through innovation and knowledge production; Wuchty *et al.* (2007), for instance, document that research across nearly all areas is increasingly dominated by teams.

Although the optimal mix of joint and individual efforts might vary widely across firms and corporate cultures, several papers have studied optimal teamwork and the right incentives to achieve it.[2] In the theoretical literature on incentives and team effort, two main types of incentives have been analyzed: pay systems and promotions. Concerning pay systems, two extreme pay systems have been looked at: individual piece rates (that reward individual performance) and group-based piece rates (that rewarded own and other workers' output). For example, Drago and Turnbull (1988) find that moving from an individual to a group-based system fosters cooperation. This prediction seems to be empirically confirmed by Drago and Garvey (1998), Heywood *et al.* (2005), and Encinosa *et al.* (2007). By and large, cooperation is found to be positively correlated with the use of group-based pay incentives like profit-sharing, employee stock ownership, and firm-based performance bonuses; and negatively correlated with individual performance pay systems. In an experiment involving bicycle messengers in Switzerland and the US, Burks *et al.* (2009) also obtain that cyclists paid on commission for individual jobs tended to be less cooperative than cyclists paid by the hour or paid a share of the group total

[2]For example, Itoh (1991) derives conditions under which teamwork, as opposed to a specialized task structure where each worker focuses on his own task, is optimal. Drago and Turnbull (1988) show that using incentive structures that foster cooperation might or might not lead to an optimal mix of own and helping effort, depending on worker expectations of their coworkers behavior. They use the examples of Japan and the US to support this difference in corporate cultures regarding worker cooperation. From a different perspective, Kosfeld and von Siemens (2011) study the use of incentives to induce workers to self-select into more and less cooperative firms according to their preferences for cooperation.

revenues.

As for promotions, Drago and Turnbull (1991) find that competitive promotion schemes (or tournaments) in which workers compete against each other for a more senior position in the firm discourage cooperation. Lazear (1989) even finds that tournaments can lead to sabotage (i.e., negative helping efforts). By contrast, non-competitive promotion systems (or quotas), as analyzed by Drago and Turnbull (1991), are found to encourage cooperation if workers think that coworkers would reciprocate. The impact of tournaments on cooperation has been empirically tested by Drago and Garvey (1998), who find a negative and statistically significant correlation between tournaments and worker cooperation, after controlling for observable characteristics (such as education, occupation, job tenure, and individual characteristics) and using residual wage dispersion across workers as a proxy for the 'promotion prize'. In a firm-based field experiment, Bandiera *et al.* (2013) compare the effect of piece rate payments, tournaments, and rank incentives on team composition and worker team efforts. They find that, while rank incentives (in the form of information released regarding relative performance, so a tournament without monetary prizes) do not seem to affect effort or team productivity, the use of tournament incentives across teams increases worker effort within teams.

The incentives that lead agents to cooperate in a more general context - and not only at the firm level - have been extensively examined recently in the experimental literature and in a number of designed field experiments. Recent data from experiments demonstrate that people do in fact deviate from self-interest in systematic ways (Camerer, 2003).[3] In this vein, Itoh (2004) and Englamaier and Wambach (2010) emphasize the relevance of other-regarding preferences from a theoretical point of view. Furthermore, Englamaier and Leider (2012) study optimal reciprocal contracts (i.e., contracts with limited performance-based pay and generous average compensation). Reciprocity has also been empirically analyzed in the works by Englamaier *et al.* (2013).[4] Our paper complements this literature as we also put our focus on mechanisms that elicit intrinsic motivation (instead of the extrinsic motivation associated to monetary premiums).

More precisely, our paper complements the existing literature by focusing on the allocation of decision rights (what we refer to as the firm's vertical organizational design) and teamwork using firm-level data.[5] As Bloom and Van Reenen (2011) suggest, teamwork and decision delegation

[3]Rabin (2002) provides a perspective on the recent trend towards integrating psychology into economics.

[4]Other related papers deal with applicant screening, complementarities of workplace practices and their effect on cooperation and productivity (e.g., see Huang and Capelli, 2010; and Kolaska, 2014).

[5]Althoough it has been pointed out that delegation of decision making has a positive impact on firm outcomes such as productivity and profitability (Bloom and Van Reenen, 2011; Colombo *et al.*, 2013) and product innovation (Arvanitis *et al.*, 2013), the specific mechanisms that connect decentralization of decisions with those

are likely to be complementary because when responsibility is transferred downstream, it is most often delegated to teams of workers generally involved in multi-tasking. Furthermore, more decentralized firms require workers to know more about the activities of other workers and to coordinate more which, in turn, calls for greater interaction and collaboration among workers. As far as we are aware of, our paper is the first one making a theoretical and empirical analysis of the interaction between teams and decentralization of decision rights, which are two of the most popular instruments on how to manage workers.

Teamwork might also be associated with other firm practices such as problem-solving and semi-autonomous groups that foster worker interactions, or production and information protocols (PIPs) like quality circles, suggestion boxes or total quality management practices that facilitate effective worker communication and coordination. If all these workplace practices (including pay incentives) are complementary and firms tend to adopt them together, omitting them might lead to important biases on the estimated effects of pay incentives on teamwork.[6]

More broadly, this paper also contributes to the vast literature on the adoption of innovative work practices and their impact on firm outcomes. Beginning with Milgrom and Roberts (1990), several works have documented changes in the US production and industrial relations model since the 1980s.[7] In terms of personnel policies, these changes have implied a shift from traditional to modern workplace practices such as incentive pay, problem-solving teams, job rotation, information sharing, increased delegation, etc. To date, most research efforts have focused on identifying the impact of such practices on firm productivity (see Ichniowski *et al.*, 1997; Black and Lynch, 2001 and 2004; Bartel *et al.*, 2007; and, for broader management practices, Bloom and Van Reenen, 2007 and 2011). Only recently, some papers have discussed the impact of workplace practices on other firm outcomes such as innovation (e.g., see Laursen and Foss, 2003). In this paper, we also consider the relationship between these workplace practices and teamwork.

3 The theoretical model

We propose a simple way to model worker cooperation in a firm, in the spirit of Itoh (1991) and of Homstrom and Milgrom (1991). Workers contribute to two types of projects: an individual or exclusive project and a joint or teamwork project. They optimally decide the amount of

outcomes are not well known. A possible channel that we explore here is through the relationship between delegation and teamwork.

[6] See Ichniowski and Shaw (2003) for an excellent review on workplace practices and their complementarities.

[7] E.g., see Osterman (1994 and 2000).

effort to exert in each of the projects, a decision that depends on the firm organizational design. Consequently, each worker produces an *exclusive output* that depends on his exclusive effort and a *teamwork output* that depends on his coworker's collaborative effort along with his *absorptive capacity*. This concept of absorptive capacity is taken from the literature of economics of innovation where it is defined as 'firm's ability to identify, assimilate, and exploit knowledge from the environment' (Cohen and Levinthal, 1989). We adapt and extend this concept to measure 'a worker's ability to identify, assimilate, and exploit collaboration from coworkers to produce teamwork output'.[8]

Depending on whether *firm strategic decisions* (i.e., medium and long run decisions) and *production decisions* (i.e., short run decisions) are decentralized, we consider three different organizational structures: *i*) centralization of firm strategic decisions and production decisions (scenario *cc*), *ii*) centralization of firm strategic decisions and delegation of production decisions (scenario *cd*), and *iii*) delegation of firm strategic decisions and production decisions (scenario *dd*). Top-down delegation of decision rights gives workers greater freedom over their actions but also requires them to exert some communication efforts for coordination purposes. Specifically, under scenario *cc*, workers only have to decide their cooperative efforts because the manager establishes formal production and information protocols (PIPs) that facilitate effective worker communication and coordination (e.g., quality circles, suggestion boxes or total quality management practices) and imposes a certain level of exclusive effort for each worker. Under scenario *cd*, workers have two choice variables (i.e., exclusive efforts and cooperative efforts) since the manager's restriction on the level of exclusive effort is removed. Finally, under scenario *dd*, workers have three choice variables (i.e., exclusive efforts, cooperative efforts, and communication efforts) since the manager's formal PIPs are replaced by workers' communication efforts.[9] Quite naturally, in more decentralized structures, worker choice is enhanced while that of the manager is reduced.

[8]Furthermore, if output is measured in terms of product innovation (as suggested in in Kretschmer and Puranam, 2008), the concept of absorptive capacity can be directly applied. As we will make clear in Subsections 3.1, 3.2, and 3.3, a worker's absorptive capacity is either determined by the manager (under centralization of firm strategic decisions) or by the worker himself (under delegation of firm strategic decisions).

[9]The case of delegated strategic decisions and centralized production decisions is not analyzed here because we believe it is unlikely to be observed. In an environment where workers make strategic decisions, restrictions on exclusive efforts (i.e., centralized production decisions) seem unnatural.

3.1 Scenario *cc*: Centralization of firm strategic decisions and production decisions

When firm strategic decisions and production decisions are centralized, managers affect workers' decisions on two levels. First, the manager establishes formal PIPs (this is centralization of firm strategic decisions), so workers do not have to make decisions regarding their own communication efforts. Second, the manager imposes a certain level of exclusive effort on each worker, thereby reducing discretionality regarding effort choice (this is centralization of production decisions).

Assuming the simplest possible organization with a manager and just two workers, i and j, worker i's output is given by

$$\pi_i = \underbrace{x_i}_{exclusive\ output} + \underbrace{zy_j}_{teamwork\ output}, \tag{1}$$

where x_i is the effort worker i invests in their exclusive task and y_j denotes the collaborative effort from a coworker j.[10] That is, employees exert an *exclusive effort* and an *collaborative effort* to produce teamwork output. Worker i's teamwork output (zy_j) depends on his coworker's collaborative effort (y_j) along with the level of formal PIPs established by the manager (z) that makes cooperation more effective. These PIPs therefore determine worker i's *absorptive capacity* and constitute an indirect way for managers to affect the impact of collaborative effort on the beneficiary's output and, ultimately, teamwork output. In practice, such protocols may be quality circles, suggestion boxes or total quality management practices that facilitate worker interaction and collaboration. The fact that workers cannot alter these PIPs reflects the less flexible environment of centralization of firm strategic decisions, compared to delegation where workers exert some communication and coordination effort that determine their absorptive capacity, which has an impact on the level of teamwork output.

The cost of effort is assumed to be convex. To generate determinate results, we model it in the standard quadratic form as follows:

$$\mu_i = \theta\left(x_i^2 + \varphi y_i^2 + \eta x_i y_i\right), \tag{2}$$

with φ being worker i's cost of an additional unit of collaborative effort, where $\varphi > 1$ is assumed because contributing to teamwork projects requires an extra effort to understand others' tasks (e.g., see Heywood *et al.*, 2008). The parameter $\eta \in [0, 2]$ suggests that both exclusive and collaborative efforts may come from the same source, in such a way that one's level of effort

[10] The corresponding expression for worker j is identical to (1) after interchanging subscripts.

has implications for the marginal costs of the other effort.[11] The case $\eta = 0$ means that both types of effort are unlinked, i.e., they 'come out of different buckets', whereas $\eta = 2$ represents highly linked efforts.[12] Finally, $\theta \geqslant 1$ captures the inflexibilities that can be generated by the centralized structure, since the manager's control can constitute a source of inefficiencies.[13]

The manager can also create incentives for collaboration when designing worker remuneration schemes. Worker i's pay is assumed to be given by

$$\psi_i = \Lambda_i + \alpha\pi_i + \beta\pi_j, \tag{3}$$

and includes a fixed amount (Λ_i) and a variable component that depends on both workers' outputs; more precisely, α and β represent the share of worker i's pay related to his own and the other worker's outputs, respectively. As in Kretschmer and Puranam (2008), we refer to β as collaborative incentives or incentive breadth. The surplus that remunerates the manager is a function of the total corporate output $f(\pi_i + \pi_j)$, which, after discounting workers' pay and the control cost $g(z)$, can be written as

$$\pi_m = f(\pi_i + \pi_j) - \underbrace{(\Lambda_i + \alpha\pi_i + \beta\pi_j)}_{\psi_i} - \underbrace{(\Lambda_j + \alpha\pi_j + \beta\pi_i)}_{\psi_j} - g(z), \tag{4}$$

where $g(z)' > 0$ and $g(z)'' > 0$ are assumed. Defining $\pi = \pi_i + \pi_j$, $\Lambda = \Lambda_i + \Lambda_j$, and $\kappa = \alpha + \beta$, the above expression can be rewritten as

$$\pi_m = f(\pi) - (\Lambda + \kappa\pi) - g(z), \tag{5}$$

where κ denotes the incentive intensity or *incentive depth*. Since workers cannot be paid more than the total output, an implicit constraint to the above expression is $\Lambda + \kappa\pi \leqslant \pi$ or, alternatively, $\kappa \leqslant 1 - \Lambda/\pi$,[14] where Λ/π is a fixed average cost for the manager. Note that the fixed and variable parts of workers' pay are indirectly linked through κ: an increase in Λ/π reduces the maximum incentive depth that can be offered by the manager to the workers.

[11] In particular, exclusive and collaborative efforts are substitutes and collaborative efforts do not reduce the disutility of exclusive efforts. However, a positive collaborative effort is an equilibrium outcome, a result that differs from that reported in Itoh (1991).

[12] We cannot say that efforts become *fully linked* when $\eta = 2$. The reason is that the marginal cost functions with respect to x_i and y_i are asymmetric due to the condition $\varphi > 1$, as we have $\frac{\partial \mu_i}{\partial x_i} = \theta(2x_i + \eta y_i)$ and $\frac{\partial \mu_i}{\partial y_i} = \theta(2\varphi y_i + \eta x_i)$. Therefore, $\eta = 2$ makes efforts fully linked for $\frac{\partial \mu_i}{\partial x_i}$ but not for $\frac{\partial \mu_i}{\partial y_i}$.

[13] There seems to be a consensus in the literature that more decentralized organizational structures generally convey efficiency gains (e.g., see Dewatripont and Maskin, 1995). However, this assumption can easily be relaxed by assuming $\theta = 1$. A similar inefficiency measure is used by Alonso-Pauli (2007) in a corporate governance context.

[14] For $\Lambda = 0$, this inequality becomes $\kappa \leqslant 1$.

Finally, a worker's *net pay* is given by the wage received minus the effort's cost, i.e., $\omega_i = \psi_i - \mu_i$. The manager imposes on each worker a minimum level with respect to effort invested in their exclusive task ($x_i \geqslant \underline{x}_i$).[15] Therefore, worker i maximizes his net pay taking into account the requirement to exert at least effort level $\underline{x}_i$ in his exclusive task:

$$\begin{aligned} \max \omega_i &= \psi_i - \mu_i \\ s.t.\ x_i &\geqslant \underline{x}_i. \end{aligned} \tag{6}$$

We assume that workers simultaneously and independently decide their own and team efforts, x_i and y_i, in order to maximize (6); by contrast, pay schemes and PIPs are determined by a corporate agreement.[16] We obtain the following first-order conditions after plugging (1) (and the corresponding expression for π_j) into (3), then (2) and (3) into (6), and maximizing:

$$\frac{\partial \omega_i}{\partial x_i} = \alpha - 2\theta x_i - \theta\eta y_i, \tag{7}$$

$$\frac{\partial \omega_i}{\partial y_i} = \beta z - 2\theta\varphi y_i - \theta\eta x_i. \tag{8}$$

From (7) we can conclude that the worker will make the minimum exclusive task effort (i.e., $x_i = \underline{x}_i$) whenever the marginal cost of increasing x_i (i.e., $2\theta x_i + \theta\eta y_i$) exceeds marginal revenue (i.e., α). Second-order conditions require $4\varphi - \eta^2 > 0$, which is always observed since $\varphi > 1$ and $\eta \in [0, 2]$. At this point, depending on whether the constraint is binding or not, two possible solutions may arise: a *corner solution* (i.e., $x_i = \underline{x}_i$) or an *interior solution* ($x_i > \underline{x}_i$).

Production decisions are centralized under scenario *cc*, which is tantamount to assuming that the manager imposes the level of exclusive effort $\underline{x}_i$. Analytically, this is equivalent to considering a corner solution in the maximization problem (6). Therefore, worker i makes the minimum effort $\underline{x}_i$ (the interior solution occurs under delegation of production decisions - i.e., under scenarios *cd* and *dd* - and is examined in the following subsection). From $x_i = \underline{x}_i$ and $\partial\omega_i/\partial y_i = 0$, we obtain

$$y_i^{cc} = y_j^{cc} = \frac{\beta z - \theta\eta \underline{x}_i}{2\theta\varphi}, \tag{9}$$

where superscript *cc* denotes equilibrium values when firm strategic decisions and production decisions are centralized. Logically, the share α does not appear in (9) since the worker is

[15] For instance, some firms have implemented different types of software that monitor the time workers spend executing certain computer applications (i.e., working on their exclusive tasks).

[16] Manager decisions concerning pay schemes and PIPs are considered exogenous in our setting since our main purpose is to analyze the effect of decision delegation on worker cooperation. Studying all manager's optimal choices would merely complicate the analysis and confound effects.

compelled to make the minimum effort $\underline{x}_i$ and no payment incentives are needed. Positivity of y_i^{cc} requires $z > \theta\eta\underline{x}_i/\beta$, meaning that workers will not collaborate unless the manager establishes a certain level of PIPs that foster worker interactions. A straightforward comparative-static analysis, conducted by inspecting (9), is summarized in the lemma below.

Lemma 1 *Under centralization of firm strategic decisions and production decisions, collaborative effort rises with an increase in incentive breadth (β) and with the level of PIPs (z). It falls with an increase in the collaborative effort cost (φ), the inefficiencies associated with centralized structures (θ), and the linkage between exclusive and collaborative efforts (η).*

All the effects described in the lemma above are natural and to be expected. The effect on cooperation of the linkage between exclusive and collaborative efforts (η) is negative because, given that x_i is fixed, an increase in η only raises the marginal cost of y_i (i.e., $\frac{\partial \mu_i}{\partial y_i} = \theta\left(2\varphi y_i + \eta x_i\right)$). An additional question would be the impact on collaborative effort of a change in the fixed part of the workers' compensation (Λ). This change would have no effect as long as the restriction $\Lambda + \kappa\pi \leqslant \pi$ is not binding. This seems the most natural result since $\Lambda + \kappa\pi = \pi$ would mean that workers would receive the total corporate output.[17]

3.2 Scenario *cd*: Centralization of firm strategic decisions and delegation of production decisions

Under scenario *cd*, is the level of formal PIPs (z) is still chosen by the manager (centralization of firm strategic decisions) but there is no restriction on one's own effort and workers freely choose their exclusive and collaborative efforts (delegation of production decisions). The maximization problem is as in (6) except that there is no restriction on x_i. From the first-order conditions, at the (symmetric) equilibrium we obtain

$$y_i^{cd} = y_j^{cd} = \frac{2\beta z - \alpha\eta}{\theta\left(4\varphi - \eta^2\right)}, \tag{10}$$

where superscript *cd* denotes equilibrium values in this scenario. Positivity of y_i^{cd} requires $z > \alpha\eta/2\beta$.[18] This positivity condition reflects the fact that the use of PIPs facilitates worker

[17] In the case that the restriction $\Lambda + \kappa\pi \leqslant \pi$ is binding, an increase in Λ would require a reduction in incentive depth (κ) which, in turn, would translate into a lower α and/or β.

[18] Although our main focus is on worker collaborative efforts, the expression for the equilibrium exclusive effort is also computed and results in $x_i^{cd} = x_j^{cd} = \frac{2\alpha\varphi - \beta\eta z}{\theta(4\varphi - \eta^2)}$. Note that the positivity of x_i^{cd} requires $z < 2\alpha\varphi/\beta\eta$. It is easy to check that the existence of an interval $z \in (\alpha\eta/2\beta, 2\alpha\varphi/\beta\eta)$ is guaranteed since it requires $4\varphi - \eta^2 > 0$, always observed given that $\varphi > 1$ and $\eta \in [0, 2]$.

cooperation, and so a lower bound is required. An exhaustive comparative static analysis, obtained by inspecting (10), is provided in the lemma below.

Lemma 2 *Under centralization of firm strategic decisions and delegation of production decisions, collaborative effort: i) rises with an increase in incentive breadth (β) and with the use of PIPs (z) and ii) falls with an increase in the collaborative effort cost (φ), the inefficiencies associated with centralized structures (θ), and the share of the workers' income associated with their own production (α); nonetheless, the effect of the linkage between exclusive and collaborative efforts (η) remains ambiguous.*

There are two main differences with respect to Lemma 1. On the one hand, α now plays an active role (under scenario *cc*, the worker is obliged to exert a certain x_i and incentives on workers' exclusive effort are not required) and, on the other hand, the effect of η becomes ambiguous because it increases the marginal cost of x_i and y_i. As in the former scenario, changes in the fixed part of the workers' pay (Λ) have no impact on effort as long as the restriction $\Lambda + \kappa\pi \leqslant \pi$ is not binding.

3.3 Scenario *dd*: Delegation of firm strategic decisions and production decisions

Under scenario *dd*, workers freely choose their exclusive and collaborative efforts (delegation of production decisions) and the manager's formal PIPs are replaced by *workers' communication and coordination efforts* (delegation of firm strategic decisions). Therefore, worker i's output is now given by

$$\pi_i = \underbrace{x_i}_{\textit{exclusive output}} + \underbrace{(z_i + z_j)\, y_j}_{\textit{teamwork output}}, \tag{11}$$

where the teamwork output is given by $(z_i + z_j)\, y_j$. Note that worker i's absorptive capacity is now given by both workers' communication and coordination efforts $(z_i + z_j)$. These efforts constitute a crucial element in determining the actual impact of collaboration and overall output, since collaboration from coworkers is only effective when it can be taken advantage of. Therefore, when firm strategic decisions and production decisions are delegated, workers decide their exclusive, collaborative, and communication efforts. Consequently, their degree of choice is increased and that of the manager is relaxed. Worker i's cost function is now given by

$$\mu_i = x_i^2 + \varphi y_i^2 + \eta x_i y_i + \phi z_i^2. \tag{12}$$

The differences with respect to (2) are as follows: *i*) the presence of ϕz_i^2, which accounts for the worker's cost of absorbing collaborative efforts from coworkers (where $\phi > 0$ is the marginal communication and coordination cost) that is assumed to be independent from x_i and y_i since this is not a production effort; and *ii*) the absence of θ (i.e., $\theta = 1$ is assumed), which captures the idea of a more efficient decentralized organizational structure.

Thus, worker i freely chooses x_i, y_i, and z_i to maximize

$$\omega_i = \psi_i - \mu_i, \tag{13}$$

where ψ_i and μ_i are given by (3) and (12), respectively. Given that production decisions are decentralized, the manager does not have to bear the cost of setting up PIPs and her remuneration becomes $\pi_m = f(\pi) - (\Lambda + \kappa\pi)$. Plugging (11) (and the corresponding expression for π_j) into (3), plugging (3) and (12) into (13), and maximizing, the first-order conditions are given by

$$\frac{\partial \omega_i}{\partial x_i} = \alpha - 2x_i - \eta y_i, \tag{14}$$

$$\frac{\partial \omega_i}{\partial y_i} = \beta(z_i + z_j) - 2\varphi y_i - \eta x_i, \tag{15}$$

$$\frac{\partial \omega_i}{\partial z_i} = \alpha y_j + \beta y_i - 2\phi z_i. \tag{16}$$

From (14) and (15), it can be observed that higher collaborative effort comes at the expense of lower exclusive effort (and vice versa) since the two kinds of effort are linked by η. Additionally, (15) and (16) show that the collaborative effort and the communication effort are positively related. Compliance with second-order conditions require $\beta^2 < \phi(4\varphi - \eta^2)$, which is assumed to hold. The (symmetric) equilibrium yields

$$y_i^{dd} = y_j^{dd} = \frac{\alpha\phi\eta}{\Omega}, \tag{17}$$

$$z_i^{dd} = z_j^{dd} = \frac{\alpha\eta(\alpha + \beta)}{2\Omega}, \tag{18}$$

with $\Omega \equiv 2\beta(\alpha + \beta) - \phi(4\varphi - \eta^2)$.[19] Superscript dd denotes equilibrium values under this scenario. We impose the condition $\beta(\alpha + \beta) > 2\varphi\phi$, which ensures $\Omega > 0$ (alternatively, it is sufficient to assume a sufficiently large α to guarantee positive equilibrium efforts).[20] The comparative statics analysis under scenario dd is complex and difficult to interpret. The explanation, which comes from the effect of z_i and z_j in (11), is twofold. On the one hand, there

[19] The solution for x_i^{dd} is $x_i^{dd} = x_j^{dd} = \alpha\frac{\beta(\alpha+\beta)-2\varphi\phi}{\Omega}$.

[20] The condition $\beta(\alpha + \beta) > 2\varphi\phi$ also ensures $x_i^{dd} > 0$.

is a substitution effect between z_i and y_i since both ultimately determine the level of teamwork output $(z_i + z_j)\, y_j$. On the other hand, the worker's communication effort increases his own output; hence, the share of worker's income related to his own production (α) can have a positive effect on collaboration from coworkers.

3.4 Comparison

In this subsection, we compare collaborative efforts under scenarios *cc*, *cd*, and *dd*. From (9), (10), and (17), we can conclude that $y_i^{cc} < y_i^{dd}$ for $z < z_L$, $y_i^{dd} < y_i^{cd}$ for $z > z_M$, while $y_i^{cc} < y_i^{cd}$ for $z > z_H$, with $z_L < z_M < z_H$. Then the following proposition follows.[21]

Proposition 1 *Assuming that* $\underline{x}_i < \frac{\alpha}{2}\left(\frac{1}{\theta} - \frac{\phi\eta^2}{\Omega}\right)$, *the comparison of collaborative effort levels under scenarios cc, cd, and dd yields:*
i) For $z < z_L$, *then* $y_i^{dd} > y_i^{cc} > y_i^{cd}$.
ii) For $z > z_L$, *then* $\max\left\{y_i^{cc}, y_i^{cd}\right\} > y_i^{dd}$.

The above proposition indicates that the impact of delegation on collaborative effort is dependent upon the level of PIPs (z) established by the manager. For small levels of z (see Proposition $1i$)), cooperation is highest when all decisions are delegated (scenario *dd*), and lowest when only production decisions are delegated (scenario *cd*). For larger values of z (see Proposition $1ii$)), collaborative efforts are highest either when all decisions are centralized (scenario *cc*) or when only production decisions are delegated (scenario *cd*).

As we explain in the next section, the firms considered in our empirical application are mostly small, many of them *family firms* where the owner is the manager. In this type of firm we would not expect managers to use numerous sophisticated PIPs (i.e., we would expect low levels of z). Focusing on the case described in Proposition $1i$) above and starting from centralized firm strategic decisions and production decisions (i.e., scenario *cc*), the following effects on worker collaboration are to be expected. Delegation of production decisions (i.e., the move from *cc* to *cd*) produces a negative impact on the level of collaborative effort effectively implemented by workers; however, when firm strategic decisions are also delegated (i.e., the move from *cd* to *dd*), the opposite effect is observed, i.e., the level of collaborative effort among workers increases. The corollary below summarizes this result.

[21] The precise values of z_L, z_M, and z_H along with some details and the proof of the proposition are provided in the Appendix.

Corollary 1 *For $z < z_L$, overall delegation of decision making (i.e., both firm strategic decisions and production decisions) has a positive effect on worker cooperation and teamwork. However, this positive effect is only driven by the delegation of firm strategic decisions.*

The above corollary contains our main theoretical predictions that we analyze empirically in the section that follows.

4 The empirical model

In this section, we examine the relation between top-down decision delegation as to test the theoretical predictions in Corollary1. More precisely, we estimate the following empirical model:

$$Y_{ij} = \theta_1 D_j + \theta_2 Incentives_{ij} + \delta' F_j + \lambda' W_i + \epsilon_{ij}, \tag{19}$$

where Y_{ij} measures the level of teamwork in worker i's job at firm j; D_j refers to the degree of delegation of decisions within the firm, with some specifications distinguishing between $D_j^{strategic}$ and D_j^{prod}, i.e., the delegation of firm strategic decisions and production decisions, respectively; $Incentives_{ij}$ refers to the workers pay incentive scheme; and F_j is a matrix of other firm controls including size, age, sector dummies, and production and information firm practices. We also control for worker individual characteristics (matrix W_i) that might be correlated to their preferences for cooperative behavior such as worker age, gender, education, nationality, seniority in the firm, and whether the employment contract is temporary or permanent. Finally, ϵ_{ij} is the disturbance term. The model is estimated on a dataset of small and medium Spanish firms that we describe next.

4.1 Data description

Our data comes from a unique employer-employee survey of small and medium enterprises (SMEs),[22] conducted between September 2005 and May 2006 in the Spanish region of Catalonia, and jointly sponsored by the SMEs employers' association and the Catalan government. The survey take as a model the Canadian WES and, to a lesser extent, the British WERS.[23] Firms

[22] A firm is considered a SME if it has between 10 and 250 employees.

[23] A support group made up of employers, union representatives, and academics helped design the 'master' questionnaires. Specific sectorial groups with similar composition customized it to the particularities of each sector. Site visits and pre-tests for each sector were carried out to check the questionnaires. The strategy to run the survey was the following: *i*) an initial telephone contact was made to ensure collaboration and to explain the survey, *ii*) delivery of the questionnaires by courier service, *iii*) a second call to clarify questions, if any, *iv*) collection of the filled questionnaires by courier on an agreed date, no longer than 2 weeks after delivery.

were selected randomly within 9 specific sectors of the economy: 6 manufacturing industries and 3 service industries.[24] The final sample consists of 499 firms (about 17% of the universe). This large sample of firms is representative at the industry level and consistent with respect to some key aspects of the firm like size and productivity, among others.[25] The firm-level information was completed by matching the survey to the database SABI (Sistema de Análisis de Balances Ibérico) that contains balance sheet information on firms included in the national registry of companies. Table 1 provides descriptive statistics for the firms in the sample.

−Insert Table 1 here−

Most firms are single-plant with an average of 40 employees. They are mainly national (on average, only 5% of the capital is foreign) and about three quarters of the firms are family firms, that is, firms with most capital held by one family.

The survey consists of four questionnaires: one for the CEO that incorporates firm level information and one for each of the key hierarchical levels in the firm (managers, supervisors, and core employees) that comprises individual employee information. The questionnaire for CEOs includes questions on the main characteristics of the firm (size, ownership, and degree of internationalization), evolution and position in the market, process technology, product strategy and innovation activities, human resource practices, and work organization. The questionnaire for managers, supervisors, and core non-management employees consists of a detailed information on the nature and tasks of their jobs.

The final sample contains about 4800 employees, representing 60% of the total number of targeted employees. There is a similar distribution by occupational categories among firms. Workers' characteristics are summarized in Table 2.

−Insert Table 2 here−

Most of the workers are male, 38 years old on average, and have been employed an average of 9 years in the current firm. Vocational training is the most common educational qualification and around 11% of the workers are employed on a temporary contract.

A priori, the sample could be biased for two main reasons: for the voluntary nature of the survey and due to the potential interferences of the CEOs. However, the way the whole

[24]The 6 manufacturing sectors considered in the sample are *i*) metal products exc., *ii*) metal machinery and equipment, *iii*) food and beverages, *iv*) rubber and plastics, *v*) furniture, and *vi*) electronic machinery; and the 3 service sectors are *i*) IT, *ii*) health, and *iii*) hotels.

[25]Thus the sample constitutes a good description of a diversified and modern economy: among the manufacturing industries there is both high and low-tech sectors while the service industries include intensive human capital sectors and less intensive human capital sectors.

process was conducted along with some back-of-the-envelope calculations based on additional data make us confident that no significant bias affects the sample. First, given that the survey was not known in advance and that participation was asked for by the CEO, there is no apparent reason to think that a specific demographic group was missed or underrepresented in the respondent group. Second, the process was designed as to ensure confidentiality of responses.[26] Furthermore, we also got some feedback about the process during site visits, as well as anecdotal evidence suggesting no pressure and/or discrimination from the CEOs.

4.2 Measure for teamwork and the other variables

Having good measures of teamwork is not easy. Most datasets lack this kind of information, and even when firms report implementing team-based practices, it is not guaranteed that workers actually exert team effort. These are some of the reasons why studies on teamwork and workers cooperation using actual firm data are so scarce and the existing ones use less than perfect proxies. For example, based on survey data, Heywood *et al.* (2005) use the answer to the question 'Do you get along with your colleagues?' as a proxy for workers cooperation, arguing that workers that get along will tend to collaborate with each other. Drago and Garvey (1998) use a more direct measure, although still not too satisfactory, which is the answer to the question 'To what extent do your fellow employees refuse to let others use their equipment, tools, or machinery?' The measure of teamwork we use in this paper is based on the survey question that asks workers 'how important teamwork is in your job'. Thus, it is correlated to the firm implementing teamwork practices such as problem-solving groups or semi-autonomous groups,[27] but it is different from those variables as it conveys information on the workers self-assessment of the degree of teamwork in their particular jobs. The answers to the question are categorical ranging from 1 ('not important at all') to 5 ('absolutely essential'). In order to get a sharper measure for teamwork, we construct a dichotomous variable that takes value 1 when the worker replies that teamwork is very important or absolutely essential, and zero when she says it is 'moderately important', 'not too important' or 'not at all important', and we also use the standardized raw answers to compute a continuos index of teamwork.

With regard to delegation of decision making, the survey provides information on the allocation of decision rights over a number of issues. Specifically, it reports the hierarchical category of

[26] The firm received as many questionnaires as employees in each hierarchical category; questionnaires were introduced in individual envelopes; detailed instructions on how to deliver and collect the questionnaires were suggested, and questionnaires were collected in sealed envelopes.

[27] The correlation between the worker self-reported degree of teamwork and these practices is 0.093.

the person deciding on the following 11 items: *i*) daily task planning, *ii*) weekly task planning, *iii*) follow-up of results, *iv*) customer relations, *v*) quality control, *vi*) supply purchases, *vii*) machinery and equipment maintenance, *viii*) job listing, *ix*) hiring, *x*) production technology choices, and *xi*) training. Answers to these questions range from 1 to 5, depending on who makes the decision: the owner (value 1), a manager (value 2), a supervisor (value 3), a group of workers (value 4) or a core employee (value 5). As it could be expected, decisions tend to be quite centralized at the level of the owner or the manager in the case of SMEs and family firms, and the owner and the manager are the same person in about 85% of the firms. We therefore group these answers together and interpret them as *centralized decision making*. On the other hand, only 3.6% and 2.9% of the firm-decisions correspond to core employees and groups of workers, respectively. We also group these responses together and interpret them as *delegation of decisions*. Finally, 23.2% of the decisions are taken at the supervisor level which we refer to as *partial delegation*.[28]

An important question is how to use the information on delegation of decisions. Should the decision items be considered individually or should be aggregated? Clearly, the larger the number of decisions being delegated to lower hierarchical levels, the more decentralized a firm should be considered. Moreover, the decentralization of particular decisions are not disconnected events but they respond to some latent unobserved behavior of firms. We use factor analysis to uncover the underlying factors that govern such behavior and to identify closely related decisions. Table 3 reports the factor loadings for each decision item for the first two principal components.[29] The first principal component explains 83% of the total variation in the decision variables and, as column I on Table 3 shows, the factor loadings (i.e., the parameters relating the decision variables to the principal components) are all positive and of similar sizes (they range between 0.31 and 0.55). Moreover, the p-values on column II indicate that they are also individually significantly explained by the first principal component. The second principal component suggests the existence of two categories of decisions. On the one hand, daily and weekly task planning, quality control, supply purchases, and machinery and equipment maintenance, which are affected positively by the second factor. And, on the other hand, follow up of results, customers relations (although the p-value for this variable is larger than 0.10), job listing, hiring, production technology decisions, and training. The existence

[28]To check the sensitivity of our results, we also group answers into two categories: centralization (when the decision is taken by the owner or a manager) and delegation (when the decision is taken by a lower hierarchical level, i.e., a supervisor, a group of workers or an individual worker). The results do not change in any significant way.

[29]Factor analysis retained 5 factors but only the first two had eigenvalues above 1 or close to 1.

of two categories of decisions is also confirmed by a simple correlation analysis. The decision items in the first group refer to *production decisions*, while the other set of items is what we can call *firm strategic decisions*. Consequently, we compute the following synthetic indices of delegation: one for all decisions, and two separate indices for production decisions and for firm strategic decisions, respectively.[30] Moreover, we aggregate the answers to decision items in two ways. First, we compute simple additive indices of the z-scores for the answers to each of the decision items,[31] as Bloom and Van Reenen (2007) do for similar categorical variables (in their case, questions related to management practices). Second, we use the first principal component of factor analysis.

−Insert Table 3 here−

The rest of explanatory variables include pay incentives, production and information firm practices, and other firm controls, as well as individual worker controls. Regarding pay incentives, we use a dummy variable for whether wages have a variable component or not. Only a small percentage of the workers (14%) receive this type of incentives, which is not surprising given that most of these firms are small and quite traditional. As for the use of production and information protocols (PIPs), the survey includes information on whether the following practices are used by the firms: *i*) suggestion boxes, *ii*) job turnover, *iii*) job redesign, *iv*) problem-solving teams, *v*) semi-autonomous teams, *vi*) quality circles, and *vii*) total quality management. The other firm controls used are size, age, and whether or not it is family owned.

Finally, given that our analysis is at the worker level, we also control for individual characteristics. This is important because, if workers sort themselves into firms depending on their preferences for cooperation (as suggested by Kosfeld and von Siemens, 2011), one could obtain a spurious correlation between teamwork and firm variables, including the firm organizational aspects. However, to the extent that individual preferences are correlated to observable characteristics of the workers (such as gender, age, education or others), the inclusion of individual controls should take care of this problem. Thus, we include controls for gender, age, seniority in the firm, hierarchical category (core employee, supervisor or manager), nationality, and temporary or permanent employment contracts.

[30] As the p-value for the decision on custormers relations is larger than 0.10, we do not include it in the index for delegation of firm strategic decisions.

[31] That is, we standardize the answers to each item by subtracting its mean and dividing by its standard deviation, and then add up the z-scores across decision items.

4.3 Estimation results

Table 4 shows the estimation results of the baseline model outlined in (19). Two types of models are estimated: a probit model where the dependent variable (teamwork) is dichotomous, and an ordinary least squares (OLS) model where the dependent variable is the (continuous) z-score of the self-reported importance of teamwork.

−Insert Table 4 here−

As explained above, we use two indices of delegation: *i*) the index computed by simply adding the standardized values (z-scores) of the 11 different decision items (models I, II, and IV on Table 4), and *ii*) the first principal component of factor analysis (models III and V on Table 4).[32] Column I on Table 4 shows that teamwork is positively associated with delegation of decision making, as well as with the use of variable pay incentives. With respect to the other firm and individual controls, teamwork appears to be more important in larger firms and among women, managers, and supervisors. By contrast, workers with more seniority in the firm tend to report lower levels of teamwork. It should be noted that, for sake of comparison, the inference in the model reported in Column I on Table 4 is based on robust, but not clustered, standard errors. However, as workers in the same firm share the same values for the delegation index and for the other firm variables, it is important to account for intra-group correlation of the error term by clustering standard errors at the firm level. We do so in Column II and observe that this changes importantly the significance of the estimated coefficients. Thus, throughout the rest of the models, we cluster standard errors by firm. As columns II and III on Table 4 show, the coefficient on delegation fails then to be significant for the linear models, but it is significant and positive in the probit models (columns IV and V), and the associated marginal effects (in bold) imply an increase in the likelihood of team effort of between 3.5-4 percentage points for workers in firms with a one standard deviation higher decision decentralization index. The probit models on Table 4 also show a positive effect of pay incentives and firm size on teamwork.[33] The positive effect of overall delegation of decision making on teamwork is in line with our theoretical prediction in the first statement of Corollary 1.

−Insert Table 5 here−

[32] This is essentially a weighted sum of the z-scores across the 11 different decision items, with the weights for each item being the *scores* obtained from factor analysis.

[33] In terms of our theoretical model, the positive effect of incentives on collaboration among workers would be captured by the effect of incentive breadth (β) on the collaborative effort reported in Lemmas 1 and 2 (this would mean that the restriction $\Lambda + \kappa\pi \leqslant \pi$ is binding and, hence, an increase in Λ implies a decrease in incentive depth (κ), which would, in turn, translate into a lower β under the assumption that α is fixed).

On Table 5, we investigate further the relationship between teamwork and delegation of firm decisions by exploring possible complementarities between delegation and other firm practices, and by distinguishing between firm strategic decisions and production decisions.

Column I on Table 5 includes the PIPs available in the survey as additional regressors. We exploit all the information on those practices. In particular, we know whether each practice is being used by the firm and, if so, whether it has been used for more than 2 years.[34] As observed, after including these variables, the coefficient on the delegation index becomes smaller and, what is more important, statistically insignificant, while none of the individual firm practices appears to be significant either. This could be due to multicollinearity among all these variables and the delegation index because, as different authors have pointed out (e.g., see Ichniowski *et al.*, 1997; and Milgrom and Roberts, 1995 among others), they are likely to be complementary and firms tend to adopt them together.[35] Moreover, if PIPs and the delegation of decision making are complementary, the inclusion of individual practices would miss their combined effect. Thus, we use factor analysis again to identify their underlying common factors and use the first principal component (which explains 54% of the total variation) as an aggregate index for delegation of decisions and PIPs. Table 6 shows the factor loadings for each decision item and PIP practice. As observed, they all have positive signs, which corroborates that there are underlying factors that lead firms to decentralize decisions and also use PIPs. The marginal effect of this index on teamwork (see column II on Table 5) is significant and of similar magnitude (0.032) to those reported on Table 4.

Finally, column III on Table 5 distinguishes between delegation of firm strategic decisions and delegation of production decisions. While the estimated marginal effects are both positive, the effect for the delegation of production decisions is much smaller and not statistically different from zero. Thus, consistently with our theoretical results in the previous section, it is the delegation of firm strategic decisions the one that leads to more teamwork. Therefore, this empirical result confirms the positive effect of delegating firm strategic decisions on teamwork reported in the second statement of Corollary 1.

−Insert Table 6 here−

[34] Consequently, these variables are categorical taking on 3 possible values: 0 if the practice is not being used by the firm, 1 if it is being used for less than one year, and 2 if it is being used for longer. The analysis on the use of these practices with simple dummy variables yields similar qualitative results.

[35] To allow for complementarity effects among human resource management practices and to deal with the multicollinearity problem among them, Ichniowski *et al.* (1997) use groups or systems of practices. Systems of practices are also used by Laursen and Foss (2003).

Although it is not the goal of this paper to establish a causal relationship between delegation of decision making and teamwork, we also follow an instrumental variable strategy as a way to check our results. To that aim, we instrument delegation with some variables that are correlated with it while orthogonal to the error term in (19). Based on the literature, the factors associated with delegation of decisions in the firm can be classified in two broad groups: *i*) factors internal to the firm, such as firm size, internal organization, use of information and communication technology (ICT) systems, distance to the technological frontier, and workforce characteristics, and *ii*) factors external to the firm, such as market competition and other market demand conditions.[36] In our database, the best candidates to being instruments are the firm's export intensity (a proxy for market competition and exposure to international markets) and the use of shared information systems between managers and workers. The export intensity is highly correlated with delegating decisions and, therefore, we expect it to be a relevant instrument.[37] At the same time, as an external factor, it is less likely to be correlated with unobserved factors that might affect workers' actual team effort. As for the use of shared information systems between managers and workers, Garicano and Rossi-Hansberg (2006) and Bloom *et al.* (2014) provide some theoretical foundations for why information and communication technologies (ICT) can affect the decentralization of decisions. ICT can increase centralization if they facilitate flows of information from lower to higher hierarchical levels and thus reduce the control costs of centralization. By contrast, ICT can increase decentralization when they enable workers to solve problems autonomously without having to refer to their bosses. Thus, we expect an ambiguous effect of shared information systems between managers and workers on the delegation of decisions which, in any case, will depend on the nature of the decisions. As for the validity of this variable as instrument, since it mainly affects the transmission of information between managers and workers, but not among workers, it is likely to be exogenous to workers cooperating with each other.

−Insert Table 7 here−

Columns I, IV, and V on Table 7 show the result of the first-stage instrumental variable

[36]There is a vast theoretical literature on decentralized decision making within the firm that has recently been tested empirically (e.g., see Colombo and Delmastro, 2004; Acemoglu *et al.* 2007; Bloom *et al.*, 2014; and Meagher and Wait, 2014). Perez and Iranzo (2012) explore the determinants of delegation for the dataset of Spanish SMEs used here.

[37]Such correlation has been found in other studies and for other datasets as well. For instance, Meagher and Wait (2014) find that exporting firms have a 15% higher probability of decentralizing decision making than firms selling exclusively in the domestic market. Guadalupe and Wulf (2010) find that trade liberalization led US firms to flatten their hierarchical structure, i.e., to decentralize more.

estimation. On column I, the overall index of delegation is regressed on export intensity, as well as on all the other exogenous controls. As expected, delegation is positively and significantly correlated with export intensity. Moreover, the partial R-squared (i.e., the percentage variability of delegation explained by export intensity once the effect of all other covariates has been partialed out) is 0.005, and the F-statistic is about 14, which is above the values recommended to rule out weak instruments. Thus, even after all other covariates are controlled for, export intensity has some explanatory power. On columns IV and V, the delegation of firm strategic decisions and the delegation of production decisions are regressed on export intensity and the use of shared information systems between managers and workers. Export intensity is again positively and significantly associated with both types of delegation. As for shared information systems, they are positively correlated to the delegation of firm strategic decisions and negatively correlated with the delegation of production decisions. This seems consistent with Garicano and Rossi-Hansberg (2006) hypothesis on the role of ICT. The ease of communication between managers and workers facilitates the centralization (or lower delegation) of task planning and everyday production issues while, at the same time, it can help to delegate 'important' decisions to more knowledgeable workers because, in case of doubt or if a problem arises, workers can easily check with their bosses. In both cases, the F-statistic of joint significance of the instruments is acceptable (11.3 and 15.6, respectively) and the partial R-squared indicates that the instruments are relevant.

Columns II and III on Table 7 report the instrumental variable estimation results using teamwork as a dichotomous variable (instrumental variable probit model) and as a continuous z-score variable respectively (instrumental variable linear model). Rather than the actual value of the point estimates, the main thing to take away from the estimations is that, in both specifications, overall decision delegation has a positive and highly significant impact on teamwork.[38] The regressions also corroborate that teamwork is positively and significantly associated to pay incentives and firm size. Among the individual controls, teamwork appears positively and significantly correlated with being female in the linear model, which is consistent with Kuhn and Villeval (2015) that find women to be more cooperative.

Taken together, the empirical results corroborate the main theoretical predictions in Corollaries 1 and 2. Overall delegation of decision making (i.e., both firm strategic decisions and production decisions) has a positive effect on worker cooperation and teamwork. However, this

[38] With respect to the comparable coefficients of models II and IV on Table 4, the instrumental variable point estimates are about 10 times larger. But, as argued, we are not interested in establishing a causal relationship and so the actual value of the estimate is not key. We just consider these estimations as a robustness check that confirm the positive correlation between teamwork and the delegation of decisions.

positive effect is only driven by the delegation of firm strategic decisions.

5 Concluding remarks

We explore the organizational aspects of the firm that are associated and can be conducive to teamwork. Unlike previous works that focus mostly on pay incentives, we take a broader view of the firm's organizational design and analyze the relationship between teamwork and delegation of decision making. To that aim we develop a simple theoretical model that considers different organizational structures according to whether or not firm strategic decisions and production decisions are delegated from the top (manager) to the bottom (workers). The following results obtain: overall delegation of decision making has a positive effect on worker cooperation and teamwork; however, this effect is only driven by the delegation of firm strategic decisions.

The model predictions are tested on a unique dataset of small and medium firms that includes information on worker self-reported importance of teamwork. This variable constitutes an improvement over the proxies for workers cooperation used in previous empirical studies. Our estimation results confirm the positive and significant correlation between teamwork an delegation, particularly delegation of firm strategic decisions. Thus, the managerial implications of this paper are clear: managers wanting to foster teamwork should opt for decentralized structures, focusing on key firm decisions such as production technology decisions but also hiring and training (i.e., firm strategic decisions).Our analysis also corroborates the findings in the previous literature regarding cooperation and pay incentives.

We believe that our analysis constitutes a step forward in the current state of the art in this literature that can produce subsequent pieces of research from different perspectives, such as industrial organization, experimental economics, labor economics or management. Therefore, our baseline model can give rise to more sophisticated studies on the generation of more collaborative workplaces. More precisely, it could be extended in three different directions. First, managers' decisions regarding the level of PIPs and pay schemes could be endogenized. Second, our analysis could be generalized to allow for n-worker teamwork (since many-partner teams are observed in reality). Finally, information asymmetries across workers could be introduced since more decentralized firms may require workers to know more about the activities of other workers which, in turn, calls for greater worker interaction and collaboration.

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A Appendix: Details and proof of Proposition 1

From (17), (10), and (9), we conclude that $y_i^{cc} < y_i^{dd}$ occurs for $z < z_L$ with $z_L = \frac{\theta\eta}{\beta}\left(\underline{x}_i + \frac{2\alpha\varphi\phi}{\Omega}\right) > 0$ and that $y_i^{dd} < y_i^{cd}$ is observed for $z > z_M$, with $z_M = \frac{\alpha\eta}{2\beta}\left(1 + \frac{\phi\theta\left(4\varphi-\eta^2\right)}{\Omega}\right) > 0$. Finally, $y_i^{cc} < y_i^{cd}$ occurs for $z > z_H$, with $z_H = \frac{2\alpha\varphi-\theta\underline{x}_i\left(4\varphi-\eta^2\right)}{\beta\eta}$ where $z_H > 0$ requires $\underline{x}_i < \frac{2\alpha\varphi}{\theta(4\varphi-\eta^2)}$. Hence it can be checked that $0 < z_L < z_M < z_H$ is observed for $\underline{x}_i < \frac{\alpha}{2}\left(\frac{1}{\theta} - \frac{\phi\eta^2}{\Omega}\right)$ with $\frac{\alpha}{2}\left(\frac{1}{\theta} - \frac{\phi\eta^2}{\Omega}\right) < \frac{2\alpha\varphi}{\theta(4\varphi-\eta^2)}$ (which guarantees $z_H > 0$).

Therefore, we can conclude that, assuming that $\underline{x}_i < \frac{\alpha}{2}\left(\frac{1}{\theta} - \frac{\phi\eta^2}{\Omega}\right)$, the comparison of collaborative effort levels under scenarios cc, cd, and dd yields:

- For $z < z_L$, then $y_i^{dd} > y_i^{cc} > y_i^{cd}$.
- For $z_L < z < z_M$, then $y_i^{cc} > y_i^{dd} > y_i^{cd}$.
- For $z_M < z < z_H$, then $y_i^{cc} > y_i^{cd} > y_i^{dd}$.
- For $z > z_H$, then $y_i^{cd} > y_i^{cc} > y_i^{dd}$.

But we still need to check that these conditions for the value of z are consistent with the positivity conditions $z < \frac{2\alpha\varphi}{\beta\eta}$ ($x_i^{cd} > 0$), $z > \frac{\alpha\eta}{2\beta}$ ($y_i^{cd} > 0$), and $z > \frac{\theta\eta\underline{x}_i}{\beta}$ ($y_i^{cc} > 0$). More precisely:

- We can check that $x_i^{cd} > 0$ (which requires $z < \frac{2\alpha\varphi}{\beta\eta}$) is possible for $z > z_H$. Note that $\frac{2\alpha\varphi}{\beta\eta} > z_H$ is tantamount to $\theta\underline{x}_i\left(4\varphi - \eta^2\right) > 0$, which is always true.
- We can check that $y_i^{cd} > 0$ (which requires $z > \frac{\alpha\eta}{2\beta}$) is possible for $z < z_L$. Note that $\frac{\alpha\eta}{2\beta} < z_L$ can be rewritten as $\underline{x}_i > \frac{\alpha}{2\theta} - \frac{2\alpha\varphi\phi}{\Omega}$ and it can be shown that the interval $\underline{x}_i \in \left(\frac{\alpha}{2\theta} - \frac{2\alpha\varphi\phi}{\Omega}, \frac{\alpha}{2}\left(\frac{1}{\theta} - \frac{\phi\eta^2}{\Omega}\right)\right)$ is non-empty since $\frac{\alpha}{2\theta} - \frac{2\alpha\varphi\phi}{\Omega} - \frac{\alpha}{2}\left(\frac{1}{\theta} - \frac{\phi\eta^2}{\Omega}\right)$ yields $4\varphi - \eta^2$, which has been assumed to be positive.
- We can check that $y_i^{cc} > 0$ (which requires $z > \frac{\theta\eta\underline{x}_i}{\beta}$) is possible for $z < z_L$. Note that $\frac{\theta\eta\underline{x}_i}{\beta} < z_L$ is tantamount to $0 < \frac{2\alpha\varphi\phi}{\Omega}$, which is always true. ■

B Tables

Table 1: Firm Characteristics

	Observations	Mean	St. deviation
Size (number of employees)	503	40.17	77.02
Of which sampled (%)		46.33	68.42
Age (years)	503	25.16	24.20
Family firm (%)	489	75.87	
Owner = manager (%)	488	84.63	
Firm is part of a group (%)	489	12.68	
Firm has foreign capital (%)	492	4.88	
Sector:	503		
- Metal products except		20.68	
- Metal machinery & equipment		12.92	
- Food and beverages (%)		13.12	
- Rubber and plastics (%)		6.56	
- Furniture (%)		5.37	
- Electronic machinery &		13.12	
- IT sector (%)		12.13	
- Health sector (%)		8.95	
- Hotels (%)		7.16	

Table 2: Workers Characteristics

	Observation	Mean	St. deviation
Age	4676	37.82	10.95
Seniority at firm (years)	4402	9.20	9.05
Female (%)	4676	31.33	
Foreign (%)	4596	4.96	
Occupational category:	4836		
- Core employees (%)		72.23	
- Supervisors (%)		14.52	
- Managers (%)		13.25	
Education:	4791		
- No formal studies (%)		12.31	
- Primary school (%)		23.29	
- Secondary school (%)		9.89	
- Vocational school (%)		32.25	
- College and more (%)		22.25	
Temporary contract (%)	4691	11.77	

Table 3. Factor loadings for delegation of decision variables

Variable	Factor1
Daily task plannning	0.4376
Weekly task plannning	0.4637
Follow-up of results	0.3682
Customers relations	0.3135
Quality control	0.4728
Supply purchases	0.4288
Machinery and equipment maintenance	0.4818
Job listing	0.5045
Hiring	0.4633
Production technology decisions	0.5084
Training	0.5535

Table 4. Baseline Models -- Relation between Teamwork and Delegation of Decisions

	Linear Model -- OLS Estimation			Probit Model - Maximum Likelihood Estimation			
Dependent variable:	(I)	(II)	(III)	(IV)		(V)	
Worker self-reported teamwork				Mg Effects		Mg Effects	
Delegation Index[A] -- All Decisions	**0.0580****	**0.0580**		0.1355*	**0.0392***		
	(0.029)	**(0.045)**		(0.073)	**(0.021)**		
Delegation Index[B] -- All Decisions			**0.0491**			0.1219*	**0.0353***
			(0.044)			(0.071)	**(0.021)**
Dummy - Wage has a variable component	0.0943**	0.0943	0.0942	0.1794*	0.0493**	0.1792*	0.0493**
	(0.045)	(0.058)	(0.058)	(0.094)	(0.024)	(0.094)	(0.024)
Firm controls:							
Firm Size (log)	0.1095***	0.1095***	0.1095***	0.1141***	0.0330***	0.1138***	0.0330***
	(0.018)	(0.029)	(0.029)	(0.043)	(0.012)	(0.043)	(0.012)
Firm Age (log)	0.0289	0.0289	0.0295	0.0680	0.0197	0.0690	0.0200
	(0.021)	(0.032)	(0.032)	(0.048)	(0.014)	(0.048)	(0.014)
Family firm	-0.0328	-0.0328	-0.0320	-0.0602	-0.0172	-0.0584	-0.0167
	(0.040)	(0.057)	(0.057)	(0.084)	(0.024)	(0.084)	(0.024)
Individual controls:							
Age	0.0009	0.0009	0.0009	0.0038	0.0011	0.0038	0.0011
	(0.002)	(0.002)	(0.002)	(0.003)	(0.001)	(0.003)	(0.001)
Female	0.0793**	0.0793*	0.0791*	0.0998	0.0285	0.0996	0.0284
	(0.040)	(0.046)	(0.046)	(0.073)	(0.020)	(0.073)	(0.021)
Schooling	0.0045	0.0045	0.0046	0.0043	0.0012	0.0043	0.0013
	(0.004)	(0.004)	(0.004)	(0.006)	(0.002)	(0.006)	(0.002)
Spanish	-0.0070	-0.0070	-0.0071	-0.1376	-0.0378	-0.1378	-0.0379
	(0.079)	(0.094)	(0.094)	(0.153)	(0.040)	(0.153)	(0.040)
Seniority in firm	-0.0063***	-0.0063**	-0.0063**	-0.0091**	-0.0026**	-0.0091**	-0.0026**
	(0.002)	(0.002)	(0.002)	(0.004)	(0.001)	(0.004)	(0.001)
Temporary contract	0.0179	0.0179	0.0173	0.0546	0.0156	0.0536	0.0153
	(0.054)	(0.056)	(0.056)	(0.086)	(0.024)	(0.086)	(0.024)
Manager	0.3198***	0.3198***	0.3194***	0.4662***	0.1159***	0.4655***	0.1158***
	(0.048)	(0.050)	(0.050)	(0.092)	(0.020)	(0.092)	(0.020)
Supervisor	0.4313***	0.4313***	0.4313***	0.6415***	0.1508***	0.6413***	0.1508***
	(0.039)	(0.042)	(0.042)	(0.084)	(0.016)	(0.084)	(0.016)
Sector Fixed Effects	YES	YES	YES	YES	YES	YES	YES
R-squared/ Pseudo R-squared	0.093	0.093	0.093	0.0625	0.0625	0.0622	0.0622
Observations	3,604	3,604	3,604	3,589	3,589	3,589	3,589

Notes: Robust standard errors in parentheses. Except for model I standard errors are clustered by firm. *** p<0.01, ** p<0.05, * p<0.1
A - index computed as the sum of z-scores of the variables;
B - index computed as a weighted sum of the variables z-scores using the weights (scores) from the main principal component of factor analysis.

Table 5. Relation between Teamwork and Delegation of Decisions --Probit Models, Marginal Effects

	(I)	(II)	(III)
Delegation Index -- All Decisions	**0.0219**		
	(0.023)		
Delegation Index - Task Decisions			**0.0071**
			(0.016)
Delegation Index - Strategic Production Decisions			**0.0340***
			(0.021)
Interaction Task & Strategic Production Decisions			**-0.0181**
			(0.021)
Delegation and PIP Index		**0.0320****	
		(0.014)	
Dummy - Wage has a variable component	0.0311	0.0476**	0.0497**
	(0.028)	(0.024)	(0.024)
Use of Other Production and Info Practices (PIP):			
Suggestion practices	0.0081		
	(0.013)		
Job turnover	-0.0027		
	(0.013)		
Workplace redesign	0.0223		
	(0.014)		
Problem solution teams	-0.0026		
	(0.015)		
Semi-autonomous working groups	0.0053		
	(0.014)		
Quality circles	0.0124		
	(0.015)		
TQM	0.0031		
	(0.019)		
Firm controls:			
Firm Size (log)	0.0246	0.0310**	0.0337***
	(0.015)	(0.012)	(0.012)
Firm Age (log)	0.0295*	0.0197	0.0186
	(0.017)	(0.014)	(0.014)
Family firm	-0.0167	-0.0193	-0.0158
	(0.027)	(0.024)	(0.024)
Individual controls:			
Age	0.0009	0.0011	0.0011
	(0.001)	(0.001)	(0.001)
Female	0.0171	0.0276	0.0283
	(0.023)	(0.020)	(0.020)
Schooling	0.0012	0.0013	0.0014
	(0.002)	(0.002)	(0.002)
Spanish	-0.0487	-0.0391	-0.0365
	(0.039)	(0.039)	(0.040)
Seniority in firm	-0.0023*	-0.0026**	-0.0026**
	(0.001)	(0.001)	(0.001)
Temporary contract	0.0212	0.0153	0.0151
	(0.025)	(0.024)	(0.024)
Manager	0.1208***	0.1162***	0.1149***
	(0.021)	(0.020)	(0.020)
Supervisor	0.1531***	0.1502***	0.1500***
	(0.017)	(0.016)	(0.016)
Sector Fixed Effects	YES	YES	YES
Pseudo R-squared	0.0759	0.0642	0.0627
Observations	2,931	3,589	3,589

Notes: Robust standard errors, clustered by firm, in parentheses. *** p<0.01, ** p<0.05, * p<0.1
The delegation indeces are computed as the weighted sum of the variables z-scores using the weights (scores) from the main principal component of factor analysis.

Table 6. Factor loadings for delegation of decision and PIP variables

	Factor1
Production and Information Practices Variables:	
PIP1: Suggestion boxes	0.4174
PIP2: Job turnover	0.1944
PIP3: Job redesign	0.3251
PIP4: Problem-solving teams	0.3919
PIP5:Semi-autonomous teams	0.2718
PIP6: Quality circles	0.4019
PIP7:Total Quality Management	0.4174
Delegation of decisions variables:	
Daily task plannning	0.2171
Weekly task plannning	0.3100
Follow-up of results	0.3759
Customers relations	0.2563
Quality control	0.3047
Supply purchases	0.3334
Machinery and equipment maintenance	0.3234
Job listing	0.4719
Hiring	0.5528
Production technology decisions	0.5102
Training	0.5048

Table 7. IV Regressions

Dependent Variable:	First Stage Reg **Delegation Index All Decisions** (I)	IV Probit **Teamwork** (II)	IV 2SLS **Teamwork** (III)	First Stage Reg **Delegation Index Task Decisions** (IV)	First Stage Reg **Delegation Index Strategic Production Decisions** (V)	2SLS IV **Teamwork** (VI)
Export Intensity	0.0250**			0.0443***	0.0119**	
	(0.012)			(0.008)	(0.006)	
Manager-workers Shared Information Systems				-0.0230*	0.0563***	
				(0.014)	(0.013)	
Delegation Index -- All Decisions		**1.3177*** **	**0.6786***			
		(0.423)	**(0.396)**			
Delegation Index - Task Decisions						**0.1615**
						(0.215)
Delegation Index - Strategic Production Decisions						**0.8719****
						(0.400)
Dummy - Wage has a variable component	-0.0366	0.1895**	0.1270*	0.0443	-0.0866***	0.1662***
	(0.052)	(0.093)	(0.067)	(0.036)	(0.028)	(0.064)
Firm controls:						
Firm Size (log)	0.0297	0.0485	0.0892**	0.0874***	-0.0101	0.1080***
	(0.037)	(0.069)	(0.040)	(0.014)	(0.012)	(0.031)
Firm Age (log)	0.0456	-0.0065	-0.0025	0.0427***	0.0779***	-0.0310
	(0.033)	(0.064)	(0.040)	(0.014)	(0.012)	(0.039)
Family firm	0.0404	-0.1061	-0.0687	0.0016	0.0254	-0.0768
	(0.066)	(0.110)	(0.082)	(0.027)	(0.023)	(0.051)
Individual controls:						
Age	-0.0003	0.0033	0.0009	0.0010	-0.0014	0.0009
	(0.001)	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)
Female	-0.0230	0.1061	0.0927*	0.0077	-0.0389	0.1066**
	(0.031)	(0.068)	(0.049)	(0.030)	(0.024)	(0.051)
Schooling	0.0081**	-0.0064	-0.0005	0.0113***	0.0033	-0.0013
	(0.003)	(0.007)	(0.006)	(0.003)	(0.003)	(0.006)
Spanish	0.0092	-0.1301	-0.0225	0.0974*	-0.0684	-0.0136
	(0.060)	(0.136)	(0.093)	(0.053)	(0.066)	(0.099)
Seniority in firm	-0.0004	-0.0064	-0.0061**	0.0003	-0.0004	-0.0057**
	(0.002)	(0.004)	(0.003)	(0.002)	(0.001)	(0.003)
Temporary contract	-0.0617	0.0944	0.0372	-0.1182***	-0.0152	0.0186
	(0.039)	(0.085)	(0.067)	(0.039)	(0.037)	(0.070)
Manager	-0.0719**	0.4631***	0.3825***	-0.0890**	-0.0358	0.3850***
	(0.031)	(0.105)	(0.062)	(0.038)	(0.034)	(0.063)
Supervisor	-0.0073	0.4951***	0.4444***	-0.0479	0.0154	0.4481***
	(0.029)	(0.142)	(0.047)	(0.033)	(0.033)	(0.052)
Sector Fixed Effects	YES	YES	YES	YES	YES	YES
R-squared/ Pseudo R-squared	0.083			0.194	0.118	
Partial R-squared	0.005			0.011	0.007	
F-statistic	14.347			15.578	11.299	
(p-value)	0.0002			0.0000	0.0000	
Observations	3,523	3,468	3,483	3,234	3,234	3,234