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DELEGATION OF AUTHORITY IN BUSINESS ORGANIZATIONS: AN EMPIRICAL TEST*

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This paper tests the predictions of economic theory on the determinants of the allocation of decision-making power through the estimates of ordered probit models with random effects. Our findings show that the complexity of plants' operations and organization, the characteristics of the communication technologies in use, the ownership status of plants and the product mix of their parent companies figure prominently in explaining whether authority is delegated to the plant manager or not. In addition, the nature of the decision under consideration turns out to affect the allocation of authority.

I. INTRODUCTION

ECONOMISTS ARE INCREASINGLY CONCERNED with the internal working of firms and in particular with the determinants of the allocation of decision-making power. A rich stream of theoretical papers which will be briefly surveyed in what follows, has recently addressed such issues. Nevertheless, empirical studies are much less numerous and generally rely upon 'personal experience' and anecdotal evidence. Probably, the most severe problem that economists find in addressing these issues empirically is collecting data which may be suitable for testing theoretical hypotheses.

As far as we know, this paper represents the first attempt to provide systematic quantitative evidence on the determinants of the allocation of

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decision-making authority in business organizations.[1] More precisely, the aim of the paper is to test some of the predictions of economic theory in a comprehensive and robust way through the estimates of econometric models. For this purpose, we have designed a questionnaire analysis which has provided detailed information for a sample of 438 Italian manufacturing plants on the delegation to the plant manager of the responsibility for a number of strategic decisions relating to production activity or its centralization at a higher corporate level. The inquiry has also provided additional data on a series of variables that describe the organizations of both the plant and its parent firm.

Theoretical studies have highlighted that different factors shape the allocation of decision-making power. Namely, delegation of decision authority implies benefits and costs for the firm. There are mainly two kinds of models that analyze this issue. The first focuses on information processing, the second on decentralization of incentives.[2]

The information processing stream ignores the problem of conflicting objectives among bureaus (teams or agents) and analyzes the issue of coordination of imperfectly informed agents. The rationality of agents is bounded *à la* Simon, in the sense that 'the scarce resource is not information; it is processing capacity to attend to information' (Simon [1973]). Suppose that in each period a firm selects one or more out of N possible projects of m types and that the firm's screening over the projects is not perfect. Sah and Stiglitz [1986] and [1988] show that since centralized organizations select a relatively lower number of projects than decentralized architectures do, then decentralization emerges as an efficient arrangement in situations where projects are on average of a good type. If we allow for heterogeneous tasks and increasing returns from task specialization (Bolton and Dewatripont [1994]), decentralization permits agents to specialize in different types of tasks. By delegating decision-making to the agent who has the best information relating to a given decision, firms can fully exploit economies arising from local capabilities and tasks specialization (Geanakoplos and Milgrom [1991]).

Furthermore, the information processing stream highlights the fact that hierarchical organizations that centralize the decision-making function suffer from organizational failures due to information transmission leaks (Keren and Levhari [1979], [1983] and [1989]) and delays (Radner [1993], van Zandt [1999]) in transmitting information from the pinnacle to the bottom of the hierarchy. Hence, general strategies defined by the superior (i.e. the top management) might differ from those implemented by subordinates simply because of inefficiencies in intra-firm communication. In addition, they may

[1] For a similar attempt in a different context see Lerner and Merges [1998].

[2] A more detailed classification of the theoretical literature lies beyond the scope of the present paper, given its empirical nature. For a review, see Radner [1992] and van Zandt [1998].

fail to produce the expected benefits because of implementation delays. In particular, decentralization reduces delays because it allows tasks to be performed concurrently.

Turning to the decentralization of incentives setting, Laffont and Martimort [1998] argue that decentralization emerges whenever limits of communication and collusive behavior among agents are taken together into account. Otherwise, centralization dominates decentralization. Aghion and Tirole [1997] consider a situation in which an agent is assigned the task of selecting and implementing one out of *N* projects, even though the principal keeps the right to overrule his decisions (that is, formal authority remains with the principal). Projects differ as to both the (non contractible) monetary gains for the principal and the private benefits they provide to the agent. So principal's and agent's objectives may not be congruent. Under such circumstances, it is shown that the transfer of decision authority to the agent depends positively on the information advantage he enjoys with respect to the principal[3] and the extent of the private benefits he can extract from exercise of decision-making power. Namely, if the agent's private benefits are large, delegation may increase both his initiative to acquire information and his participation in the contractual relationship.

The cost of delegating authority is the superior's loss of control over the choice of the project. Thus, loss of control assumes the form of deviation of the firm's activity from the objectives of the superior. As is natural in a context of asymmetric information, agents are tempted to hide valuable information in order to pursue objectives that in general are different from those of their superior, and maximize their own utility. Therefore, if monitoring agents' behavior is difficult, centralization of decision-making follows.[4] In addition, when the principal's and the agent's interests are not aligned, decisions about projects that possibly involve a large pay-off to the principal tend to be centralized, as there is a great opportunity cost for the principal if the agent selects a sub-optimal project (see again Aghion and Tirole [1997]).

To sum up, factors that influence the above mentioned benefits and costs of delegating decision-making authority (i.e., increase of agent's initiative and participation, exploitation of agent's competencies, avoidance of information leaks, and timely decision-making on the one hand; increase of

[3] In Aghion and Tirole's model, if the parties are uninformed they incur the risk of selecting a project with negative pay-off (negative monetary gains for the principal and negative private benefits for the agent). Therefore, the less informed the principal, the more likely that he optimally rubber-stamps the agent's proposal.

[4] It is worth noticing that in this paper the term 'monitoring' is used broadly to include both the direct observation of the agents' actions and the availability of good performance measures on which efficient incentive schemes can be based. See for instance Milgrom and Roberts [1992, Chapters 6 and 7].

principal's loss of control on the other) make delegation more or less profitable, hence more or less likely.

The remaining part of the paper is organized as follows.The next section is devoted to the analysis of some of the crucial factors that, according to economic theory, shape the allocation of decision-making power between a plant manager (i.e., the agent) and his corporate superior (the principal). Section III presents the design of the empirical analysis we have run in order to collect data on the allocation of decision-making authority within Italian manufacturing plants. In Section IV, the econometric model is specified and the explanatory variables are illustrated. In Section V we show the empirical results. Section VI sums up conclusions.

II. DETERMINANTS OF THE DELEGATION OF DECISION-MAKING POWER IN MANUFACTURING PLANTS

In this section, we are interested in factors that, in accordance with the theoretical literature that has been synthesized above, are likely to influence the relative allocation of decision-making power between a plant manager and his corporate superior. Such factors relate to both the characteristics of a firm's organizational structure, other plant-specific variables and the nature of the decisions at hand. They can be grouped into three families.

Firstly, there are factors that increase the need to delegate authority to the plant manager as they make centralization of decisions relatively ineffective. These include factors limiting the flow of information within the firm and factors making local knowledge or a quick response important. For instance, *complexity* and *size of organizations*, by generating overload of information within the firm, increase the principal's marginal disutility of getting informed, and press him to leave decision-making power to the plant manager who is closer to plant's operations and therefore enjoys an information advantage. Similarly, if prompt implementation is valuable for a firm, *urgency* of decisions should also favor assignment of authority to the plant manager (Keren and Levhari [1989], Radner [1993]). Aghion and Tirole [1997] analyze the effect of urgency in an extension of their basic model; they conclude that 'the principal is more likely to rubber-stamp, the more urgent the decision' (p. 26).[5] Accordingly, whenever a plant's organization is shaped by the desire to reduce 'time to market' and assure quick response to external stimuli, we expect responsibility for decision-making to be quite decentralized. In addition, Aghion and Tirole [1997] show that the need to delegate authority to a (plant) manager is higher for *decisions that involve large private benefits for the agent*; these include, for

[5] The reason is that for any level of principal's effort, urgency in decision-making results in an increase of his marginal disutility: the more he oversees, the slower the decision-making process, the lower the returns from implementing the selected project.

instance, decisions relating to a plant's workforce that affect both the plant manager's power and personal relationships with subordinates (for further details see Section IV(ii)).

Nevertheless, it is important to recognize that the information advantage of the plant manager on local matters and the leaks and delays of transmitting orders down the corporate hierarchy can be reduced through use of *advanced communication technologies*. Indeed, the costs of using information[6] and of communicating[7] are altered by recent technological improvements. Such improvements increase the ability of the corporate headquarter to collect and process information on a plant's operations; since the principal's costs of investigation decrease, assignment of decision authority to the plant manager should be less frequent (Aghion and Tirole [1997]). The inefficiencies of communicating orders down the managerial hierarchy also are reduced. This reinforces the tendency to centralization of decisions, consistent with the arguments highlighted by the information processing literature (Keren and Lehvari [1979] and [1983], Radner [1993).

Secondly, there are factors that hinder decentralization because they make coordination important. This set of factors is mostly relevant for firms with more than one plant. So, a plant's *ownership status* is likely to affect the organization of decision-making between a plant manager and his corporate superior. Within multi-plant firms, investment and pricing policies, for example, might need to be coordinated in order to properly exploit economies of scale (e.g., in purchasing equipment) or avoid counter-productive internal competition (i.e., cannibalization). Hence, locally optimal decisions are less likely to also be optimal for the firm as a whole, as there are externalities on other units. With all else equal, centralization of decision-making at the level of the plant manager's corporate superior is more likely than in a single-plant firm.[8] More generally, coordination is important independently of a plant's ownership status whenever decisions involve considerable financial resources, since a plant competes with the other organizational units of its parent firm for the use of fixed corporate resources. In particular, we expect the *externality* argument to have a greater influence on decisions that concern capital rather than labor (for further details, see again Section IV(ii)).

[6] The cost of using information about the environment is not simply the cost of collecting the information, but also the human cost of processing and understanding information (van Zandt [1998], p. 25).

[7] The cost of communication within an organization includes the receiver's processing cost and the sender's cost of formulating the message (van Zandt [1998], p. 25).

[8] It is crucial to emphasize that the impact of a plant's ownership status upon the organization of decision-making may be moderated by other variables which influence the costs for the principal of collecting and transmitting information, of checking agent's behavior, and of designing and implementing high powered incentive schemes. In particular, such argument applies to the adoption of advanced communication technologies. We will come back to this issue in Section IV(ii).

Thirdly, the observed degree of decentralization is also crucially influenced by a firm's ability to decentralize. This in turn depends on the ability of the corporate superior (i) to observe the behavior of the plant manager or (ii) to design efficient incentive schemes if there are substantial ex-post information asymmetries, thus realigning agent's and principal's objectives (Hubbard [2000]). This means that any factor that increases the observability of the plant manager's decisions or makes available better performance indicators to which the plant manager's compensation can be tied, thus rendering monitoring easier for the corporate superior, should translate into greater decentralization. Two such factors are worth mentioning here. On the one hand, *multi-plant firms* should be better able to design effective incentives schemes as they can rely on some form of yardstick competition. This would be especially effective if plants had similar product lines (i.e., for non diversified multi-plant firms). So, with all else equal (in particular, the need for greater coordination in a multi-unit setting), multi-plant firms with homogenous product lines should adopt a more decentralized organization than other firms. On the other hand, adoption of *advanced communication technologies* may result in greater transparency of plant managers' decisions. Again, with all else equal, more delegation to lower levels will follow.

As a final remark, it is important to emphasize that the theoretical arguments illustrated above indicate that some of the above mentioned variables (e.g., ownership status of plants, use of advanced communication technologies) may have different and contrary effects on the delegation of decision-making authority to plant managers. So determining which effect prevails is a matter of empirical testing.

III. DATA

So far, the greatest obstacle to the direct measurement of the allocation of decision-making activities and the analysis of its determinants has been the lack of large scale data sets. In this paper, we use information on the organization of plants and their parent companies for a sample composed of 438 Italian manufacturing plants.[9] The analysis was conducted in 1997. A questionnaire was mailed to the plant managers of 708 Italian manufacturing plants that were in operation in June, 1997;[10] the response rate was 62%.

[9] Actually, the sample plants are in the metalworking sector which includes the following two-digit NACE-CLIO industries: production of metals (27), fabricated metals (28), non-electrical machinery (29), computers and office equipment (30), electrical machinery and electronics (31), communication equipment (32), scientific, precision, medical and optical instruments (33), automotive industry (34), and other transportation equipment (35).

[10] The sample was initially drawn in 1989 and was composed of 810 plants that were in operation in 1986. It was stratified for plant size, industry and geographical location so as to fully represent the 1986 universe of all Italian metalworking plants with more than 10

All the information relating to the organization of plants has been provided by the plant managers. For each plant, the plant manager was directly contacted either by phone or personally in order to check the accuracy of answers (and to complete the questionnaire if needed). In particular, detailed data was provided by the questionnaire survey on the decision-making structure of each sample plant.[11] The data used in this paper concern who within the firm (that is, which managerial level) takes strategic decisions related to the plant's activity. We consider the following six plants' strategic decisions: (i) introduction of new technologies, (ii) investment in new production lines, (iii) investment in stand-alone machinery, (iv) hiring and dismissal of personnel, (v) career paths, and (vi) design of individual and collective incentive schemes.[12]

We focus on the relationship between the plant manager (the agent) and his corporate superior (the principal), where the latter is either the firm's owner or a salaried manager. In the latter case the principal is an intermediary of the owner(s), a situation typical of (even though not confined to) establishments that are owned by large multi-plant firms. The former case especially applies to small entrepreneurial firms. Further, notice that when firms are very small, there may be no plant manager, at least formally. In such cases the agent is the person responsible for supervising production. In what follows, for the sake of brevity and simplicity, we shall always use the term 'plant manager.'

In order to test the determinants of the delegation of decision-making authority, we have distinguished three ranked modes of allocating plants' strategic decisions.

1. *Centralization (C)*. Decisions under scrutiny are taken autonomously by the plant manager's corporate superior, with the plant manager being assigned an implementation role. In this case, the plant manager can make proposals, but decision-making is a superior's matter. So this situation corresponds to the minimum degree of delegation.

2. *Partial delegation of decision authority (DI)*. The plant manager is in charge of the decision, but formal authorization by the corporate superior

employees. Nevertheless, the sample used in this work is not random. First, it does not include plants that were established after 1986. In addition, the attrition of 102 plants between 1986 and 1997 is not random (see Colombo and Delmastro [2001]). Lastly, the plants that decided not to participate in the 1997 survey might differ from those that did in a way that we are not able to assess. What is important to emphasize here is that there is no reason to assume that the biases that may affect the sample significantly influence the relation between the explanatory variables considered in this work and the allocation of decision authority.

[11] See Colombo and Delmastro [1999] and Delmastro [2002] for quantitative evidence on some key variables of the organization of sample plants such as the number of hierarchical levels, the span of control and the allocation and concentration of decision-making activities.

[12] Both decisions ii) and iii) concern investments in new capital equipment, with the main difference being the greater amount of financial resources involved on average by the former decision.

is needed. In this case, decision authority is partially delegated to the plant manager, even though his decisions may be overruled by the superior.

3. *Full delegation of decision authority (DII)*. In this case, decisions are taken autonomously by the plant manager with no intervention by the superior. Note that as a matter of fact, the superior always keeps the right to overrule the plant manager, as he ultimately can fire him. Nonetheless, this situation corresponds to the maximum degree of decentralization of decision authority, as the plant manager has far greater autonomy than in the previous cases.

Thus, for each sample plant and for each of the six aforementioned plant-strategic decisions, we know who (the plant manager or his corporate superior) is in charge and how the decision is taken. In other words, we know how authority is allocated between the two parties. In particular, in 42% of the 2,638 observations (i.e., 438 plants time 6 decisions) decision authority is centralized at the corporate superior's level; partial and full delegation account for 32% and 26% of total observations, respectively.

IV. THE ECONOMETRIC MODEL

IV(i). *The Specification of the Econometric Model*

We test theory by analyzing the impact of the explanatory variables which will be illustrated in Section IV(ii), on the allocation of decision-making. The choice faced by the parent firm of plant j is the definition of the optimal degree of delegation of authority over decision i (i.e., D^*_{ij}). This can be modeled as a discrete choice problem. As was said earlier, we let the firm allocate each of the six aforementioned plants' strategic decisions into three different ranked modes: centralization (C), partial delegation of decision authority (DI), and full delegation of decision authority (DII), with $C < DI < DII$ (in terms of degree of delegation of authority to the plant manager).

The choice of the decision mode reflects the maximization of the firm's profits. Let D^*_{ij} be the 'optimal' degree of delegation (i.e., the one that maximizes firm's profits) which is a random attribute of feasible choices. For each plant j ($j = 1, \ldots, 438$) and decision i ($i = 1, \ldots, 6$) we define D^*_{ij} as:

$$D^*_{ij} = V_{ij} + \varepsilon_{ij}$$

where ε_{ij} is a random disturbance and V_{ij} is a deterministic component, which depends on two sets of explanatory variables: one, denoted by X_j, includes plant-specific characteristics, the other, denoted by Z_i, includes decision-specific variables.

Clearly D^*_{ij} is unobserved. What we observe is D_{ij}, which assumes ranked values equal to C, DI and DII, and whose relation with the optimal degree of delegation is:

$$D_{ij} = C \quad if\, D^*_{ij} \leqslant \mu_0$$
$$D_{ij} = DI \quad if\, \mu_0 < D^*_{ij} \leqslant \mu_1$$
$$D_{ij} = DII \quad if\, D^*_{ij} > \mu_1$$

where μ_k ($k = 0,1$) are the thresholds that separate the different discrete categories of delegation of authority. With no loss of generality, we can set $\mu_0 = 0$ and $\mu_1 = \mu$.

Given the categorical ordered nature of the dependent variable we proceeded to estimate ordered probit models. Note that the sample is composed of 438 plants and for each plant there are six decisions so that the total number of observations is 2,628. However, these are not 2,628 independent observations. In fact, there are only 438 independent observations as observations relating to different strategic decisions in a given plant are likely to be correlated. This correlation is due to unobserved plant-specific effects that influence the overall allocation of decision-making of plants, independently of the nature of individual decisions. For instance, in the family-owned firms that account for the large majority of the sample, owner-managers may be unwilling to delegate authority downwards to plant managers due to psychological motivations (i.e., personal preferences for autocratic decision-making). In addition, the allocation pattern of decision authority as observed at the survey date may depend on the specific history of each plant, due to irreversibilities and organizational inertia (see Colombo and Delmastro [2002]). To deal with this problem, we estimated ordered probit models with random effects.[13]

Before proceeding further with the definition of the explanatory variables, an additional remark is in order. In this paper, we focus on the optimal allocation of decision-making power and relate the degree of decentralization of decision authority, the dependent variable of the econometric model, to a set of plant-and decision-specific characteristics. However, it is clear that the allocation of authority over strategic decisions is but one element in a set of decisions firms make as regards the organization of plants. Such decisions include for instance the size of the managerial hierarchy, the number and quality of plant employees, the use of incentive schemes to motivate employees, the type of technologies in use and more generally the overall organization of the parent firm. In other words, there likely is simultaneity between D^*_{ij} and other variables that in this work are considered as independent. Nonetheless, the great number of potentially endogenous

[13] It is worth noticing that fixed effects models cannot be estimated since most of the independent variables are plant-specific and do not vary across types of decisions.

TABLE I
THE EXPLANATORY VARIABLES OF THE ECONOMETRIC MODELS

Variable	Description
Size	Logarithm of the number of plant employees
Level	Number of hierarchic levels of plant organization
Just-in-time	1 for plants that have adopted just-in-time production methods; 0 otherwise
Multi-plant	1 for plants that belong to multi-plant parent companies; 0 otherwise
Multi-plant diversified	1 for plants that belong to multi-plant parent companies and meet the following two conditions: a) the parent company has more than 25,000 employees and b) no one of its product lines accounts for more than 70% of total sales; 0 otherwise
Multi-plant dominant business	1 for plants that belong to multi-plant parent companies and do not meet conditions (a) and/or (b); 0 otherwise
Subcontractor	1 for plants with more than 75% of total sales earned as a subcontractor; 0 otherwise
Capital intensity	1 for plants that have invested in large-scale capital equipment, such as (inflexible) manufacturing line systems (IMSs); 0 otherwise
Network	1 for plants that have adopted advanced network technologies (i.e. use of network technology to exchange technical data and general information with other departments, headquarters, and between different points on the factory floor); 0 otherwise
D-Capital	1 for decisions concerning purchase of plant capital equipment, i.e. technological innovations, large-scale capital equipment, stand-alone machinery; 0 otherwise
D-Labor	1 for decisions concerning plant workforce, i.e. hiring and dismissal, career paths, incentive schemes; 0 otherwise
D-Technology	1 for decisions concerning the introduction of technological innovations; 0 otherwise
D-Capital equipment	1 for decisions concerning the purchase of large-scale capital equipment; 0 otherwise
D-Machinery	1 for decisions concerning the purchase of stand-alone machinery; 0 otherwise
D-Hiring and dismissal	1 for decisions concerning hiring and dismissal; 0 otherwise
D-Career path	1 for decisions concerning plant employees' career paths; 0 otherwise
D-Incentive schemes	1 for decisions concerning the design and/or implementation of incentive schemes; 0 otherwise

variables and their non linear nature make it impossible to estimate a simultaneous equation model.

IV(ii). *Explanatory Variables*

In order to test the predictions of economic theory as to the determinants of the allocation of decision-making power, we considered plant-specific characteristics (X_j) and decision-specific variables (Z_i) that reflect the three sets of factors illustrated in Section II: factors that increase the need to decentralize, factors that hinder decentralization because of coordination issues, and factors that influence the ability to decentralize.

Before presenting the explanatory variables, a preliminary comment is in order. While some variables are unambigously associated with a particular set of factors, others capture various effects. In this latter case, as opposed forces may be at work, the sign of the coefficient of such variables cannot be predicted ex-ante. In Table I we report the definition of the explanatory

TABLE II
THE EXPECTED EFFECTS OF THE EXPLANATORY VARIABLES ON DELEGATION OF AUTHORITY TO THE PLANT MANAGER

Variables	Increased need for delegation	Increased need for coordination	Greater ability to delegate	Net effect
Complexity of plant's operations (Size, Level)	+			+
Urgency (Just-in-time)	+			+
Multi-plant diversified	+	–	–	?
Multi-plant dominant business	+	–	+/–	?
Subcontractor		–		–
Capital intensity		–		–
Network	–		+	?
Network × Size	–			–
Network × Multi-plant	–		+	?
Just-in-time × Multi-plant		–		–
Just-in-time × Subcontractor		–		–
Labor decisions	+			+
Capital decisions		–		–

Legend
(+) Predicted positive coefficient.
(–) Predicted negative coefficient.
(?) Ambiguous predictions.

variables. A synthesis of their expected impact on decentralization of decision authority is illustrated in Table II.

Complexity and size of plants' organization increase the need to delegate decision-making authority to plant managers; they are captured by two variables. *Level* is the number of hierarchical levels of the plant. *Size* is the logarithm of the number of plant employees.

A number of variables reflect the structure and organization of plants' parent companies. *Multi-plant* is a dummy variable that is one when a plant belongs to a multi-plant firm, and is zero when the plant is owned by a single-plant firm. Further, we distinguished multi-unit firms according to their mix of product lines: *Multi-plant diversified* is a dummy variable that is one when a plant's parent company is large and diversified (i.e., it has more than 25,000 employees and no one of its product lines accounts for more than 70% of total sales), while *Multi-plant dominant business* is a dummy variable that is one for the remaining multi-plant parent companies (i.e., smaller and/or non diversified multi-unit firms).[14] The expected sign of the two multi-plant variables is uncertain as opposed forces may be at work. On the one hand, in a multi-unit setting there is greater need for coordination, which may hinder delegation of authority to plant managers. On the other hand, recourse to yardstick competition may increase the ability of the corporate head-

[14] Data are derived from R&B [1998], Hoover *et al.* [1998a and 1998b], and Company Reports.

quarters, to decentralize decision-making. This especially applies to dominant business multi-plant firms (i.e., *Multi-plant dominant business* equals 1). In addition, physical distance between the plant manager and his corporate superior generally is greater if the plant belongs to a multi-unit firm. This again may have opposite effects on delegation. On the one hand, greater physical distance reinforces the information advantage on local matters enjoyed by the plant manager and makes communication with the corporate superior more difficult, thus favoring decentralization of decision-making. On the other hand, it also makes it more difficult for the superior to directly check the decisions taken by the plant manager. Absent efficient incentive schemes, this should lead to more centralization.

The fact that a plant is involved in subcontracting relations with customer(s) is likely to negatively affect delegation of authority to the plant manager due to greater need for coordination. Since subcontractors are pressed to adjust their production operations according to the needs of main customer(s), we expect them to have a more centralized allocation of decision-making power than other plants. We captured this effect by the dummy variable *Subcontractor* which equals one for plants with more than 75% of total sales earned as a subcontractor.

On the contrary, urgency of decisions favors delegation. It is proxied by *Just-in-time*, a dummy variable which equals one whenever a sample plant makes use of 'just-in-time' (JIT) production methods. Indeed, firms that adopt JIT are pressed to deliver their products quickly, and to adjust production schedules over time in accordance with variations of the demand; consequently, they heavily rely on the speed of taking and implementing production decisions. However, the expected sign of *Just-in-time* appears also to depend on the type of activity of a plant and the overall structure of its parent firm. As to this latter aspect, if a plant belongs to a multi-unit firm and mostly produces goods that are used by other plants/divisions of the same firm, then the greater need for coordination engendered by adoption of such new production techniques (Brynjolfsson and Hitt [2000]) might determine less, and not more, delegation to the plant level. A similar reasoning applies to plants that are mainly involved in subcontracting. For this reason, we investigated possible interactions between *Just-in-time* and the ownership status (i.e., whether multi-plant or not) and main type of activity (whether subcontracting or not) of sample plants.

Adoption of advanced communication technologies is captured by *Network*, a dummy variable that equals one if a plant has adopted Local Area Network (LAN) and/or on-line connection with the corporate headquarters. As was pointed out in Section II, more efficient communication technologies may reduce both the information advantage of the plant manager on local matters and the leaks and delays of transmitting orders down the corporate hierarchy; accordingly, centralization of decision-making may follow. Nonetheless, we also stressed that the enhanced capabilities of the corporate headquarters to monitor plant managers' decisions due to use of advanced network technologies positively influence firms' ability to decentralize decision-making. Therefore, the net impact of *Network* on the allocation of decision-making authority is uncertain.

In addition, the relative importance of the above mentioned effects (i.e., decrease of the information advantage of the plant manager with respect to his corporate superior, greater efficiency of transmitting orders to the plant manager and of monitoring his behavior) may be contingent on other variables. Among them, the size and ownership status of plants figure prominently. For this purpose, we introduced into the econometric models the interactive terms *Network* × *Size* and *Network* × *Multi-plant*. The former term aims to investigate the interaction between complexity of a plant's operations and the decrease of the cost of using information due to the adoption of advanced communication technologies (see footnote 6); in particular, we expect the positive influence exerted by plant size on delegation of decision-making power to be considerably reduced if a plant is equipped with advanced communication technology, as the plant manager no longer enjoys a substantial information advantage as regards local matters. The latter term considers interaction between decreases in the costs of communicating (see footnote 7) and of monitoring, due again to the use of advanced communication technologies, and physical distance between the plant manager and his corporate superior which, as was said earlier, generally is greater in a multi-unit setting. Whenever the net effect (positive or negative) of *Network* on delegation of authority, such effect is likely to be more pronounced the greater the distance between agent and principal (and hence the costs for the principal of being informed on local matters, communicating with and monitoring the behavior of the agent).

Lastly, let us draw attention to the nature of strategic decisions. First of all, one might argue that if decisions relating to a plant's activity involve on average a greater amount of resources, they also involve greater externalities as a plant competes with other organizational units (e.g., other functional departments, other manufacturing units in multi-plant firms) for use of firm's financial resources. As more is at stake, less decentralization of decision-making follows due to the need for effective coordination of decisions. The above condition depends, among other things, on the characteristics of a plant's production technology and organization of production activity. For instance, it generally holds true for plants that are involved in mass production of rather standardized goods and are characterized by large, highly indivisible investments in automated capital equipment, since strategic decisions relating to production factors (both capital and labor) basically are of discrete nature (i.e., adding or closing a production line). So, we introduced into the econometric estimates the dummy variable *Capital intensity*, that is set at one for plants that have introduced large-scale capital equipment, such as (inflexible) manufacturing line systems. This variable takes into account situations in which capital intensity is high, hence decisions on a plant's activity involve on average a greater amount of resources.

In addition, in a given plant, strategic decisions relating to different matters may be organized differently, with some being delegated to the plant manager and others being retained at the corporate superior's level, according to the specific characteristics of the decision. In Section II it was claimed that as a general rule (see Aghion and Tirole [1997]), decisions that have little (great) impact on the principal's economic returns and great (little) impact on the agent's private benefits should be decentralized (centralized). Furthermore, absent efficient incentive schemes, decisions that require greater coordination, as the objectives pursued by a plant manager are likely to diverge from those of the firm as a whole, should be retained with the plant manager's superior, while decisions for which the plant manager clearly enjoys an information advantage should be delegated. Such reasoning has a number of implications.

First, decisions concerning *capital investments* should be kept more centralized than those concerning the *workforce* due to the greater amount of financial resources and the greater externalities involved in each individual decision. In addition, the information advantage of the plant manager with respect to his corporate superior is greater for decisions about whom to hire, promote, or fire, as such decisions rely on personal, largely tacit knowledge of local conditions within the plant, as opposed to the more codified, technical nature of capital investment decisions. Note also that control over such labor-related decisions is the very essence of a plant manager's personal power, and that his superior's choices in this matter may be very detrimental to him, as they may jeopardize personal relations with his own subordinates. This means that the private benefits the plant manager can extract from decisions concerning the workforce are on average larger than those relating to capital investment decisions.[15]

Second, as to decisions concerning investments in capital equipment, the larger the amount of the investments the less likely decentralization. As to decisions concerning a plant's labor force, decision authority is more likely to be kept centralized if decisions affect other units of the firm and decentralized if they have a larger impact on the plant manager's activity. Decisions on the adoption of general schemes of payment of the labor force belong to the former category, as generally congruence is needed within the

[15] Of course, there are exceptions to this general rule relating to specific decisions. For instance, the plant manager is likely to care more about an investment decision which may make his job trivial than about whom to hire for office cleaning. Nevertheless, the point we want to make here is that lack of power as regards decisions that concern management of the labor force is generally perceived by a plant manager as a serious impediment to the exercise of his function and a potential source of personal problems.

same firm. On the contrary, the latter category includes decisions on career paths within the plant as such decisions are key to motivating the plant manager's subordinates. Lastly, decisions as to hiring and dismissal of a plant's personnel lie somewhat in an intermediate position, as both effects possibly are at work.

We measured the effect of decision-specific variables on the degree of decentralization by introducing the following six dummies: *D-technology*, *D-capital equipment*, *D-machinery*, *D-hiring&dismissal*, *D-career path*, *D-incentive schemes*. They are set to 1 when (once for each plant) the observation under consideration relates to the given decision, that is, the introduction of process innovations, the purchase of large-scale capital equipment, the purchase of stand-alone machinery, hiring and dismissal decisions, decisions relating to the career paths of plant employees, and the definition of incentive schemes, respectively. We initially aggregated different types of decisions into two homogeneous groups: decisions concerning capital investments (i.e., *D-capital*) and those concerning plant's workforce (i.e., *D-labor*). With *D-capital* being chosen as the baseline of the estimates, we predict a positive coefficient for *D-labor*. We also analyzed the impact of each individual decision. In that case, since the six decision variables are exclusive and exhaustive, one (i.e., *D-technology*) has been chosen as baseline and will not appear in the estimates. As to the remaining variables, in accordance with the arguments illustrated above, we expect their coefficients in the estimates to be as follows: *D-capital equipment* < *D-machinery* < 0; *D-career path* > *D-hiring and dismissal* > *D-incentive schemes* > 0.

Table III shows descriptive statistics of the explanatory variables. The distribution of the number of plant's hierarchic levels is concentrated between 3 and 4; the average number of employees is 195 (the mean value of *Size* is 4.48). 58.2% and 71.7% of sample plants have adopted network technology and inflexible manufacturing systems respectively. 46.3% of them have introduced JIT management techniques and 13.7% operate as subcontractors. As to ownership status, more than 22% of sample plants belong to a multi-unit organization. Of them, 10.5% are owned by a large firm characterized by a diversified type of organization. Lastly, decision dummies have obviously both the same mean (given by the ratio between the number of plants, 438, and the number of observations 2,628) and standard deviation.

V. EMPIRICAL RESULTS

Results of an ordered probit estimation with random effects are presented in Table IV; *Model I* is a pooled model where the coefficients of the independent variables are restricted to be the same across the six types of

TABLE III
DESCRIPTIVE STATISTICS OF EXPLANATORY VARIABLES

	Mean	Max	Min	Std. Dev.
Size	4.4818	8.4118	1.6094	1.1854
Level	3.4726	6.0000	2.0000	0.8376
Just-in-time	0.4635	1.0000	0.0000	0.4988
Multi-plant	0.2283	1.0000	0.0000	0.4198
Multi-plant diversified	0.1050	1.0000	0.0000	0.3066
Multi-plant dominant business	0.1233	1.0000	0.0000	0.3288
Subcontractor	0.1370	1.0000	0.0000	0.3439
Capital intensity	0.7169	1.0000	0.0000	0.4506
Network	0.5822	1.0000	0.0000	0.4933
D-Capital	0.5000	1.0000	0.0000	0.5001
D-Labor	0.5000	1.0000	0.0000	0.5001
D-Technology[a]	0.1667	1.0000	0.0000	0.3727
D-Capital equipment[a]	0.1667	1.0000	0.0000	0.3727
D-Machinery[a]	0.1667	1.0000	0.0000	0.3727
D-Hiring and dismissal[a]	0.1667	1.0000	0.0000	0.3727
D-Career path[a]	0.1667	1.0000	0.0000	0.3727
D-Incentive schemes[a]	0.1667	1.0000	0.0000	0.3727

Legend
(a) When one of the six dummies concerning capital and labor decisions is set to 1, then the others are equal to 0. Thus they are exhaustive and mutually exclusive (one has to be chosen as benchmark in the estimates). Obviously, they have the same mean, given by the ratio between the number of plants, 438, and the number of observations 2,628 (meaning for instance that 1/6 of the observations relate to decisions on the introduction of new process technologies) and standard deviation.

TABLE IV
RESULTS OF THE RANDOM EFFECTS ORDERED PROBIT MODEL

Variables	Model I
Constant	– 3.0733 (0.6146) c
Size	0.4675 (0.1444) c
Level	0.3535 (0.1105) c
Just-in-time	0.2889 (0.1934)
Multi-plant diversified	– 1.8575 (0.7714) b
Multi-plant dominant business	– 1.1564 (0.6692) a
Subcontractor	0.0658 (0.3089)
Capital intensity	– 0.6619 (0.1855) c
Network	2.1099 (0.7569) c
Network $\times$ Size	– 0.5499 (0.1790) c
Network $\times$ Multi-plant	1.6517 (0.6943) b
Just-in-time $\times$ Multi-plant	0.4606 (0.4182)
Just-in-time $\times$ Subcontractor	– 0.9084 (0.4944) a
μ	1.3940 (0.0299) c
Log-likelihood	– 1,925.640
LR χ^2-test	34.186 (12) c
Number of plants	428
Number of records	2,628

Legend
Usual *t*-tests. Standard errors and degrees of freedom in parentheses.
(a) Significant at 10%.
(b) Significant at 5%.
(c) Significant at 1%.

TABLE V
MARGINAL EFFECTS OF EXPLANATORY VARIABLES

Variables	Marginal effects[a]		
	$P[D = C]$	$P[D = DI]$	$P[D = DII]$
Size (Network = 0)	– 0.1861	0.1088	0.0773
Size (Network = 1)	0.0255	– 0.0478	0.0233
Level	– 0.1362	0.0634	0.0729
Just-in-time	– 0.1123	0.0550	0.0573
Multi-plant diversified (Network = 0)	0.4899	– 0.3985	– 0.0915
Multi-plant diversified (Network = 1)	0.0350	– 0.0492	0.0142
Multi-plant dominant business (Network = 0)	0.3887	– 0.3030	– 0.0857
Multi-plant dominant business (Network = 1)	– 0.1136	0.0923	0.0213
Subcontractor	– 0.0261	0.0148	0.0114
Capital intensity	0.2507	– 0.1819	– 0.0689
Network (Size = small)	– 0.2885	0.2299	0.0587
Network (Size = average)	0.1328	– 0.0887	– 0.0441
Network (Size = large)	0.5697	– 0.1711	– 0.3986

Legend
(a) In computing marginal effects, all dummy variables (with the exception of *Network*, see infra) are set at 0 and continuous (discrete) variables are evaluated at their mean (median) value (i.e. Size = 4.48, 195 employees, and Level = 3). The marginal effect of *Network* is computed for different values of *Size*: small (number of employees equals 10), average (employees = 195), and large (employees = 1,000). The marginal effects of *Size, Multi-plant diversified* and *Multi-plant dominant business* are computed with both *Network* = 0 and *Network* = 1. For dummy variables, reported values are the differences between the probabilities that result when the dummy variable under scrutiny takes its two different values.

decisions. In order to provide further insights into the issues at hand, marginal effects have been calculated. These are illustrated in Table V.

Generally speaking, the evidence on the allocation of authority is rather robust and interesting. First, as to the complexity and size of plant's organization, the number of hierarchic levels under the superior, captured by *Level*, significantly affects (at the 1% level) the allocation of authority. In particular, more complex organizational structures are characterized by decentralization of authority to the plant manager. Such a finding confirms theoretical predictions relating to the alleged rapid increase of the superior's information costs when plant organization becomes complex. In other words, being close to operations seems a key factor for optimality of decision-making activity in complex organizations.

Similarly, a higher number of direct and indirect subordinates, that is, a larger value of *Size* induces the superior to increasingly delegate authority to the plant manager: the coefficient of *Size* is positive and significant at 1%. However, our estimates suggest that as to this aspect, one has to distinguish between plants that have adopted advanced network technologies and plants that have not: the previous remark holds true only for the latter category (see infra).

Let us now draw attention to the effects of a plant's ownership status. Multi-plant organizations turn out to be more likely to centralize decision-making activities outside the plant: the coefficients of *Multi-plant diversified* and *Multi-plant dominant business* are both negative and significant. This result confirms the importance of coordination issues: in a multi-unit firm, locally optimal decisions are less likely also to be optimal for the firm as a whole, so that centralization of decision-making at the level of the plant manager's corporate superior is more likely. The fact that checking a plant manager's actions is more difficult due to greater physical distance between him and his corporate superior reinforces such tendencies. In addition, the coefficients of *Multi-plant diversified* and *Multi-plant dominant business* are found by a Wald test to be significantly different at conventional levels ($\chi^2 = 2.72$); diversification of product lines, making benchmarking more difficult, implies less decentralization of decision-making at the plant level.

The impact of the adoption of advanced communication technologies on the allocation of decision-making authority is quite complex and deserves a detailed discussion. In general, delegation is more frequent in plants that have adopted network technologies than in those that have not; in fact *Network* exhibits a positive, significant at 1%, coefficient. Such positive impact is even more pronounced for plants owned by multi-unit organizations, as is apparent from the positive, significant at 5%, coefficient of the interactive term *Network* × *Multi-plant*.[16] This result is consistent with the argument that network technologies enhance the monitoring capabilities of the corporate headquarters and that such an effect is especially important whenever monitoring the behavior of the plant manager is difficult, due for instance to the greater physical distance between the plant manager and his superior in multi-plant firms. In addition, as was noted above, in plants that have adopted sophisticated network technologies, allocation of decision authority turns out not to be dependent on plant size: the value of the Wald test relating to the sum of the coefficients of *Size* and the interactive term *Network* × *Size* is not significant at conventional levels ($\chi^2 = 1.12$). In other words, in plants in which intra-firm communication capabilities are limited, decision-making authority is more likely to be assigned to the plant manager the greater the number of plant employees. With better communication technologies, the positive effect of plant size on delegation vanishes, as is apparent from the values of the marginal effects reported in Table V. This may be a consequence of the fact that the extent of the information advantage of the plant manager with respect to the corporate superior no longer depends on the complexity of plant's operations. It follows that among medium-large plants (according to our estimates, plants with more than 80 employees), those that adopted advanced intra-firm communication

[16] Note also that the sum of the coefficients of *Network x Multi-plant* and *Multi-plant* (either *diversified* or *dominant business*) is found to be null at conventional levels by two Wald tests ($\chi^2 = 0.03$ and 2.00 for multi-plant diversified and dominant business firms, respectively). In other words, with the use of advanced communication technologies, the negative effect of multi-plant ownership vanishes (see also the marginal effects reported in Table V).

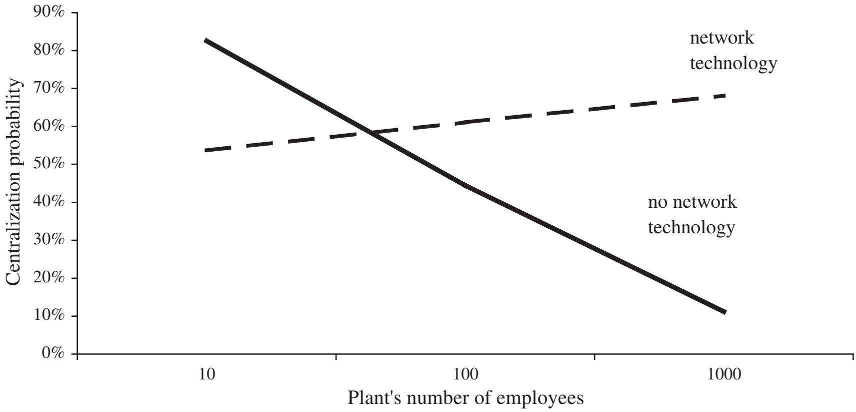

Figure 1
Plant size, use of advanced communication technologies, and probability of centralization of decision authority

technologies are characterized by less delegation of decision-making authority than those that did not (see marginal effects in Table V). The opposite pattern applies to smaller plants; that is, when the number of plant employees is small (less than 80), decentralization of decision power at the plant manager level is more likely for plants that have introduced sophisticated network technologies (see again marginal effects in Table V). Figure 1 provides an illustration of this relation.

Plants involved in subcontracting do not display a different allocation of decision-making activities than other plants, with the coefficient of the variable *Subcontractor* being insignificant in the estimates. As to the effect of urgency, the coefficient of *Just-in-time* is positive as predicted, though insignificant at conventional levels. In addition, the value of the Wald test relating to the sum of the coefficients of *Just-in-time* and the interactive term *Just-in-time* $\times$ *Multi-plant* is significant at 5% ($\chi^2 = 5.92$). Contrary to our expectations, adoption of JIT production techniques has a more positive impact on the probability of delegating authority to the plant manager for plants that belong to a multi-unit firm than for independent plants. The sum of the coefficients of *Just-in-time* and *Subcontractor* $\times$ *Just-in-time* is found to be insignificant by a Wald test ($\chi^2 = 1.80$); for subcontractors there is no evidence that JIT requires greater coordination of decisions. Lastly, *Capital intensity* displays a strong, statistically significant (at 1%) negative effect on the degree of delegation. For plants that invest in large-scale capital equipment, decisions relating to production activities involve a great amount of resources; so responsibility for production decisions is centralized outside the plant.

Let us now focus attention on the evidence about the effects of the dummy variables related to the different types of strategic decisions (decision-

TABLE VI
RESULTS OF RANDOM EFFECTS ORDERED PROBIT MODELS: FIXED EFFECTS OF DECISIONS

Variables	Model II	Model III
Constant	– 3.2972 (0.6127) c	– 3.2310 (0.6109) c
Size	0.4730 (0.1439) c	0.4847 (0.1435) c
Level	0.3622 (0.1088) c	0.3692 (0.1078) c
Just-in-time	0.2950 (0.1921)	0.2987 (0.1920)
Multi-plant diversified	– 1.9088 (0.7691) b	– 1.9422 (0.7680) b
Multi-plant dominant business	– 1.1729 (0.7691) a	– 1.1888 (0.6729) a
Subcontractor	0.0698 (0.3046)	0.0883 (0.3051)
Capital intensity	– 0.6764 (0.1921) c	– 0.6913 (0.1834) c
Network	2.1319 (0.7507) c	2.1724 (0.7475) c
Network × Size	– 0.5577 (0.1772) c	– 0.5687 (0.1760) c
Network × Multi-plant	1.7073 (0.6937) b	1.7437 (0.6942) b
Just-in-time × Multi-plant	0.4663 (0.4093)	0.4644 (0.4046)
Just-in-time × Subcontractor	– 0.9143 (0.4864) a	– 0.9410 (0.4868) a
D-Labor	0.3509 (0.0367) c	–
D-Capital equipment	–	– 0.2903 (0.1673) a
D-Machinery	–	– 0.1191 (0.1462)
D-Hiring and dismissal	–	0.2526 (0.0998) b
D-Career path	–	0.4179 (0.1073) c
D-Incentive schemes	–	– 0.0199 (0.1053)
μ	1.4204 (0.0313) c	1.4413 (0.0329) c
Log-likelihood	– 1,907.065	– 1,892.904
LR χ^2-test	71.336 (13) c	99.658 (17) c
Number of plants	428	428
Number of records	2,628	2,628

Legend
Usual *t*-tests. Standard errors and degrees of freedom in parentheses.
(a) Significant at 10%.
(b) Significant at 5%.
(c) Significant at 1%.

specific variables). In Table VI, we report results of two ordered probit models with random effects where dummies indicating the type of decisions are included.[17] *Model II* aims to test whether capital investment decisions differ from decisions relating to the management of the labor force. Accordingly, the baseline is represented by all decisions on a plant's capital equipment (*D-capital*). Since the coefficient of *D-labor* is positive and significant, we argue that in accordance with theoretical predictions, decisions concerning a plant's workforce are more likely to be delegated to the plant manager than those regarding capital investments. In *Model III*, we consider each individual decision. The baseline is represented by the decision concerning the introduction of technological innovations (*D-technology*). Overall, decision variables display a significant impact on

[17] For the sake of synthesis, we do not report marginal effects. They are available from the authors upon request.

plants' decision-making structure; indeed, the null hypothesis of joint equality to zero of their coefficients is rejected by an LR test at the 1% level ($\chi^2 = 65.53$). Moreover, the difference between decisions concerning capital equipment and those concerning the workforce that was highlighted by *Model II*, is confirmed. In fact, dummy variables relating to the former decisions display a negative impact on the likelihood of decentralization of authority, whilst those relating to the latter generally have positive, statistically significant coefficients (*D-Incentive scheme* is the only exception, see infra). Note also that the null hypothesis that the coefficients of all capital decisions be equal can be rejected by a Wald test at conventional confidence levels ($\chi^2 = 2.73$); the same holds true for the labor decisions ($\chi^2 = 7.90$). In particular, among capital decisions, the coefficient of *Capital equipment* is statistically different from that of *Technology*, the benchmark in the estimates (see Model III in Table VI), while the other differences are not statistically significant. Among labor decisions, the null hypothesis that the coefficients of *Hiring and dismissal* and *Incentive schemes* and those of *Career path* and *Incentive schemes* be equal can be rejected by Wald tests at conventional confidence levels (respectively, $\chi^2 = 6.90$ and $\chi^2 = 8.74$); conversely, one cannot reject the equality of *Hiring and dismissal* and *Career path* ($\chi^2 = 1.52$). In sum, the individual decision dummies are better measures than the pooled dummies.

As to decisions concerning investments in capital equipment, the larger the amount of the investment the less likely the assignment of decision-making power to the plant manager. As to decisions-making on labor, delegation of decisions is more likely when the decisions do not affect other units and have a direct impact on the plant manager's activity, such as decisions relating to the careers of plant employees and to a lesser extent to the hiring and dismissal of a plant's workers. Overall, these results provide support to the view that different types of decisions, having a different importance both to the corporate superior and to the plant manager, are allocated following different patterns. Moreover, they suggest that the exploitation of a plant manager's specific knowledge about the characteristics of the plant's workforce may have played a key role in shaping the plant's decision structure.

Lastly, we proceeded to estimate an ordered probit model with random effects in which the coefficients of the explanatory variables are not restricted to be the same across the different types of decisions. In order to do this, we run an econometric model (*Model IV*) in which we included all interactive terms between the explanatory variables and *D-Labor*. Results are presented in Table VII, while Table VIII briefly summarizes signs and significance of the coefficients of the explanatory variables for labor and capital decisions, respectively. Overall, the results that have been illustrated previously are confirmed, with some (but no major) differences in the determinants of the allocation of authority on capital and labor decisions

TABLE VII
RESULTS OF RANDOM EFFECTS ORDERED PROBIT MODELS: LABOR VS. CAPITAL DECISIONS

Variables	Model IV
Constant	– 3.3233 (0.6301) c
D-Labor	0.2041 (0.3027)
Size	0.4660 (0.14678) c
D-Labor × Size	0.0437 (0.0689)
Level	0.3323 (0.1118) c
D-Labor × Level	0.0817 (0.0504)
Just-in-time	0.2109 (0.1996)
D-Labor × Just-in-time	0.1619 (0.0984) a
Multi-plant diversified	– 2.2182 (0.8504) c
D-Labor × Multi-plant diversified	0.5570 (0.4730)
Multi-plant dominant business	– 1.3531 (0.7619) a
D-Labor × Multi-plant dominant business	0.3163 (0.4324)
Subcontractor	0.2485 (0.3268)
D-Labor × Subcontractor	– 0.2548 (0.1562)
Capital intensity	– 0.3526 (0.1903) a
D-Labor × Capital intensity	– 0.6659 (0.0915) c
Network	1.9498 (0.7592) b
D-Labor × Network	0.4907 (0.3864)
Network × Size	– 0.5366 (0.1789) c
D-Labor × (Network × Size)	– 0.0750 (0.0875)
Network × Multi-plant	1.9973 (0.7857) b
D-Labor × (Network × Multi-plant)	– 0.5433 (0.4284)
Just-in-time × Multi-plant	0.4763 (0.4156)
D-Labor × (Just-in-time × Multi-plant)	0.0342 (0.1850)
Just-in-time × Subcontractor	– 1.2722 (0.4889) c
D-Labor × (Just-in-time × Subcontractor)	0.5707 (0.2237) b
μ	1.4456 (0.0330) c
Log-likelihood	– 1,889.795
LR χ^2-test	105.876 (25) c
Number of plants	428
Number of records	2,628

Legend
Usual *t*-tests. Standard errors and degrees of freedom in parentheses.
(a) Significant at 10%.
(b) Significant at 5%.
(c) Significant at 1%.

(see again Table VIII). In particular, in plants that make use of a JIT production system, decisions on a plant's workforce are more likely to be delegated to the plant manager; conversely, the effect on delegation is insignificant for capital investment decisions.

As a final exercise, we introduced into the estimates a variable which captures the adoption of monetary incentive schemes for plant personnel (results are reported in the Appendix). This dummy variable is one when plants have introduced 'non-traditional' individual incentive schemes. In particular, we focus on monetary incentives which apply to individual workers and are sensitive to quality as well as quantity aspects of output. The introduction of such incentive schemes may be considered as a proxy for the existence within a plant of decent measures of performance to which the

TABLE VIII
THE DETECTED EFFECTS OF EXPLANATORY VARIABLES ON DELEGATION OF AUTHORITY

Variables	All decisions	Labor decisions	Capital decisions
Size	+ + +	+ + +	+ + +
Level	+ + +	+ + +	+ + +
Just-in-time	= 0	+	= 0
Multi-plant diversified	− −	− − −	− − −
Multi-plant dominant business	−	= 0	−
Capital intensity	− − −	− − −	−
Subcontractor	= 0	= 0	= 0
Network	+ + +	+ + +	+ +
Network × Size	− − −	− − −	− − −
Network × Multi-plant	+ +	+ +	+ +
Just-in-time × Multi-plant	= 0	= 0	= 0
Just-in-time × Subcontractor	−	= 0	− − −
Labor decisions	+ + +		
Capital decisions	− − −		

Legend
For all decisions signs are detected effects of explanatory variables of Models I and II.
For capital decisions signs are detected effects of explanatory variables of Model IV.
For labor decisions signs are results of linear tests on the sum of the coefficients of explanatory variables and their interactive effect (i.e. *Variable* + *Variable* × *D-Labor*).
(= 0) Insignificant.
(+ / −) Sign positive/negative and significant at 10%.
(+ + / − −) Sign positive/negative and significant at 5%.
(+ + + / − − −) Sign positive/negative and significant at 1%.

compensation of the plant manager can be tied. With high powered incentives in place, the objectives of the plant manager would be aligned with those of the firm: delegation of decision-making to the plant manager would follow. However, since the degree of decentralization of decision-making and reliance on incentive pay are chosen simultaneously, the estimates suffer from an endogeneity bias. Results, reported in the Appendix, confirm that decentralization of authority to the plant manager is more likely when monetary incentives are introduced.

VI. CONCLUSIONS

Recent theoretical work has identified several factors that may influence the assignment of authority over strategic decisions to a plant manager or its centralization at the corporate superior level. In this paper, we have considered six strategic decisions relevant to a plant's activity and have tested the predictions of economic theory for a sample composed of 438 Italian manufacturing plants through estimates of ordered probit models with random effects. The empirical results can be synthesized as follows.

First, the information advantage enjoyed by plant managers with respect to the corporate headquarters appears to be a key determinant of delegation.

Accordingly, when a plant's organization is complex, consisting of a high number of managerial levels, the superior's information regarding the plant's internal activity is limited. This raises the stimulus toward delegation of authority to the plant manager, who is closer to and so has greater knowledge of the plant's activity. A similar reasoning applies to an increase of the number of a plant's employees if intra-firm communication efficiency is low: delegation increases with plant size. Conversely, such an effect vanishes for plants that have adopted advanced intra-firm communication technologies (see infra).

Second, when strategic decisions involve substantial externalities, there is no guarantee that decisions that are optimal for a given plant will also be optimal for its parent company. Under such circumstances, the need to closely coordinate decisions across a firm's different units results in greater centralization. Consequently, in plants owned by multi-unit firms, decision authority is far more centralized than in other plants. The fact that, absent efficient incentive schemes, in such plants it is quite difficult for the corporate superior to monitor the plant manager's behavior due to great physical distance, reinforces the tendency toward centralization of decision-making. In contrast, when pursuit of individual objectives is costly for the plant manager due to use of sophisticated communication technologies which enhance the monitoring capability of the corporate superior, the negative effect on delegation of a multi-plant ownership status disappears. In addition, such a negative effect is less pronounced in plants that belong to multi-plant, non-diversified firms, which arguably can design incentive schemes based on some forms of 'yardstick competition' among different plants.

Third, the use of advanced communication technologies seems to favor the decentralization of decision-making. This confirms the role played by ease of monitoring on the allocation of decision authority.

On the other hand, the evidence in support of the arguments raised by the information processing stream in the theoretical literature is weaker. In particular, we did not find compelling evidence that decentralization arises from leaks and delays in transmitting plans from corporate headquarters to local managers. From one side, as was said above, better communication technologies favor delegation rather than centralization. From the other side, the urgency of decisions turns out to have a positive, yet statistically insignificant, impact on delegation of decision-making authority. Note however that this may be the result of using a rather crude proxy (adoption of just-in-time production techniques). Therefore, it is fair to recognize that in this domain, additional empirical work is needed with explanatory variables that allow us to disentangle more clearly the predictions of the information processing and decentralization of incentives streams.

Lastly, in accordance with the predictions of economic theory, authority over different types of plants' strategic decisions turns out to be allocated differently. Assignment of decision-making authority to the plant manager depends on: a) the importance of the individual decision to the plant manager and to his corporate superior (i.e., the relative extent of the private benefits of the plant manager with respect to the monetary gains for the firm), b) the extent of intra-firm externalities, and c) the desire to take advantage of the plant manager's local knowledge and specific capabilities. Accordingly, when strategic decisions involve considerable financial resources, as is often the case in plants that have adopted capital intensive production technologies, delegation of decision-making is quite unlikely. In addition, decisions concerning capital equipment are found to be more centralized than those relating to the workforce. Among the former, decisions regarding the purchase of large-scale capital equipment involving a larger amount of financial resources, are more centralized than those relating to individual items of a machinery. Among the latter, decisions on the career paths of a plant's personnel, and to a lesser extent on hiring and dismissal, are less likely to affect other of the firm's units than decisions regarding the adoption of general payment schemes, while they have a more direct impact on the plant manager's activity; therefore they are more frequently delegated to the plant manager.

We think that this paper represents a significant step toward an empirically robust test of theoretical predictions on the allocation of decision-making. Nonetheless, we are aware that much remains to be done in this field. Two avenues for future research seem especially promising. On the one hand, the allocation of authority over a plant's strategic decisions is just one aspect of organizational design, which also includes several other aspects relating, for instance, to the size of the managerial hierarchy, the number and characteristics of a plant's employees, the introduction of high powered incentive schemes to motivate employees, the adoption of new technologies, and many others. It may be argued that decisions as to these different aspects are made simultaneously; therefore, an endogeneity problem arises. We could not deal with it in this paper absent a full structural model of organizational choice. This suggests that additional theoretical work on this issue is much needed. On the other hand, in this paper we have adopted a cross-sectional approach; in fact, we have analyzed the allocation of decision-making authority over several strategic decisions in different plants. It would also have been interesting to follow the evolution over time of the delegation of decision making authority to plant managers, trying to identify which factors trigger changes in the allocation of decision-making. This would have the additional advantage of allowing us to control for unobserved heterogeneity across plants. We could not do so because of lack of proper data. Nonetheless, we are convinced that the availability of longitudinal data sets with sufficient within-plant (firm) heterogeneity is crucial to extend our understanding of the determinants of firms' organizational choices.

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APPENDIX

Table A. I Results of the Random Effects Ordered Probit Model with Monetary Incentives

Variables	Model I
Constant	– 2.4660 (0.6521) c
Size	0.3392 (0.1496) b
Level	0.2891 (0.1132) b
Just-in-time	0.1989 (0.1963)
Multi-plant diversified	– 1.9576 (0.8385) b
Multi-plant dominant business	– 1.1434 (0.7293)
Subcontractor	– 0.3049 (0.3207)
Monetary incentives	0.3036 (0.1743) a
Capital intensity	– 0.5946 (0.1857) c
Network	1.8499 (0.7726) b
Network × Size	– 0.4481 (0.1876) b
Network × Multi-plant	1.3867 (0.7470) a
Just-in-time × Multi-plant	0.7583 (0.4187) a
Just-in-time × Subcontractor	– 0.5907 (0.5194)
μ	1.3897 (0.0302) c
Log-likelihood	– 1,924.928
LR χ^2-test	35.610 (13) c
Number of plants	428
Number of records	2,628

Legend
Usual *t*-tests. Standard errors and degrees of freedom in parentheses.
(a) Significant at 10%.
(b) Significant at 5%.
(c) Significant at 1%.

Table A. II Results of Random Effects Ordered Probit Models with Monetary Incentives: Fixed Effects of Decisions

Variables	Model II	Model III
Constant	– 2.6313 (0.6500) c	– 2.5149 (0.6476) c
Size	0.3378 (0.1485) b	0.3468 (0.1478) b
Level	0.2835 (0.1129) b	0.2760 (0.1134) b
Just-in-time	0.2041 (0.1949)	0.2166 (0.1950)
Multi-plant diversified	– 2.0376 (0.8388) b	– 2.0957 (0.8315) b
Multi-plant dominant business	– 1.1695 (0.7311)	– 1.1965 (0.7234) a
Subcontractor	– 0.2967 (0.3218)	– 0.2921 (0.3219)
Monetary incentives	0.3235 (0.1734) a	0.3446 (0.1725) b
Capital intensity	– 0.6097 (0.1858) c	– 0.6275 (0.1867) c
Network	1.8624 (0.7661) b	1.9086 (0.7643) b
Network × Size	– 0.4508 (0.1856) b	– 0.4628 (0.1848) b
Network × Multi-plant	1.4360 (0.7480) a	1.4802 (0.7421) b
Just-in-time × Multi-plant	0.7969 (0.4128) a	0.8110 (0.4054) b
Just-in-time × Subcontractor	– 0.6048 (0.5143)	– 0.6169 (0.51330)
D-Labor	0.3517 (0.0371) c	–
D-Capital equipment	–	– 0.2892 (0.1662) a
D-Machinery	–	– 0.1171 (0.1463)

Variables	Model II	Model III
D-Hiring and dismissal	–	0.2531 (0.0997) b
D-Career path	–	0.4203 (0.1070) c
D-Incentive schemes	–	– 0.0166 (0.1051)
μ	1.4157 (0.0318) c	1.4361 (0.0333) c
Log-likelihood	– 1,906.267	– 1,892.162
LR χ^2-test	79.932 (14) c	101.142 (18) c
Number of plants	428	428
Number of records	2,628	2,628

Legend
Usual *t*-tests. Standard errors and degrees of freedom in parentheses.
(a) Significant at 10%.
(b) Significant at 5%.
(c) Significant at 1%.

Table A. III Results of Random Effects Ordered Probit Models with Monetary Incentives: Labor vs. Capital Decisions

Variables	Model IV
Constant	– 2.6915 (0.6572) c
D-Labor	0.1553 (0.3063)
Size	0.3379 (0.14688) b
D-Labor × Size	0.04889 (0.0702)
Level	0.2658 (0.1137) b
D-Labor × Level	0.0834 (0.0500) a
Just-in-time	0.1231 (0.2039)
D-Labor × Just-in-time	0.1590 (0.0988)
Multi-plant diversified	– 2.3048 (0.9118) b
D-Labor × Multi-plant diversified	0.5805 (0.4712)
Multi-plant dominant business	– 1.3399 (0.7839) a
D-Labor × Multi-plant dominant business	0.3372 (0.4277)
Subcontractor	– 0.2129 (0.3266)
D-Labor × Subcontractor	– 0.2432 (0.1551)
Monetary incentives	0.2539 (0.1819)
D-Labor × Monetary incentives	0.0701 (0.0877)
Capital intensity	– 0.2696 (0.1923)
D-Labor × Capital intensity	– 0.6655 (0.0929) c
Network	1.7251 (0.7660) b
D-Labor × Network	0.4858 (0.3887)
Network × Size	– 0.4445 (0.1833) b
D-Labor × (Network × Size)	– 0.0752 (0.0884)
Network × Multi-plant	1.7500 (0.7971) b
D-Labor × (Network × Multi-plant)	– 0.5579 (0.4232)
Just-in-time × Multi-plant	0.7560 (0.4410) a
D-Labor × (Just-in-time × Multi-plant)	0.0148 (0.1875)
Just-in-time × Subcontractor	– 0.8756 (0.5182) a
D-Labor × (Just-in-time × Subcontractor)	0.5532 (0.2252) b
μ	1.4394 (0.0331) c
Log-likelihood	– 1,889.093
LR χ^2-test	107.28 (27) c
Number of plants	428
Number of records	2,628

Legend
Usual *t*-tests. Standard errors and degrees of freedom in parentheses.
(a) Significant at 10%.
(b) Significant at 5%.
(c) Significant at 1%.