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Shedding New Light on the Organization: An Empirical Analysis of Some Key Aspects of Business Organizations

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Declaration

A related (more theoretical) version of Chapter 1 has been presented at the EARIE Conference with the title "Organizational forms and firm decision-making in a bounded rational context", Vienna, September 1996.

From Chapter 2 I derive a paper titled "Some stylized facts on the organization and its evolution" joint with Massimo G. Colombo, forthcoming in the *Journal of Economic Behavior and Organization*, 40(3), November 1999. The paper has also been presented at the EARIE Conference, Copenhagen, August 1998.

From Chapter 3 I derive a paper titled "A static model of the organizational structure: theory and evidence", which has been presented at the EARIE Conference, Turin, September 1999. In addition, a related version is under review (revised and resubmitted) in the *International Journal of Industrial Organization*.

From Chapter 4 I derive a paper titled "Formal and real authority in organizations: testing the determinants of the allocation of decision-making" joint with Massimo G. Colombo, circulated as a Working Paper of Università di Pavia (*Quaderni del Dipartimento di Economia e Metodi Quantitativi* 95, 11-98). The paper has been presented at the AiIG Workshop, University of Bari, June 1999, and at the EEA Conference, Santiago de Compostela, September 1999.

From Chapter 5 I derive a paper titled "Proxies of what? A note on the measures of firm's organization".

From Chapter 6 I derive a paper titled "The determinants of structural inertia: influence activities and technology adoptions".

The papers have also been presented in various seminars at Politecnico di Milano, University of Ferrara, Pavia, Warwick.

Summary

There is a striking difference between the large number of theoretical papers on firm organization and the lack of quantitative empirical evidence. If on the one side economists are increasingly concerned with organization of firms, on the other side organization still remains an ambiguous concept, hardly analyzed empirically.

In this thesis I develop a new empirical methodology based upon business history (see Chapter 1) and previous theoretical work which allows me to describe (some aspects of) the organization of firms in quantitative terms. This approach is instrumental to analyzing the hierarchical structure and the allocation of decision-making activities in a sample composed of 438 Italian metalworking plants. I also study the dynamics of firm organization in the 1980s and 1990s. The results of Chapter 2 show that the (static) choice of the organizational form crucially relies upon the "loss of control phenomenon". They also illustrate that the dynamics of hierarchical structure follows an inertial process, characterized by incremental adjustments. Lastly, both the organization and, more interestingly, its evolution differ from one category of plant to another depending crucially on plant size.

Moreover, I test (some of) the predictions of economic theory on the size of the management hierarchy (Chapter 3), the allocation of real and formal authority (Chapter 4), and structural inertia (Chapter 6) through the estimates of econometric models (i.e., multinomial logit,

ordered logit, and survival). The findings of Chapter 3 show that the plant size, the characteristics (i.e., vintage and extent of use) of the production and communication technology in use, the plant's ownership status (i.e., State versus private ownership, and differences in the nationality of firms to which plants belong) are key in explaining the complexity of a plant's management hierarchy.

In addition, in accordance with theoretical work, the findings of Chapter 4 show that the size of a plant's organization, the characteristics of the production and communication technologies in use, the urgency of decisions, and the presence of monetary incentive schemes aligning plant manager's objectives with those of the firm as a whole figure prominently in explaining whether authority is delegated to the plant manager or not. The structural and organizational characteristics of a plant's parent firm do also play a role, with the likelihood of decentralization of decision-making increasing with parent firm's size and decreasing with the adoption by the parent firm of a M-form type of organization. Lastly, the nature of the decision turns out to affect the allocation of formal authority, with decisions concerning the labor force being more frequently delegated to plant managers than those related to investments in capital equipment. On the contrary, it does not influence the allocation of real authority when the formal right to decide remains with the corporate superior.

Finally in Chapter 6 I find that both influence activities and technology adoptions are key in explaining the evolution of business organizations. Influence activities tend to inhibit organizational change causing structural inertia, whilst the technology adoptions increase the likelihood of changing the structure of the management hierarchy.

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Chapter 6

Introduction: The Empirical Methodology

The present research aims at finding robust evidence on some key characteristics of the organization of firms such as the allocation of decision-making, the span of control, the size of the management hierarchy, and the adoption of managerial and technological innovations. There are no institutional sources that provide data on such features of business organizations. Thus, I designed, conducted - with the help of senior and junior researchers of Politecnico di Milano and Univeristà di Pavia - and coordinated a questionnaire analysis directed at collecting information on the organization of Italian manufacturing plants. The present section provides details of the methodology of the empirical survey. In addition, each chapter, save the first, contains further information of the organizational, technological and plant-specific variables that comprise the data set.

The Sample

The current data set derives from the FLAUTO database developed in 1989 at Politecnico di Milano. The sample was originally composed of 810 plants and was stratified by industry, geographical area and plant size so as to faithfully represent the universe of all Italian metalworking plants with more than 10 employees which were in operation in 1989 (for a detailed description of the FLAUTO database see Cainarca *et al.* 1989). For each sample plant, the 1997 updated version of FLAUTO (i.e., FLAUTO97) provides information as to whether it was shut down during the period June 1989-June 1997. Plant closure is distinguished from situations where a plant has changed either its ownership structure as a consequence of merger and acquisition activity or its location. Thus, I am able to avoid possible measurement errors resulting from localization, ownership and other administrative changes (e.g., change of the name of the parent firm) which are quite usual in this type of exercise (for a discussion of such problems see Dunne *et al.* 1988). Out of the 810 plants, 708 turned out to be still in operation in 1997.[1] The current data set constitutes an update and an extension of the old database.

In June 1997, a questionnaire was mailed to the plant managers of the 708 plants of the initial sample that were still in operation. The response rate was 62%, so that the current database includes 438 plants. So, it is the plant managers who provided all the information relating to the organization of plants and its changes during the '80s and '90s. For each plant of the final sample, the plant manager was

[1] This corresponds to a 12.6% failure rate over an eight years period. Previous empirical work found considerably lower survival rates among newly established units. For instance, Dunne *et al.* (1989) find that only between one quarter and one third of US manufacturing plants owned by single-plant firms survive 15 years. However, the likelihood of survival is substantially higher for large establishments owned by multi-plant firms. Mata *et al.* (1995) show that more than 20% of new Portuguese plants closed within two years from birth and only 30% survived seven years. Nonetheless, the sample includes plants in existence in 1989, which were at least three years old. In addition, smaller units (i.e., those which, in 1989, had less than 10 employees) are excluded. As hazard rates are usually found to rapidly decline with both age and size, the value of the average failure rate in the sample is not surprising. For further details see Colombo and Delmastro (1999).

directly contacted by phone in order to check the accurateness of answers (and to complete the questionnaire if needed).

Thus, the current sample may contain some biases with respect to the Italian universe of metalworking plants from which was originally drawn in 1989. However, I have important reasons to justify the use of FLAUTO97. The statistical robustness of questionnaire analyses highly depends on firms' response rate. In particular, empirical investigations that build on low response rates are very likely to suffer from sample selection bias problems. Industrial practitioners know very well difficulties in reaching a high response rate. A means of obtaining a high level of managers' collaboration is to link the fieldwork with a previous survey. In my case, the very high response rate was due to two reasons. First, I already knew the person (the plant manager) to contact within each of the 708 sample plants. Second, managers knew the institution, Politecnico di Milano, and they usually remembered the previous survey as well. Indeed, I overall found the cooperation of most plant managers that led not only to a high response rate but also to clean and robust answers.[2] Even more importantly, FLAUTO database provides information over a very long length of time (namely, from 1975 to 1997). Lastly, the very low failure rate of sample plants during the period 1989-'97 (see

[2] Notice that I was able to control some answers with the information provided by FLAUTO89. For instance, I knew if a plant had already adopted, during the period 1970-89, some advanced manufacturing technologies (such as FMS, LAN and Robots).

footnote 1) has caused the exclusion of a very small proportion of sample plants.

As regards the conduct of the fieldwork, I started the survey in autumn 1996 with the definition of the questionnaire, which has involved the active support of statisticians, sociologists, economists and managers. In March 1997, I conducted 10 personal pilot interviews with managers of plants of very different size and industry (within the metalworking sector), so as to test the effectiveness of the questionnaire. These interviews have included managers of ABB, Alenia, Ansaldo, Contraves, Electrolux, FIAT Ferroviaria, Mannesmann, Merloni, Romana Lamiere, and Semikron. In April and May 1997, I personally contacted each plant manager of the 708 sample plants of FLAUTO that were in operation, in order to inform them of the research. Then, in June I sent the questionnaire by mail with an introductory letter in which I further explained the objectives of the research and the links with the previous investigation. Finally, telephone follows-up aimed both at checking the accurateness of answers and at completing questionnaires when needed.

Table 1 shows the geographical and size distribution of sample plants. As to the size distribution, most of plants have a number of employees lower than 100. This clearly reflects the overall size distribution of the Italian manufacturing sector, which is characterized by the presence of small and medium sized firms. Similarly, the sample plants are mainly located in the industrialized northern part of Italy. Lastly, if we compare the geographical distribution of the initial sample composed of 708 plants to that of the final sample (438), it is evident that there is no manifest localization bias.[3]

Tab. 1 - Size and geographical distribution of sample plants

	final sample		initial sample	
	n. of plants	%	n. of plants	%
small plants (n. of employees < 100)	247	56.4	-	-
medium plants (n. of empl. 100 - 500)	157	35.8	-	-
large plants (n. of employees > 500)	34	7.8	-	-
North-west of Italy	248	56.6	390	55.1
North-east of Italy	111	25.4	173	24.4
Middle of Italy	54	12.3	91	12.9
Southern Italy and islands	25	5.7	54	7.6
Total	438	100.0	708	100.0

In sum, FLAUTO97 is a comprehensive and reliable database that includes dynamic information over a large spectrum of plants' characteristics (see the next paragraph). It derives from a preceding survey conducted by Politecnico di Milano in 1989. A possible source of bias of the current version concerns the exclusion of closed plants. However, the very high response rates of both investigations

[3] Of course, I have no data concerning the number of plant employees in 1997 for plants that did not answer to the questionnaire. So, I can only confront the

counterbalances this potential problem.[4] Furthermore, FLAUTO97 covers a period of time of almost 20 years, with detailed information at the plant level.

The Industry

The metalworking sector includes the following *nine* two-digit industries (NACE-CLIO classification): production of metals (NACE-CLIO 27), fabricated metals (NACE-CLIO 28), non-electrical machinery (NACE-CLIO 29), computers and office equipment (NACE-CLIO 30), electrical machinery and electronics (NACE-CLIO 31), communication equipment (NACE-CLIO 32), scientific, precision, medical and optical instruments (NACE-CLIO 33), automotive industry (NACE-CLIO 34), and other transportation equipment (NACE-CLIO 35). In 1996 such industries accounted for 45% and 36% of total employment and number of firms of the Italian manufacturing sector, respectively (see Censimento Intermedio dell'Industria e dei Servizi, Istat).

Generally speaking, most of metalworking industries are the ones that most make use of information and flexible automation technologies. Moreover, in the 1980s and 1990s these industries were rapid adopters of new technologies in the spheres of production (e.g., NC and CNC machine tools, flexible manufacturing systems and

geographical distribution of the two samples.

[4] In this respect, it worth noticing that in 1989 the response rate was nearly of 100%, since the analysis was conducted with the cooperation of the association of Italian manufacturing firms.

cells), design and engineering (CAD, CAM and CAD-CAM), and communication (local area networks), and of innovative organizational techniques (just-in-time, total quality management). Finally, as is pointed out in the management literature (see Kenney and Florida 1988 and Womack *et al.* 1990), the "lean production" model has been developed and initially applied in (some of) these industries. So, they constitute an ideal testbed to analyze quantitatively the organization of plants and firms and its evolution. In sum, the metalworking macro-sector covers almost half of the Italian manufacturing sector and in particular those industries that are of basic importance in the study of the technological and organizational change.

Tab. 2 - Industry distribution of sample plants

	n. of plants	%
NACE-CLIO 27	38	8.7
NACE-CLIO 28	127	29.0
NACE-CLIO 29	153	34.9
NACE-CLIO 30	2	0.5
NACE-CLIO 31	45	10.3
NACE-CLIO 32	23	5.3
NACE-CLIO 33	15	3.4
NACE-CLIO 34	19	4.3
NACE-CLIO 35	16	3.7
Total	438	100.0

FLAUTO97

The current version of the database, FLAUTO97, contains technological, organizational and other plant-specific variables (see the Appendix for the list of all variables).

Plant-specific variables relate to: the number of employees in 1989 and 1997, plant's location and industry, and the ownership status. In particular, individual plants are assigned to the industry, which accounts for the largest share of production. As to ownership status, I know if the plant is owned by a single- or multi-plant firm. Further, I can distinguish between foreign and Italian business groups as well as between State and private ownership. I actually know the nationality of the group, its size (in terms of number of employees) and other information that I derived from institutional sources (such as R&B 1998, and the Hoover's Handbook of World and American Business 1998) and Company Reports.

Information relating to technological change concerns the date of first adoption of the following technologies: local area network (LAN), intercompany network (EDI), machining centers, NC and CNC stand-alone machine tools, flexible manufacturing systems (FMS), programmable robots, inflexible manufacturing systems (IMS), Internet/Intranet, personal computers (PC), and mainframes. Therefore, I can distinguish between technologies pertaining to the production and network spheres. Further, I may be interested (see for instance chapter 3) in looking at the differences between plants that adopt old Tayloristic technologies (such as IMS) and those that make use of innovations that belong to the flexible automation paradigm (such as FMS).

The data on the organization of plants represent the main novelty with respect to FLAUTO and, more generally, to the empirical literature. First, I know the first date of adoption of the following managerial innovations: non-traditional individual pay incentive plans, job rotation, quality groups, just-in-time manufacturing, and total quality management. For a detailed definition of all technological and managerial innovation variables see Table A.1 in the Appendix of this chapter.

In addition, I collected information that allows me to define quantitatively some key characteristics of the organization. These are the number of managerial levels that compound the plant's organization and the allocation of plant's strategic and operating decisions. For each sample plant I have data on the current organizational structure. Moreover, I know if plants have changed their organization during the 1980s and 1990s, meaning that they have changed one and/or both aforementioned aspects of the organization. If the answer is affirmative, I have also information on the "old" organization, meaning the organizational architecture that was in operation before the current one. I devote chapter 2 for a more detailed description of organizational variables and their use in order to test theory.

Appendix

A.1 List of the Variables of FLAUTO97

General:

- NACE-CLIO 3 digit code
- date of establishment
- employees details
- legal form of business and ownership status
- proportion of total production as a subcontractor
- production structure (job shop or line)

Technology: date of first adoption of

- NC and CNC machine tools
- machining centers
- programmable robots
- inflexible manufacturing systems (IMS)
- flexible manufacturing systems (FMS)
- intra-firm network: local area network and/or on-line connection with headquarter (LAN)
- intercompany network: electronic data interchange (EDI) with customers, suppliers and/or subcontractors
- mainframe
- personal computer (PC)
- internet/intranet

Managerial Innovations: date of first adoption of

- quality circles
- job rotation
- non traditional individual incentive schemes
- just in time manufacturing (JIT)
- total quality management (TQM)

Organization:

- number of hierarchic levels of plant's organization
- allocation of plant's strategic and operating decisions (see chapter 2)
- date of change (period: 1975-96) of the number of levels and the allocation of strategic and operating decision-making, and eventually the characteristics of the previous organization

A.2 *Definition of Technological and Managerial Innovation Variables*

Table A.1

Variable	*Definition*
NC/CNC machine tools	NC machines are controlled by numerical commands punched on paper or plastic mylar tape, whereas CNC machines are controlled through internal computer
Machining centers	Machining centers are CNC machine tools which integrate a series of operations, as opposed to stand-alone NC (and CNC) machine tools which instead are able to perform just one of them
Robots	A reprogrammable, multifunctioned manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions
FMS	Flexible manufacturing systems (and cells) are manufacturing equipment composed of two or more machine tools or programmable robots connected through material handling devices and controlled by computers, which render them capable of performing a variety of operations in a variable sequence
IMS	Automated inflexible manufacturing systems differ from the previous category due to the absence of computerized control and programmable equipment; as the sequence of performed operations is fixed, they are specialized in the production of a pre-specified output
LAN	Use of LAN technology to exchange technical data and general information with other departments, headquarters, and between different points on the factory floor (within the plant)
EDI	Intercompany computer network linking the plant to subcontractors, suppliers, and/or customers
Quality circles	Formal work teams either on the line or for the purposes of problem-solving activities according to an established policy with at least some operators involved in team activities
Job rotation	When operators rotate across jobs or tasks on the line
Incentives	"Nontraditional" incentive pay plan which applies to individual workers and which is sensitive to quality as well as quantity aspects of output
Just-in-time	Just-in-time production schedule methods with customers and /or suppliers aimed at reducing the plant's stock
Total quality management	Formal practices which apply at each step of the production chain aimed at controlling product quality

Part I

Ex-Ante Anecdotal Evidence

Chapter 1

Stylized Facts on the Organization and its Evolution

1.1 Introduction

This introductory chapter is an overview of the organizational forms of businesses that have emerged during this last century. The focus is on the main characteristics of the internal structure of the firm. In particular, I sketch out a classification of the different organizational architectures that are historically relevant, based upon features such as *the decision-making allocation, the number of corporate levels, the span of control, and production and administrative practices.* I argue that these capture key aspects of the internal working of firms and plants.

In the next chapters, I will often emphasize two aspects of the current state of the art of studies on the organization. First, there is a huge theoretical interest on the organization, which comprehends very different approaches. In spite of the richness of such stream of literature, it seems to me that there are still many pieces missing in empirical studies. In particular there are important aspects such as the allocation of decision-making that totally lack of empirical evidence, except for business history studies. I argue that business history should constitute a starting point of the empirical work on the organization and not the main source of evidence. In particular, large-scale quantitative data sets are needed in order to test econometrically predictions of economic theory.

This review is neither historically original nor exhaustive, but it is highly instrumental to introduce the overall argument of this thesis, which is nicely summarized by Simon (1959) "to predict the short-run behavior of an adaptive organism, it is not enough to know its goals. We must also know a great deal about its internal structure and particularly its mechanism of adaptation". So, the aim of the chapter is to provide introductory stylized facts on the organization of firms and its evolution, relying mainly on business history, which is the main source of evidence on some key aspects of organizations. Business history studies use aforementioned features in order to define taxonomies of business organizations (see for instance Williamson and Barghava 1972). In this thesis, I focus on these aspects, but I depart from qualitative taxonomies of organizations by defining quantitative measures of these features (see in particular chapter 2). This is not, of course, a criticism to business history that faces conditions of very constrained data, but it is a suggestion for a foundation of empirical studies on the organization of firms.

Before I proceed further a consideration is in order. As I said, in this chapter and overall in this thesis I am concerned with some characteristics of plants and firms. I argue that these organizational variables are central in defining the actual set up of the internal structure of business organizations. However, there are other important features such as firm's wage scale and the financial and ownership structures, which are not at the core of the present work. I will tackle these only in a limited way.

This chapter is organized as follows. Section 1.2 indicates the reasons why modern businesses have developed hierarchically. Section 1.3 concerns the classification of organizational forms in terms of few key aspects that are analyzed throughout the present study. In particular, I show that different organizational forms are defined by different configurations of the allocation of decision-making, the size of the management hierarchy, the span of control, and production and administrative practices. Section 1.4 concentrates on the relation between (production) routines and the organization. In Section 1.5 I look at the mechanism of transition of organizations. I emphasize three main aspects of organizational change: structural inertia, diffusion of knowledge and imitation, and the relation between (technological and market) complexity and changes of the internal structure. Section 1.6 is an example of organizational dynamics in the case of the American car industry. Finally, section 1.7 sums up major results of business history literature and introduces next chapters.

1.2 The Rise of the Management Hierarchy

Marglin (1974) points out that the passage from the pre-modern to the modern form of organization was characterized by both the rise of a managerial hierarchy and the specialization of workers in fixed, planned and repetitive tasks. In the pre-factory organization workers were directly linked to the owner/entrepreneur and they frequently changed their tasks and positions along the layout of production. The modern enterprise is based upon two opposite features "it contains many distinct operating units and it is managed by a hierarchy of salaried executives" (Chandler 1977), who control and head blue collars, in order to implement the centrally defined plan of production.

The evolution of the factory system followed the opposite pattern of that of agriculture (*Dahlman paradox*, Leijohnuhvud 1986). The factory arose with a process of coordination and consolidation of disperse units of production within the same centralized production system. This was mainly due to the technological advances of the second industrial revolution and to an expanding market. Whereas Jenks (1961) claims that the modern enterprise was born in the second half of the last century within railroad companies, Carlos and Nicholas (1988) argue that chartered trading companies had already adopted this complex and hierarchic form of organization in the seventeenth century. However, from the point of view of this research, the main historical fact is not the exact moment when the modern corporation first appeared, but the reasons why enterprises evolved towards a complex hierarchical form of organization. From this respect, O'Donnel (1952) emphasizes the role of market and technological complexity: modern firms developed a structure that gathered and processed information and took decisions faster and better than pre-modern firms did, given the mutated environment characterized by both increasing market complexity and fast technological change.

Economies of scale and scope of managerial work depend crucially on technology. As a consequence, the advances of the second industrial revolution allowed an increase in the optimal size of the organization of firms by sharply decreasing costs of communication and transportation (see Chandler 1977 and chapter 3 for further evidence on this issue). So, even if chartered companies had already adopted a modern form of organization, the expansion of their management hierarchies was strongly constrained by the technological state of the art. To sum up,

Fact 1:

a) *The rise of the modern enterprise coincided with the rise of the management hierarchy. This in turn was due to an increasing number of items of information to gather, store and process, decisions to take and implement, and production, marketing and financial activities to run and coordinate.*

b) *The achievements of a new technological paradigm raised the extent to which it was viable to internalize production and administrative operations into the management hierarchy.*

The passage from a craft (and parallel) to a hierarchical (and vertical) system of organization induced a profound change in the allocation of decision-making (Montgomery 1987). Whilst in the pre-factory system workers had authority over a large spectrum of production decisions, the development of a hierarchic structure shifted real and formal authority to managers and foremen. Using Taylor's (1967) own words "it is only through enforced standardization of methods, enforced adoption of the best implements and working conditions, and enforced cooperation that this faster work can be assured. And the duty of enforcing the adoption of standards and enforcing this cooperation rests with the management alone". Often business historians concentrate on the allocation of authority at upper hierarchical levels. Instead, it is worth noticing that these changes were particularly profound at the shop floor. In any case

Fact 2:

The passage to a modern hierarchic organization implied a drastic change of the allocation of decision-making. Authority shifted up the (new) management hierarchy.

It is important to stress that the re-allocation of power within the firm is neither smooth nor easy to implement. Since authority is a fixed resource its change implies its re-allocation, which damages some agent and favors some other. Hence, there is a strong inertial pressure that contrasts any change of the decision-making structure. Indeed, this was particularly evident in the passage from the craft system of production to the modern organization.

1.3 Organizational Forms

In this section I analyze very briefly some forms of business organizations drawing upon studies of business history. I am concerned only with some particular characteristics of the organization. The aim is to show that *organizational forms are characterized by different: allocations of decision-making, size of the management hierarchy, span of control, and production and administrative practices.* Therefore, I shall describe and display the evolution of organizational forms by looking at these aspects.

1.3.1 The Multiunit Functional Form (U-Form)[1]

The structure of the multi-unit functional form is depicted in Figure 1.[2] The organizational chart captures both the presence of a deep

[1] This and the next paragraphs are heavily based upon Chandler (1962)(1977)(1990), Chandler *et al.* (1996) (chapters 15-17). In addition, Dyas and Thanheiser (1976) and Hannah (1976) provide a thorough analysis of the evolution of organizational forms in Germany and France and Britain, respectively. Suzuki (1991) draws a historical picture for Japan. Overall, these studies emphasize common characteristics as well as some idiosyncratic differences of business organizations in various countries. Differences are mainly due to domestic market regimes, antitrust laws, norms and conditions on the labor market.

[2] For each organizational form I shall provide its chart. For the functional and multidivisional organizations charts are based upon Chandler (1962)(1977)(1990). In the case of the Japanese form the chart is original and it is based upon many recent studies of managerial literature (see for instance Carrol 1994, Drucker 1988, Krafcik 1988, and Womack *et al.* 1990). The aim is to develop a simple framework that shows how organizational structures differ in the aforementioned

managerial hierarchy and the key role of vertical coordination and control. Decision-making is highly centralized at the pinnacle of the hierarchy, where corporate offices - e.g., the board of directors and the executive committee - operate. Managers that hold each functional department (e.g., sales, production, finance and R&D) are also members of the top management, so that real and formal authority is mainly centralized at upper levels. High corporate officers take strategic decisions and define the production plan which is implemented on spot. The central management defines long-run and short-run plans and strategies, drawing on the information coming from lower levels. The vertical and upward structure of the information flow is a key element of this organization. At the bottom of the hierarchy, within operating units, lower level managers and foremen supervise the implementation of the plan operated by blue collars.

The organization depends heavily on the availability of computable data upon which the firm's plan is based. From this respect, the development of new accounting methodologies for planning and monitoring operations was an essential element (Johnson 1975). For instance, Chandler (1962) points out that the Du Pont enterprise developed a revolutionary accounting and data system: "among the

characteristics. Figures are rather stylized and should be read as follows: straight lines denote both authority relations and information flows; circles indicate the existence of ranked hierarchical levels; ovals define circles with the same decision-making power. All figures are reported in the Appendix of the chapter.

notable advances made during these years in the working out of information so essential for central planning, coordination, and appraisal were the techniques that F. Donaldson Brown devised for calculating the rate of return of investment".

In sum, the functional form is a complex organization composed of a deep hierarchy of managerial executives who are ranked vertically. Strategic decision-making is highly centralized and is based on a bottom-up information network.

1.3.2 The Multidivisional Organization (M-Form)

The multidivisional form developed independently in three countries (recall however the existence of national differences, see footnote 1). During the first decade of the century it arose in Germany (at Siemens, Kocha 1971) and Japan (at Mitsubishi, Moriwaka 1970). In the USA, instead, Du Pont Corporation and General Motors adopted this organizational form at the beginning of the 1920s (Chandler 1962, chapters 2-3). The chart of the M-form is depicted in Figure 2.

The multidivisional organization is an evolution of the functional structure in which 'organizational complexity' increases and authority is partially re-allocated downwards. Middle management is now composed of divisional offices as well as functional departments. So, the organization is first sub-divided by divisions (product and market divisions) and then is functionally structured. Given the introduction of new corporate levels, the size of the management hierarchy expands.

Besides changes in the number and structure of hierarchic relations, the multidivisional structure implies relatively to the functional form a step towards decentralization of decision-making. Corporate offices still remain in charge of long-run strategies. However, divisions are partially autonomous, especially for short-run decisions, and they are managed functionally by a general manager. When Sloan adopted the M-form, he emphasized the autonomy of division managers in these terms: "The General Manager formulates all the policies of his particular unit subject only to the executive control of the President. The responsibility of the head of each unit is absolute and he is looked upon to exercise his full initiative and ability in developing his particular operation to the fullest possible extent and to assume the full responsibility of success or failure" (from 'General Motors Corporation - Organizational Study' quoted in Chandler 1962). Thus, we might say that the President retained formal authority and delegates real authority to division managers. This (partial) transfer of authority aimed at exploiting local knowledge and increasing initiative and participation of middle managers.

Johnson (1978) points out that the new type of organization needed new accounting procedures as well as a new information and communication network. Of course, information flows and authority links still remained vertically structured.

The organizational evolution of large enterprises towards this structure did not follow a unique pattern. Whereas many companies went through the multifunctional stage, other firms did not adopt this organizational form. In general, fast expanding firms that produced similar products were integrated into a single organization. In this way, companies exploited economies of scale through a centralized structure that coordinated operations and avoided duplications. The multifunctional structure was a response to these needs. When top management decided to diversify, then the increasing complexity of operations to coordinate and monitor imposed a decentralization of decision-making to division managers who had specific knowledge and capabilities. Conversely, in the case in which many autonomous companies merged, this process often led directly to a multidivisional organization. General Motors is an example of the second pattern, whilst Du Pont Corporation followed the first organizational evolution: "The Du Pont then was evolving from a centralized type of organization, common in the early days of American industry, while General Motors was emerging from almost total decentralization" (Sloan 1963).

To sum up, the M-form is a complex organization in which functional structures (divisions) are subsystems of a more complex and integrated system of authority relations and information flows. Decision-making is partially delegated downwards the management hierarchy in order to exploit capabilities of division managers and to stimulate their participation to firm's objectives.

1.3.3 The Japanese "Lean" Organization (J-form)

In this paragraph I discuss very briefly the emergence of a new organizational paradigm. I shall follow the definition of *J-form* (i.e., Japanese organization) provided by Aoki (1988)(1990), who emphasizes the rise of a new type of organization within the Japanese firms during the 1980s. However, it is worth noticing that other organization studies have called this form as the "lean type of organization". Since there is large managerial literature on this issue, a systematic review lies beyond the scope of this chapter. A fuller discussion of the lean type of organization will be presented in the next chapters (see for instance chapters 2 and 5). But the more general features of this new type of organization can be briefly stated here.

Aoki (1986) distinguishes a *hierarchic structure* in which a "management possesses a perfect a priori knowledge of the technical possibilities of shops, but is incapable of perfect monitoring of emerging events affecting and/or having rapid corrective actions implemented at shop", from a horizontal structure in which "productions decisions are coordinated among semiautonomous shops that have only incomplete knowledge of the technology at the outset, but gradually become capable of responding to emerging events more quickly by better uses of on-the-spot knowledge". Thus, the main difference between the multidivisional and the Japanese organization concerns both the decision-making allocation and the information network. The multidivisional form is a structure characterized by "(1) the hierarchic separation between planning and implemental operation and (2) the emphasis on the economies of specialization". Instead, in the case of the J-form the main features are "(1) the horizontal coordination among operating units based on (2) the sharing of ex-post on-site information" (Aoki 1990).

Figure 3 shows the emerging archetype of organization. First, this structure represents a step towards a decrease of bureaucratization (Womack *et al.* 1990). Whilst in the M-form tasks were rigidly defined in order to exploit economies of specialization, in the new structure tasks are loosely defined in order to achieve flexibility and exploit local learning and capabilities. Moreover, "Increased use of technologies, such as email, voice mail and shared databases, has, over time, reduced the need for traditional middle management, whose role was to supervise others and to collect, analyze, evaluate, and transmit information up, down, and across the organizational hierarchy" (Baharami 1992). Thus, the size of the management hierarchy is decreasing. In addition, Krafcik (1988) notes that the new type of organization is characterized by a higher span of control. This may be due to the new information technology paradigm (see chapter 3 for both theoretical and empirical analysis). Finally, decision-making is further decentralized (Drucker 1988, Jaikumar 1986, and Milgrom and Roberts 1995). Flexibility and agents' initiative are achieved through partial or total delegation of authority. Using Koike's (1990) words, the *white-collarization of blue collars* is a pillar of the lean organization. Therefore, whilst the multidivisional organization is based upon unskilled blue collars at the shop floor, the emerging organization is conversely based on a skilled workforce (Lazonick 1990a, 1990b).[3]

To sum up, the Japanese lean type of organization is characterized by a drastic reduction of the number of corporate tiers, an increase in the span of control and a re-allocation of decision-making that favors lower levels.[4] The recent evolution of technological change has been a major force in shaping the new organizational form. The IT paradigm is flattening managerial hierarchies, just as the second industrial revolution increased their depth.

1.4 Organization and Business Practices

This section is a sketch of the possible links between the organization and firm's routines. I shall focus only on the relation between the organizational structure and production practices. However, it is

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[3] It has been noted to the author that this picture of increasing decentralization might not be true. So, it worth noticing, here, that I do not want to put forward neither points of view. Indeed, one of the aim of the next chapters will be to challenge part of the managerial literature, by providing large scale quantitative evidence on these and other issues.

[4] "Most businesses have spent the past few decades decentralizing. Within big firms all around the world, bosses have been pushing authority down the management hierarchy" *Economist*, 1990, "The incredible shrinking company", pp.65-66.

important to recall here that there are other important links: for instance, the organizational structure may be associated with new administrative and accounting procedures. The aim is to show that the internal working of firms is characterized by routines as well as the other organization variables, and that the two may be interlinked.

1.4.1 Production Routines and Organizational Structure

Until the 1870s and 1880s there was widespread craft control in production (Montgomery 1987, ch. 1). Roughly speaking, more skilled workers, whose job was of coordinators of different tasks, defined the organization of production. Authority was partially delegated to workers in order to achieve maximum flexibility and exploit their capabilities.

The passage from the pre-modern organization of production to a hierarchic system (see section 1.2) determined both a change of the allocation of authority (fact 2) and the standardization of production. The main features of the new system of production can be summarized as follows: "(1) centralized planning and routing of the successive phases in fabrication, (2) systematic analysis of each distinct operation, (3) detailed instruction and supervision of each worker in the performance of that worker's discrete task, and (4) wage payments carefully designed to induce each worker to follow those instructions" (Montgomery 1987, ch. 7). The planning of the firm's operations corresponded to the idea of complete standardization of production and sale operations, exploiting economies of scale of a growing market.[5] For instance, Ford (1926) pointed out that "An operation in our plant at Barcelona has to be carried out through exactly as in Detroit. A man on the assembly line at Detroit ought to be able to step into the assembly line at Oklahoma City or São Paolo, Brazil". Companies could exploit dynamic economies of scale drawing upon on-spot learning-by-doing of unskilled workers (Lazonick 1990a and 1990b)[6] and on greater knowledge of the internal and external environments of top managers. Thus, the (multiunit) functional form cannot be analyzed abstracting from *scientific management procedures* in production.

As seen in previous sections, the modern corporation was a revolutionary innovation in the Schumpeterian meaning. The structure was highly centralized: top management and operating units were linked by vertical information flows and authority relations. Firm's plan was centrally defined and then implemented at the shop floor. Single-purpose machine tools were adopted and production was subdivided in single elementary operations (Carlsson 1984). The top management was, thus, able to appraise and define a precise plan of production to be implemented by blue collars who were monitored by foremen and lower level management. The

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[5] For an excellent and lengthy comparison between pre-modern and modern production routines see Coriat (1979). For a direct explanation of the *scientific management* approach to production see Taylor (1967). Alternatively, see Ford (1923) ch. 5-7.

functional organization implied new routines of running the firm. In more general terms, business history studies emphasize that,

Fact 3:

Organizational structures are associated with specific business practices. A change in the former often implies a change in the latter.

A second example of the relation between organization and firm's routines concerns the J-form. Just as the functional organization and the scientific management procedures were intertwined, so the lean type of organization would seem to based upon new production practices (called Toyota System or Ohnism). Kanban system, just in time manufacturing, total quality management, job rotation are important ingredients of the new structure (see for instance Coriat 1991 and Duimering *et al.* 1993). Kanban system and just in time are means of redefining the information structure as well as the authority relations. They are based on horizontal coordination (Aoki 1988, 1990). In addition, they put emphasis on urgency in decision-making, thus increasing the need of re-allocating authority down the management hierarchy. Total quality management and job rotation are means of exploiting local capabilities coming from production complementarities more than specialization (Ichniowski *et al.* 1997).

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[6] "The rank and file men come to us unskilled; they learn their jobs within a few hours or a few days". (Ford 1923).

However, it seems to me that managerial studies often overestimate the effect of business practices on the organizational structure. In other words, "Firms change in response to a perception that making a change represents substantial gains. When they do change, moreover, they do not necessarily *optimize* in any exact case. They search some what more haphazardly for ways in which to change, and (especially) they tend to imitate the actions of those rivals that they think are doing better. (*Think of all the manufacturing firms in the United States that have attempted to imitate Japanese manufacturing techniques over the past decade without a very clear understanding of why or how those techniques work.*)" (Kreps 1990). Thus, business practices may diffuse because are fads. Next chapters will provide new evidence on this issue.

1.5 Mechanism of Transition

How does organization change? What drives the process of adoption of new organizational structures? Econometric studies on the diffusion process of organizational forms have reached few (robust) results (see chapter 6 for a lengthier discussion of such findings and for new econometric evidence). Teece (1980) is the first attempt to provide econometric evidence on the diffusion process of organizations. He shows that when compared to technological change the evolution of organizational forms (i.e., the multidivisional structure) is indeed characterized by structural inertia. In particular, he calculates that it took 41 years before half of a sample of leading American firms adopted the M-form (14 years in the case of petroleum industry). Instead, Mansfield (1968) in his study of technology adoptions finds an average time of 7.8 years (ranging from 0.9 to 15 years). Overall, the existing evidence on organizational change shows that,

Fact 4:

Organization evolution is characterized by structural inertia.

Table 1 presents data on the diffusion process of the multidivisional form for six major countries from 1913 to 1980. Even if we consider only the largest corporations, the adoption process of the multidivisional structure appears to be very slow. For instance in Japan, Germany and France it took more than 50 years before half of the 100 largest national corporations had adopted the M-form.

Tab. 1 - Adoption of the M-Form (% of the top 100 companies)

	1913	1932	1950	1960	1970	1980
USA	0	8	17	43	71	81
Japan	1	0	8	29	55	58
Germany	1	-	5	15	50	58
France	1	3	6	21	54	58
Italy	-	-	7	17	48	-
UK	0		13	30	72	80

Source: Hannah (1996)

Thompson (1983) finds that the diffusion of the M-form follows a symmetric sigmoid process and early adopters are relatively more diversified and of greater size. Later studies (Palmer *et al.* 1987, Palmer *et al.* 1993) confirm the importance of both product and geographic diversification, hence complexity of firm's operations, but not of size which is only indirectly related, through complexity, to the adoption of a divisional structure. Moreover, they point to the role played by both the ownership status and imitation of firms that operate in the same line of business. However, the imitation hypothesis is still a very debated argument. Whereas Mahajan *et al.* (1988) find no evidence of any imitation process for the adoption of the M-form within 127 very large US companies, Venkatraman *et al.* (1994) using the same data set show that results highlight the role played by external influence (i.e., information outside the same line of business of firms) instead of internal information (i.e., number of firms that operate in the same line of business and have adopted the M-form). Finally, Kogut and Parkinson (1998) find that imitation emerges as a (significant) explanatory variable of the diffusion process only if we extend the time of observation sufficiently, that is if we analyze history from the start.

In the next three paragraphs I present in greater detail evidence on this issue coming from business history studies.

1.5.1 (Market and Technology) Complexity and Organization

At the end of the last century and the outset of the current one, railroad companies, Standard Oil, and Du Pont Corporation were operating in a growing market in which a small scale of production was no longer viable.[7] They consolidated and coordinated small activities in a unique structure. The increasing amount of similar items of information to gather and to process led to the transition to functional centralized structures, with specialized departments based upon functions (see section 1.3.1).

In business history there is wide evidence of a relation between complexity of information to gather, store and process and firm's organization (see for instance the *three stages theory* of Scott 1973). Chandler (1962)(1977) for the US, Suzuki (1991) for Japan, Channon (1973) for the UK, and Dyas and Thanheiser (1976) for Germany and France, confirm the existence of such relation. In 1970, 81% and 91% of the 100 largest single business firms[8] of France and Germany respectively were functionally structured, whilst 59% and 50% of dominant business firms had adopted a multidivisional organization so as 64% and 79% of related business firms. Similarly, 100% of the

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[7] For the history of American railroad companies I refer to Chandler (1977). For Standard Oil and Du Pont see Chandler *et al.* (1996), ch.15-16.

[8] A single business firm is defined as a firm with 95% or more of total sales that lie within a single business. Dominant business firms are those firms which, in addition to their main product line, have diversified into other related or unrelated businesses to the extent of up to 30% of total sales. Finally, related business firms are firms which have diversified by entering into related markets or by using related technology, or have combined vertical integration with such diversification so that no one product line accounts for more than 70% of total sales.

largest 500 US single business firms were functionally organized, whilst 64% and 95% of dominant business firms and related business companies respectively had adopted a multidivisional structure (Scott 1973). We can thus conclude that when firms develop a strategy of diversification they are forced to adopt a multidivisional organization.

Two major forces that being related to complexity affect organizational change. First, the market demand, both in terms of extension of the market and diversification of consumer tastes, is the first element. Periods of dramatic change of market demand have been characterized by drastic changes of the organization of firms. Moreover, domestic market differences have been a key element in causing organizational idiosyncratic differences (see footnote 1).

Second, technology affects the way in which information is gathered and spreads within the firm. Thus, it influences the efficient size and structure of the management hierarchy. As I claimed before, the advances of the second industrial revolution increased the optimal number of corporate levels of the management hierarchy (see section 1.2). Indeed, the achievements of a new communication and transportation technology made viable the development of a multi-unit vertical structure. In addition, there is plenty of evidence on the influence of the new information technology (IT) paradigm on the organization of firms (see Bresnahan *et al.* 1999). I cannot go deeper into this argument here. But it is worth noticing that organization studies stress that the IT paradigm is changing the organization by increasing the efficient number of subordinates under one manager (i.e., the span of control) and flattening the management hierarchy (see chapter 3 for further evidence).

In sum, there is a strong relation between complexity and organization. Since market conditions and technological change influence complexity, they shape the organization of firms. Thus, I agree with Alford (1994), who claims that there are alternative paths to successful capitalism depending on industry and market-specific characteristics.

1.5.2 Structural Inertia

Chandler (1962) argues that the invention of a new organization is a creative response to new needs and conditions. Moreover, there is general agreement among economists and historians that the invention of a new type of organization represents a radical innovation. At the beginning of this section I claimed that the organization is a particular kind of innovation, since its diffusion is slower than that of technological innovations. Why? In order to provide some evidence into this issue, I look at some well known cases of business history: Du Pont (Chandler *et al.* 1996), Mitsubishi (Moriwaka 1970), Siemens (Kocha 1971), and General Motors (Chandler 1962 ch.2, and Sloan 1963; for this case see the next section).

These companies were all adopters of a new organizational form. In all of these cases, innovating firms had a period of active search that started usually with a drastic change of top management. In 1902, Alfred Du Pont replaced Eugene Du Pont as president of Du Pont Corporation. Shortly after, Alfred started a process of re-organization that lasted until 1906 and was mainly due to a lack of administrative coordination. The organization followed a process of centralization from "a loose federation of many relatively small firms into a consolidated, integrated, centrally managed industrial empire". In just the same way, Kyota Ivasaki, president of Mitsubishi, steered a process of centralization of decision-making from a holding company to a multidivisional structure. This re-organization ended after 10 years. At Siemens the change of the organization started when Werner von Siemens retired. As Kocha points out "As in the case of many other companies the replacement of the founder facilitates the reforms".

Overall these cases show that since the organization of firms concerns written and unwritten rules (i.e., corporate culture), information flows, and authority relations, its change implies both sunk costs and a re-allocation of power. Thus, organization changes only when new ideas break strong inertial forces, which are the result of influence activities of firm's managers.

1.5.3 Imitation and Diffusion

Diffusion of information and imitation are two major determinants of the adoption process of organizational forms and business practices.[9] Authority relations, information flows, business practices are only partially defined by formal rules. They heavily depend on corporate culture (Kreps 1985). From this respect the organization is a long run convention. Therefore, its process of change takes time and is very costly.

My claim is that organization is a convention that follows a path-dependent process (Arthur 1985 and 1988, Sudgen 1989 and Young 1996). In particular, Delmastro (1996) shows that the widespread diffusion of information on an organizational structure is crucial. However, since the organization differs from technology because cannot be (accurately) defined, during the imitation and implementation process the organization adapts to local needs as well as to idiosyncratic firm-specific interpretations.

The historical evidence that supports this claim is ample. As I said before, Kreps (1990) notices that during the 1980s American companies have adopted Japanese organizational procedures mainly because these had become a well known convention. Thus, business practices seem to be fads. More importantly, American managerial routines were adopted in Japan after the Second World War when the

US strongly influenced Japan economic and social reforms: "Like European firm, American practices had an influence in the introduction of the multidivisional structure in Japanese firms" (Suzuki 1991). In Britain the process was very similar, "One of the reasons for the adoption of the multidivisional form in Britain in the postwar period was undoubtedly the American cultural and economic penetration of a country with whose manufacturing firms US-based international corporations had increasingly links" (Hannah 1976). Thus, the diffusion of information, imitation, and fads play an important role in the diffusion of both organizational forms and (above all) business practices.

1.6 An Example of Organizational Evolution: the US Automobile Industry, 1900-1950

The case of the US automotive industry is very illustrative for the study of the evolution of organizational forms and business practices. Indeed, American car companies were pioneers in adopting new forms of organization that spread throughout the world economy. There is an ample literature on the car industry, and this section is based upon it. Of course this overview is very brief and it is focused only on few aspects. The aim is to show that organizational change is driven by the aforementioned determinants: inertial forces due to

[9] The diffusion of information is a key determinant of the diffusion of technological innovations. Epidemic models have represented the first attempt to introduce this relation into economic models (see Davies 1977).

conservative and influence activities of members of the firm, imitation (but only when the organizational form and business practices become a sort of convention), complexity, and technological change.

Until the turn of the century the car industry was populated by many small firms. These were craft shops, which were managed by their founders who were the pioneers of a new sector (Thomas 1977). As the new century unfolded, the market grew substantially and at a fast pace, raising the complexity of production operations. As stressed by Montgomery (1987, ch.5) "During this growth period the automobile industry had completely abandoned the methods of production in which craftsmen had made the products while laborers fetched and carried". The organizational response was of two types. On the one hand, firms like Ford started to growth vertically (Langlois and Robertson 1989). Ford adopted a centralized structure, exploiting economies of scale through the definition of a functional multiunit form (section 1.3.1). On the other hand, General Motors developed as a holding company; different firms were financially integrated but organizationally autonomous. Indeed, Durant, GM's founder and president, did not manage to create a headquarters that controlled and coordinated the different companies of General Motors (Chandler 1962, ch. 3).

In 1908, with the introduction of Model T, Ford Company achieved the best competitive performance in a period of fast growing and undifferentiated demand (Abernathy and Wayne 1974 and Abernathy

1978). Its functional and centralized structure was highly efficient under those demand and technology conditions. The increasing number of items of information to gather and process was faced by a functional structure, vertically integrated that relied upon central planning (Montgomery 1979 ch. 5). As stressed by Ford (1926) "The advantages of standardization are apparent in production. The disadvantage is the expense incurred when changing from the standard". Standardization brought, therefore, static cost reductions but also a lack of production flexibility, mainly due to high sunk costs. This became dramatically evident in 1927, when plants were shut down for nine months in order to reset the layout of production for the passage from Model T to Model A. The trade-off between flexibility and economies of scale was perceived by Ford's rivals, which chose alternative strategies: "In May 1927...he (Ford) shut down his great River Rouge plant completely and kept it shut down for nearly a year to retool leaving the field to Chevrolet unopposed and opening it up for Mr. Chrysler's Plymouth. Mr. Ford regained sales leadership in 1929, 1930 and 1935, but, speaking in terms of generalities, he had lost the lead to General Motors" (Sloan 1963).

In 1921, GM adopted a new decentralized organization: the multidivisional structure. This was a creative response to the growing complexity of GM's operations, thought and realized by Alfred Sloan. Sloan was appointed in 1921, when Durant left his president position. This change of leadership occurred after a GM's sales crisis.

In that year Ford increased its sales from 463,000 to 971,000 units facing the recession with an aggressive price strategy, whilst GM's sales slumped from 393,075 to 214,799. However, the search of a new organizational form started since 1915 when a committee was appointed to analyze problems due to the lack of coordination between group's companies. Indeed, between 1919 and 1920 Sloan worked at an 'Organization Study' in which he defined the core of the new multidivisional structure. However, the process of re-organization took many years. When Sloan was appointed president of GM he needed more than two years to implement the new organizational structure: since the re-organization implied a re-distribution of power each semiautonomous division was hostile to any change.

The spread of the multidivisional structure was rather slow. The diffusion of information on the new organizational form and business practices (e.g., the new accounting system, the scientific approach to production) and the related imitation process were obviously two intertwined features of the same dynamic evolution. Followers studied and copied the technology and the organization of leaders through a direct observation of the new system of production. In the case of the French car industry (Cohen 1991), Renault went to the US in 1911 to visit Ford Corporation and to meet Henry Ford and Frederick Taylor. Citroën went to Detroit in 1912 and met Alfred Sloan in 1923. In the Italian car industry (Fauri 1996) managers of

FIAT went to US to meet Henry Ford after the First World War. However, only in 1950 FIAT was ready to adopt the multidivisional organization. Overall, European car companies studied the methods of production and organization of US leading companies and (slowly) implemented them at home.

In the United States, the first company that followed GM and adopted a multidivisional form was Ford. This happened 35 years after GM's adoption. Whilst for Chrysler the delay in the adoption of the multidivisional form was mainly due to its smaller size, the case of Ford is more complex. Henry Ford built up a functional centralized organization, which was efficient until the complexity of production, marketing, and distribution operations reached a certain level. Then, instead of changing organization he "attempted to administer his empire personally. The result was disastrous" (Chandler 1990). The market share declined constantly thereafter (see Table 2), and Ford lost completely the first mover advantage gained in 1908 with the introduction of Model T.

Thus, we might say that Ford's strategy was not optimal. After 1921 the company had an alternative dominant strategy but Henry Ford refused to pursue it. Only when, in 1946 the board of top corporate officers changed and Henry Ford left, then the company adopted a multidivisional organization. Breech was appointed to define Ford's new strategy in a period of sales crises. As stressed by Fortune in 1947 he began "chapping the GM organizational garment onto the Ford manufacturing frame...one of the Breech's first acts was to hand around copies of a semi-official GM text on decentralization". In the end "The Ford Motor Company copied the organizational structure of General Motors...It did so, as is well known, only after the retirement of its founder" (Chandler 1956).

Tab. 2 - US automobile industry (1910-50), market shares

Year/Corporation	Ford	General Motors	Chrysler
1910	10.7	-	-
1915	43.4	-	-
1921	55.4	12.3	-
1925	41.5	20.0	-
1929	31.3	32.3	8.2
1932	23.9	41.5	17.5
1940	18.9	47.6	23.7
1948	18.8	40.6	21.5
1950	24.0	45.4	17.6

Sources: Fortune (1954), Abernathy (1974), and Chandler (1990).

The story of Chrysler is also very instructive. Since the early 1920s the company enjoyed a continuous growth of market share (see Table 2). When operations grew over a certain threshold its functional organization was no longer viable. At the end of the 1940s Chrysler faced several sales crises. As a consequence its market share sharply declined and at the end of 1950 the top management was replaced by a new one. Colbart took the lead and tried to introduce a new decentralized organization. It took almost three years to implement the new structure since "Decentralization was a world practically invented by General Motors and no one at Chrysler wanted any truck with GM gadgetry", so that Colbart had to "to coin his own word, divisionalization" (from Fortune 1954).[10]

To sum up, the automobile industry is an interesting example that presents distinctive stylized facts on the organization of firms and its evolution. First, two major innovations (i.e., the multi-unit functional form and the multidivisional form) characterized the evolution of business organizations within the sector. Second, the search for a new structure was a process that lasted for a long period of time. Third, followers imitated organizational forms, production structures and (above all) business practices of leaders only when these became well known. Finally, for both leaders and followers the adoption of a new organization was inhibited by both internal conservative influence activities and sunk costs that induced structural inertia.

[10] This quotation reminds me the following words of Arrow (1974): "the learning of a code by an individual is an act of irreversible investment for him. It is therefore also an irreversible capital accumulation for the organization. It follows that organizations, once created, have distinct identities, because the costs of changing the code are those of unanticipated obsolescence". Thus, sunk costs seem to play a key role in shaping the evolution of organizations (see also chapter 6).

1.7 Concluding Remarks

The aim of this chapter was to provide historic evidence on the organization and its evolution. For this purpose, I have selected specific topics from business history literature in order to present some major facts. First, the modern organization is a hierarchic system of relations. Its is composed by a hierarchy of salaried executives that are vertically related and ranked.

Second, in this context there are some key variables that characterize each of the main organizational forms that have been analyzed by business history studies. As to the allocation of decision-making, I showed that functional, multidivisional and lean organizations are characterized by very different allocations of authority. The functional structure is very centralized, whilst the latter two forms are more decentralized with the Japanese organization being the most decentralized structure. Similarly, organizational forms differ in terms of size and structure of the management hierarchy. For instance, the Japanese "lean" type of organization represents a step towards both a reduction in the number of levels and an increase in the number of subordinates under one manager. Finally, production, managerial and administrative practices are often inter-linked with the organizational form.

Therefore, a thorough study of the organization should take into account these variables. However, empirical studies have so far faced data constrains that prevent them to operationalize these aspects of the organization in a quantitative way. Chapter 2 provides a description of a new empirical methodology upon which is based the present research.

Third, organizational evolution is dominated by structural inertia, which is mainly due to influence activities of managers and sunk costs of changing architecture. Moreover, diffusion of knowledge and imitation seem to play an important role in affecting the widespread adoption of an organizational form.

Overall, the following parts of the thesis will shed new light into these issues. Before proceeding further with the remainder of this thesis, a consideration is in order. In this chapter I focused on the organization of firms. However, the remaining chapters will analyze the organization of plants and, in some cases (see chapters 3 and 4), its relation with the overall organizational structure of the parent firm. This focus is mainly due to the data which is available to me (see the empirical methodology chapter), so that a wider analysis on the overall organization of large companies lies beyond the scope of the present research.

Appendix: figures of Chapter 1

Figure 1 - The multiunit functional form

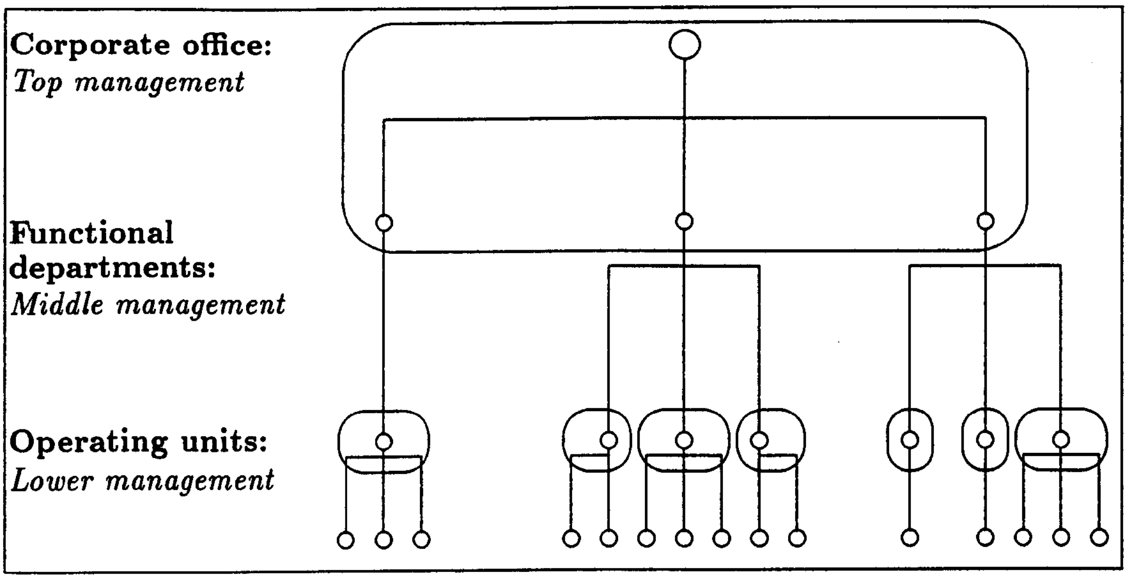


Figure 2 - The multidivisional form

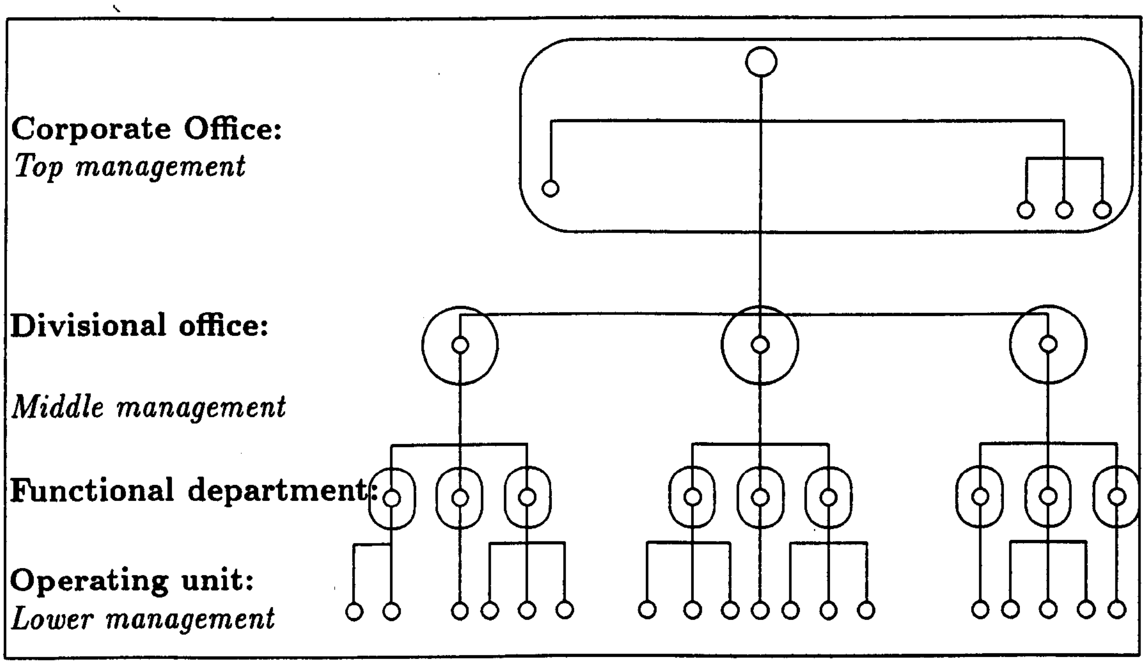
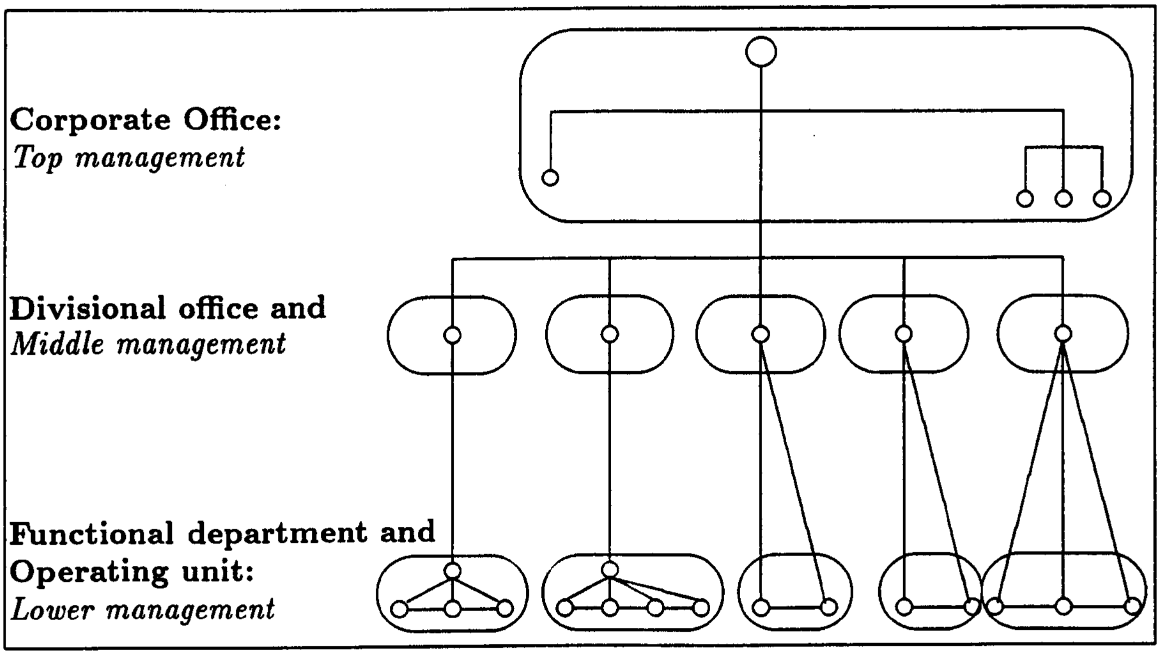


Figure 3 - The lean type of organization (J-form)



Part II

Descriptive Quantitative Evidence

Chapter 2

Evidence on the Organization and its Evolution

2.1 Introduction

The organization of firms has recently become a lively debated issue in the economic literature. Nonetheless, there is a striking difference between the large number of theoretical papers and the lack of robust quantitative empirical evidence. In spite of growing interest, organization still remains an ambiguous concept, hardly analyzed empirically. In this chapter I propose an empirical methodology based upon business history (see chapter 1) and theoretical work (see for instance chapters 3 and 4), which allows me to describe some crucial aspects of the organization of firms in quantitative terms. In other words, the emphasis is on developing new indices measuring in a standardized way some key but elusive concepts in the economics of firm organization that have so far defied systematic quantification.

In particular, I consider variables that capture the extent of the hierarchical structure of plants, span of control,[1] and the allocation of decision-making activities among the different hierarchical layers. In my opinion, this constitutes a necessary prerequisite to operationalize a series of concepts that are at the core of the debate in the theoretical literature, but on which empirical evidence is surprisingly weak and relegated mostly to case studies. In this way, I am able to provide new interesting insights into the organization of plants and its evolution.

[1] Span of control is defined, for each level of a firm's organization, as the number of subordinates under one manager.

The nature of the chapter is largely descriptive. I use the above mentioned indices to study the organization of a sample composed of 438 Italian metalworking plants. I also analyze the dynamics of plants' organization in the 1980s and 1990s. As far as I know this study represents one of the first attempts to provide large scale empirical evidence on these topics.

The remaining part of the chapter is organized as follows. In the next section I describe the empirical methodology, giving also its theoretical and empirical grounds, and provide details of the data set. Section 2.3 concentrates upon organizational architecture. First, I analyze the size of plant hierarchy, then I study the span of control. In section 2.4 I give a detailed picture of the allocation of power within firms, using two measures of centralization and one of concentration of decision-making activities. I sum up, in the conclusions, the main results of the analysis and outline further directions of applied research on the organization of firms I will develop in the remainder of the thesis.

2.2 Empirical Methodology and Data

2.2.1 Premise

The organization of firms is a complex structure made up of a large number of parts that interact in a non-simple way. Furthermore, organization is a hierarchic system, in the sense that "it is composed of interrelated subsystems, each of the latter being, in turn, hierarchic in structure until we reach some lower elementary subsystem" (Simon 1962). By relying on business history (chapter 1) and the theoretical literature (see for example Bolton and Dewatripont 1994, Calvo and Wellisz 1978 and 1979, Keren and Levhari 1979, 1983 and 1989, Qian 1994, Radner 1992 and 1993, Sah and Stiglitz 1986 and 1988, and Williamson 1967), I develop a stylized description of the internal working of firms (and plants) using a vector of quantitative variables. This allows me to provide robust large scale empirical evidence on the organization of plants, thus shedding new light on the current debate on firm structure and its dynamics.

I use three types of measures in order to define quantitatively the internal structure. First, hierarchy can be represented by a tree with the top manager at the top and the plant's employees operating machines or working at the assembly lines at the bottom. The total number of managerial levels gives the size of hierarchy. Second, the span of control, defining hierarchical relations among the plamt's layers, shapes the form of the organization. Finally, the allocation of decision-making, which defines who takes what decisions within the hierarchy, completes the definition of the organization.

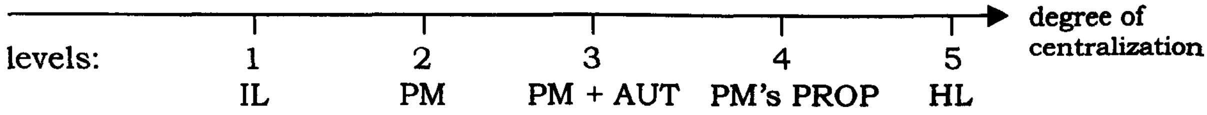
2.2.2 Data

Since quantitative data on the organization of firms are rarely available, I have conducted, with the financial and human support of

Politecnico di Milano and Università di Pavia, a fieldwork on Italian manufacturing plants (FLAUTO97 survey). I have obtained detailed information on plant's organization for a sample composed of 438 manufacturing plants (see the empirical methodology chapter at the beginning of this thesis).

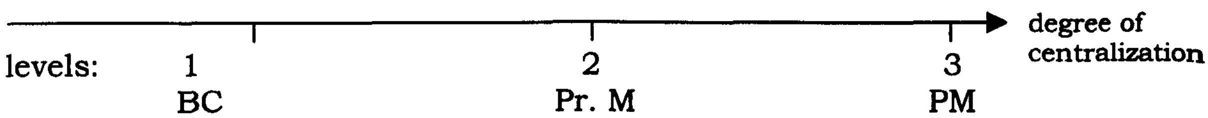
In particular, for each plant I know the total number of managerial levels. Moreover, I have detailed data on the decision-making structure. I have information on the level at which each hierarchy takes the following six strategic decisions: (i) purchase of stand-alone machinery, (ii) purchase of large-scale capital equipment, (iii) introduction of new technologies, (iv) hiring and dismissal of plants' employees, (v) individual and collective incentive schemes, and (vi) plants' employees career paths. In addition, I also know what level of the hierarchy is assigned responsibility for the following operating activities: (a) daily production plan, (b) weekly production plan, (c) definition of blue collars' tasks, (d) control of blue collars' operations, and (e) modification of production plan after sudden shocks. I have adopted a rather stylized, yet meaningful description of the decision-making structure of the firm relating to strategic and operating decisions (shown in Figure 1a and 1b respectively), which is instrumental to obtaining data that are comparable across plants of different size and ownership structure.

Figure 1a – Decision-making structure: strategic decisions



Legend:
IL: intermediate levels (such as blue collars and production middle managers);
PM: plant manager autonomously;
PM+ AUT: situations in which the plant manager needs a formal authorization before taking a decision;
PM's PROP: situations in which the plant manager can only propose but not decide autonomously;
HL: higher levels.

Figure 1b – Decision-making structure: operating decisions



Legend:
BC: blue collars;
Pr.M: production middle managers (and/or other levels between blue collars and the plant manager);
PM: plant manager.

In this way, plants can be characterized by the degree of decision-making centralization that depends on the level at which decisions are taken.[2] As concerns strategic decisions, the highest degree of decentralization corresponds to the situation in which the levels

[2] In chapter 4 I will provide a distinction between real and formal authority of strategic decisions. However, it is already evident that in levels 1 and 2 either the plant manager or some intermediate level have real and formal authority over a plant strategic decision. Instead, in level 3 the plant manager has only real but not formal authority, since he needs a formal authorization from his corporate superior (he can be overruled at any time). Finally, in levels 4 and 5 the plant manager's superior has real and formal authority.

under the plant manager are responsible for taking decisions (level 1). Going up the hierarchy we find those situations in which the plant manager is autonomously in charge of pant's strategic decisions (level 2). Otherwise his power may be limited by superiors' supervision (level 3), or he might be only entitled to make proposals (level 4). Finally, the highest degree of centralization is the case in which hierarchical levels higher than the plant manager (for example the owner in a small single-plant firm, or a middle manager in a plant that is owned by a multinational enterprise) take strategic decisions. As to operating decisions, a similar distinction can be made between centralized units, where decision-making power is concentrated at the plant manager level, and decentralized ones where responsibility for operating decisions is delegated to lower hierarchical levels (such as blue collars).

For each sample plant I have data on the 1997 organizational structure. Moreover, I know if plants have changed their organizations during the period 1975-1996 (meaning that they have changed one of the considered variables). If the answer is affirmative I have also information on the "old" organization. In the following sections I shall define the old organization as "previous organization". If a plant has not changed its structure, then the current and previous organizations coincide.

Lastly, I have additional information on sample plants, including size (i.e., number of employees in 1997 and 1989), ownership status, sector of operation, localization, and adoption of advanced manufacturing technologies (AMT), inflexible manufacturing systems (IMS), local area networks (LAN), and electronic-data-interchange (EDI), managerial innovations - such as just-in-time (JIT), and total-quality-management (TQM) - and human resources management procedures - such as job-rotation, formal team practice, and individual incentive schemes. A description of these latter and other variables is provided in the introduction of this thesis and in the following chapters, where is needed.

2.2.3 Measures of Organizational Structure

The first aspect of interest of an organization is its size. Since the seminal work of Williamson (1967) many papers have described a firm's organization by its number of managerial levels (see chapter 3, section 3.2, for a review of hierarchical models of the firm). Thus, I define the variable LEVEL as the number of hierarchical levels of plants. Of course, the minimum of LEVEL is two, corresponding to the situation in which plant organization comprehends only blue collars and the plant manager. LEVEL is a measure of organization complexity. On the one hand, firms may face problems of "loss of control" in expanding organizational size (Williamson 1967). In fact, the reliance of hierarchical organizations on serial reproduction for their functioning exposes them to serious distortions in transmission (Keren and Levhari 1979) as well as to the shirking of subordinates

(Calvo and Wellisz 1978). Hence, bounded rationality within organizations should impose a severe limitation to hierarchy's size. On the other hand, managerial hierarchy is a source of economies of scale in gathering and elaborating new information (Chandler 1962 and 1977 and Radner 1993). Indeed, the purpose of the management hierarchy is to capture scale and scope economies within and among functions through planning and coordination. If statically the choice of the number of levels is dominated by this trade-off, dynamically I would expect, especially for large plants, the elimination of (some) intermediate levels, with the adoption of a "lean production" approach (see chapter 1). In addition "Increased use of technologies, such as email, voice mail and shared databases, has, over time, reduced the need for traditional middle management, whose role was to supervise others and to collect, analyze, evaluate, and transmit information up, down, and across the organizational hierarchy" (Bahrami 1992).

The second notion of organizational structure refers to the shape of an organization. Whilst the number of hierarchical levels is a straightforward variable to define, the span of control is more tricky. In general, the span of control is, for each tier of a hierarchy, the average number of subordinates under the same superior. However, I do not have information about employees' distribution among levels. So, what I derive is an 'average span of control'[3] defined as the

[3] Keith Cowling suggested to estimate the span of control at each level. There are two main reasons why I have not proceeded in this direction. First, I am mainly interested in an aggregate measure of the span of control that is comparable

number, *SPAN*, that, given the number of employees *n* and the number of hierarchical levels (*LEVEL*), satisfies the following equation:

$$n = 1 + SPAN + SPAN^2 + \cdots + SPAN^{LEVEL-1}.$$

If for instance the number of employees is 85 and the management hierarchy comprehends 4 levels, then *SPAN* equals 4. This means, in turn, that on average managers have 4 subordinates each.

The (static) choice of span of control depends again upon the 'loss of control phenomenon'. In a context where employees are vertically related, the more subordinates a superior monitors (greater span of control), the smaller the probability of the subordinate being checked (see Calvo and Wellisz 1978 and 1979, Qian 1994, and Rosen 1982). Hence, a greater span of control will raise the likelihood of subordinates' shirking. However, a lower value of the span of control, given the number of employees, implies a higher number of hierarchical levels, expanding loss of control through information transmission failures (Keren and Levhari 1979, 1983 and 1989). Dynamically, at least for large firms, with the adoption of new

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between firms of different size. SPAN has such a nice property. Second, the estimates of the span of control might lead to very disappointing results. In fact, we cannot restrict the span of control to some value, so that it might come out to be less than one, or, worst, negative. Thus, we might well end up with results that are not economically meaningful. I cannot go into details but there are clear indications (and reasons) that this is the case.

computer-based technologies that enhance both managers' monitoring capabilities and the efficiency and speed of information transmission, I expect the span of control to be increased (Krafcik 1988).

To sum up, I claim that organizations can be viewed as complex hierarchical structures. Thus, a robust way to analyze them quantitatively is to look at the number of hierarchical tiers and the span of control. I expect to find static and dynamic regularities as to the values taken by such variables. Before doing so, I introduce other and maybe more original indices that measure firm decision-making allocation.

2.2.4 Measures of Decision-Making Allocation

In order to summarize data on the decision-making structure of firms I put forward three different measures. I claim that they give an exhaustive and comprehensive picture, both statically and dynamically, of the allocation of power within the plant (Aghion and Tirole 1995 and 1997, and Sah and Stiglitz 1986 and 1988).[4]

Since Marschak and Radner's (1972) seminal contribution the term 'organizational form' has been employed to characterize the key elements of organizations within a decision-making framework. Even though we know that there is more to organizational structure than just centralization and decentralization, it is not disputable that authority relations are a key aspect of business organizations. We may therefore conceive of a corporate hierarchy comprising various tiers of decision-making. The power to make strategic and operating decisions is not necessarily concentrated at the pinnacle of the hierarchy but may be diffused throughout the firm. In the remainder of this section, I describe indices relating to strategic decisions. Similar indices have also been calculated for operating decisions.[5]

Data on the decision-making structure are multivariate categorical ranked data (see section 2.2.2). Moreover, there are very clear indications that data relating to different strategic (and operating) decisions are correlated. The main objective is to present the main structural features of the allocation of decision-making power in terms of a small number of variables, possibly one, so that they may be better understood. In order to do this I use principal component analysis, a fairly standard approach in industrial economics in situations such as mine (see for example Levin *et al.* 1987).[6] In particular I have followed three steps. First, I have applied a linear scale to categorical ranked data on the decision-making structure (i.e., linear ranking). Second, I have conducted a principal component analysis on data related to both the present and previous

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[4] Note that I always refer to the plant level. Strategic and operating decisions relate to the plant, so that this and not the firm is the appropriate unit of analysis.
[5] For the sake of simplicity the details of the analysis relating to operating decisions are not illustrated here. They follow exactly the same steps as to strategic decisions.
[6] For strategic decisions, see Table A.2 in the Appendix, the first component explains more than 75% of sample variance. Since we do not loose much information, data reduction seems to be quite efficient (results for both strategic and operating decisions are presented in the Appendix, tables A.1-A.4).

organizations, in order to have the same indicator for the two series of observations. That is, I have run the analysis on a (438x2) x 6 matrix (where 438 is the number of sample plants, 2 refers to the previous and present organizations, and 6 is the number of strategic decisions considered), so that the first component I derive can be employed for the observations of both the "old" organization and the current one. Third, I have defined for each plant *j* (*j* =*1,..,438*) a measure of the degree of centralization of decision-making (DC), in the following way:

$$DC(j) = \sum_{i=1}^{6} a_{1i} x_i(j),$$

where a_{1i} ($i=1,..,6$) are the six coordinates of the first component and $x_i(j)$ ($i=1,..,6$) are the values of the decision variables for plant *j* once linearly ranked (recall that such variables range from 1, maximum decentralization, to 5, maximum centralization, see Figure 1a). Thus, DC will be large if plant decision-making is highly centralized. The details of the principal component analysis are given in the Appendix (see Table A.1-A.4).

In addition, I have calculated, for each plant *j* (*j* =*1,..,438*) the number, $ND_k(j)$, of strategic decisions taken by each tier *k* of the hierarchical structure. That is:

$$ND_k(j) = \sum_{i=1}^{6} D_i^k(j) \qquad k = 1,\cdots,5,$$

$$\text{with}: \quad D_i^k(j) = \begin{cases} 1 & \text{if } x_i(j) = k, \\ 0 & \text{otherwise.} \end{cases}$$

$D^k_i(j)$ is a dummy variable that equals 1 when decision i is taken by level k (namely if $x_i(j)=k$) and is zero if it is taken by another level, and 5 is the total number of hierarchical levels considered. Hence for each plant j **ND(j)** is a vector of five discrete coordinates, that range between zero (no decision is taken at that level) and 6 (all decisions are taken at that level).

Unlike the previous measure, *ND* captures, besides the degree of plant centralization, the distribution of authority within the hierarchy. Whereas from *DC* we know the plant average level of centralization of decision-making activity, from *ND* we can distinguish situations in which decision-making is concentrated at high, middle or even low hierarchical levels from cases in which it is more evenly distributed.

Lastly, I have defined a measure of the degree of concentration of decision-making power. To do so I have followed three steps. First, since the five decision levels described in Figure 1a represent not only plant hierarchical levels but also ways in which a level takes a strategic decision (in particular levels 3 and 4), I have aggregated them in three groups corresponding to three actual tiers: blue collars and production middle management (level 1), plant manager (level 2 and 3), and higher levels (level 4 and 5). Second, I have used Euclidean distance as a measure of decision concentration. That is for each plant *j* (*j* =1,..,438),

$$CONC(j) = (y_{1j}^2 + y_{2j}^2 + y_{3j}^2)^{1/2}$$

where y_{ij} is the number of decisions, out of six, taken by group *i*. Clearly, *CONC* reaches its maximum when all decision-making is concentrated at one level. Third, I have standardized *CONC* in the following way,

$$STD\_CONC(j) = \frac{CONC(j) - \min(CONC)}{\max(CONC) - \min(CONC)}$$

Notice that $0 \leq STD\_CONC \leq 1$, and that higher values represent higher concentrations of decision-making. If *STD_CONC* = 1, then all decisions are concentrated at one of the following levels: blue collars, plant manager, or higher levels.

2.3 The Organizational Structure

Table 1 shows descriptive statistics of the variable LEVEL. For each category of plants ordered by their number of hierarchical levels, columns 2 and 3 describe the sample distribution and column 4 reports average plant size measured as the number of employees in 1997. Columns 5-7 do the same for the previous organization (see section 2.2.1).

Tab. 1 - Number of hierarchical levels (LEVEL) and plant size

	1997 organization[a]			previous organization[b]		
LEVEL	obs.	%	average size	obs.	%	average size
2	29	6.6	34.4	44	10.0	43.9
3	233	53.2	121.0[‡]	217	49.5	104.6[‡]
4	126	28.8	217.1[‡]	107	24.5	238.5[‡]
5	40	9.1	569.4[†]	43	9.8	567.3[‡]
6	10	2.3	623.4	27	6.2	1023.5
total	438	100	195.3	438	100	233.3

Legend:
[a] Plant size is defined as the number of employees in 1997.
[b] Plant size is defined as the number of employees in 1989.
[‡] t-test: difference in average plant size between two consecutive LEVEL classes significant at the 99% level.
[†] t-test: difference in average plant size between two consecutive LEVEL classes significant at the 95% level.

The data presented in Table 1 reveal few surprises. First, the sample distribution is concentrated around three and four hierarchical levels. Taken together they account for 82% and 74% of the sample plants for the present and previous organizations, respectively. Second, there is a strong evidence of a positive relation between the number of hierarchical tiers and plant size. In particular, almost all differences of plant size averages between consecutive

LEVELs are statistically significant at conventional levels (see Table A.5 in the Appendix). More interestingly, the sample mean of LEVEL for the 1997 organization does not significantly differ from that for the previous organization, even if a χ^2 test shows that the null hypothesis that the distributions by LEVEL classes of the 1997 and previous organizations do not significantly differ is rejected at 99%. This is the result of two processes. On the one hand, the number of plants that adopt a two-level hierarchy is diminishing: they are evolving towards more complex structures. On the other hand, very articulated organizations, with 5 and 6 levels, are turning to less complex architectures. To gain further insights into such phenomena we need less aggregate data.

Tab. 2 - Number of levels, distributions for categories of plants

LEVEL	n. of employees < 100				n. of employees: 100 - 500				n. of employees > 500			
	1997[a]		previous[b]		1997[a]		previous[b]		1997[a]		previous[b]	
	obs.	%	obs.	%	obs.	%	obs.	%	obs.	%	obs.	%
2	28	11.3	40	15.3	1	0.6	4	3.1	0	0.0	0	0.0
3	160	64.9	163	62.2	64	40.8	49	38.0	9	26.5	5	10.6
4	48	19.4	49	18.7	68	43.3	45	34.9	10	29.4	13	27.7
5	10	4.0	6	2.3	18	11.5	23	17.8	12	35.3	14	29.8
6	1	0.4	4	1.5	6	3.8	8	6.2	3	8.8	15	31.9
total	247	100	262	100	157	100	129	100	34	100	47	100

Legend:
[a] Plant size is defined as the number of employees in 1997.
[b] Plant size is defined as the number of employees in 1989.

Table 2 distinguishes three categories of plants: small (number of employees smaller than 100), medium (between 100 and 500), and large plants (more than 500 employees). As seen in the table, small firms are becoming marginally more articulated over time, with the share of small plants with 2 tiers out of the total of small plants decreasing (from 15.3% to 11.3%) and the share of those with a number of tiers between 3 and 5 increasing (from 83.2% to 88.3%). Medium plants instead tend to adopt organizations characterized by three and four levels, with the share of five and six levels sharply decreasing (from 24% to 15.3%). Lastly, large plants are drastically simplifying their organizational structure. The percentage of large plants with 6 tiers has decreased from 31.9% to 8.8%, while the percentage of those with 3 levels has risen from 10.6% to 26.5%. In order to evaluate the statistical robustness of changes of the distributions of LEVEL for the three plant size categories, I compute χ^2 tests. Whereas the distribution by LEVEL classes does not change substantially in the period under investigation for small plants, the same does not hold true for medium and large sized plants. In fact, for the latter two categories the null hypothesis that the distributions by level classes of the 1997 and previous organizations do not significantly differ is rejected at conventional levels.[7]

[7] Values of the χ^2 tests are 5.79 (4 d.o.f.), 11.54 (4), and 14.13 (3) for small, medium and large plants, respectively.

A thorough analysis of the determinants of such phenomena lies beyond the scope of this chapter. Nonetheless, some preliminary remarks are in order. First, it is worth emphasizing that the sample does not include plants set up after 1986. Hence, as far as small plants are concerned, the data presented in Table 2 might be explained by the aging of the population of small plants, that is, by the process of consolidation of surviving small units. The lower number of hierarchical levels of large plants in 1997 might be a consequence of the downsizing of large organizations in the 1990s: the average number of employees of plants with more than 500 employees decreases between 1989 and 1997 from 1,277 to 1,143. However, in accordance with the qualitative evidence provided by the managerial literature (see, for instance, Drucker 1988) it may also reflects the adoption by large firms of a leaner kind of organizational structure, with a lower number of intermediate managerial levels (see chapter 6 that provides econometric evidence).

To further study organizational dynamics, I have computed transition probabilities, where each state is defined by the values of the variable LEVEL. In other words p_{ij} is the probability that a plant characterized by an *i-level* hierarchy turns its organization to a *j-layered* structure. Results are presented in Table 3. The first robust result is the existence of very strong inertial pressures on organization (see also Baker et al. 1994). Probabilities of maintaining a stable organizational structure over time are in general greater than those of changing it. Indeed 63% of sample plants have not changed the number of hierarchical levels in the period under scrutiny (that is from 1975 onwards). Moreover, organizational change seems to be characterized by a process of marginal adaptation instead of radical modifications. One-level changes prevail with respect to more radical ones. Lastly, and contrary to prior expectations (Hannan and Freeman 1984), more complex structures characterized by a higher number of layers have modified their organizational structure more often and more radically than simple two and three-level organizations. In particular, there are only two cases in which the likelihood of a two-level reduction is significantly greater than zero: starting from an organization comprised of 5 or 6 tiers this probability equals 0.21 and 0.26, respectively. Such data confirm a tendency within the Italian metalworking industry towards the simplification of very articulated hierarchies.

Tab. 3 – Transition probabilities (p_{ij}), number of levels (LEVEL)

N. of levels of the previous organization	N. of levels of the 1997 organization				
	2	3	4	5	6
2	0.57	0.32	0.07	0.04	0.00
3	0.01	0.79	0.17	0.03	0.00
4	0.01	0.36	0.57	0.06	0.00
5	0.00	0.21	0.44	0.28	0.07
6	0.00	0.00	0.26	0.48	0.26

Tab. 4 – Span of control

SPAN (means)	1997 organization[a]	previous organization[b]
Total	8.72	10.23
Small plants (n. of employees < 100)	7.89	9.77
Medium plants (n. of employees 100-500)	9.21	11.69
Large plants (n. of employees > 500)	12.51	8.74

Legend:
[a] Plant size is defined as the number of employees in 1997.
[b] Plant size is defined as the number of employees in 1989.

Turning now to the findings regarding span of control, Table 4 presents means for the SPAN variable. In aggregate, the average span of control has decreased over time. In the old organization each manager had more than 10 subordinates on average. Nowadays plants tend to organize their internal structure by reducing the average number of subordinates under one manager to less than 9, with the difference being significant at 95%. Moreover, as to both the 1997 and the previous organizations, small plants have a value of SPAN (7.89 and 9.77) lower than the average (8.72 and 10.23). The opposite applies to medium size plants, which have a number of subordinates under each manager (9.21 and 11.69 respectively) above the average value. Lastly, large plants have the highest value of SPAN in 1997 (12.5), while they have the lowest value as regards the previous organization (8.7). The t-tests illustrated in Appendix (Table A.6) show that the difference between the span of large and small sized plants in 1997 is significant at 95%, while other differences are not significant at conventional levels.

Again, we observe two very different dynamics. Small and medium sized plants have reduced the average number of subordinates. In particular, if one considers plants which in 1989 had less than 100 employees, a t-test for matched pairs shows that the reduction of SPAN is significant at the 99% level (see Table A.7 in Appendix). The evolution of the organization of large plants has followed an opposite pattern. They have increased the span of control, with the difference of the value of SPAN between the previous and the 1997 organizations for plants which in 1989 had more than 500 employees being significant at the 95% level (see again Table A.7). These results provide additional evidence of the adoption by large units of a leaner type of organization.

In sum, the data so far illustrate some rather interesting findings on plant hierarchical structure and its recent evolution. First, hierarchy size increases with plant size. Nonetheless, the span of control also increases with plant size (with the exception of the "old" organization of large plants). This result may be explained by the attempt of firms to limit the increase of hierarchical levels when the number of employees increases. Second, depending on their size, plants have followed different dynamic paths. Small Italian firms are adopting more articulated organizations characterized by a low span of control. Medium plants have changed their internal structure from either very complex or very simple organizations to three and four level hierarchies. In addition they are also decreasing their span. Lastly, large plants, starting from rather bureaucratic organizations, have chosen leaner structures characterized by a lower number of managerial levels and a higher span of control.

2.4 Allocation of Decision-Making

2.4.1 Strategic Decisions

Table 5 presents results for the degree of centralization of decision-making activities (DC, see section 2.2.4 for a definition and Appendix for results of principal component analysis).

Tab. 5 – Degree of centralization of strategic decision-making

DC (means)	1997 organization[a]	previous organization[b]
Total	-0.12	0.12
Small plants (n. of employees < 100)	0.13	0.23
Medium plants (n. of employees: 100-500)	-0.45	0.04
Large plants (n. of employees > 500)	-0.31	-0.36

Legend:
[a] Plant size is defined as the number of employees in 1997.
[b] Plant size is defined as the number of employees in 1989.

Over time plants have decentralized decision-making activities in the period 1975-1997. This process of downward delegation of strategic decisions leads to a statistically significant (at the 99% level) decrease of the value of DC (see Table A.9 in the Appendix). Again we can distinguish plants according to their size. Decision-making in small plants is more centralized than in medium and large units. This holds as regards both the 1997 and previous organizations, with most differences being statistically significant (or almost significant, see Table A.8 in Appendix) at conventional levels. When ownership and control are not separated, as is often the case for small enterprises strategic decisions are mostly taken at the top tier (namely, by the owner).[8] Conversely, "in large organizations, only a small fraction of the available information will be brought to bear on any single decision. Combining this observation with the fact individual decision-makers are limited in their capacities for information processing, one is led to the inevitability of decentralized decision-making in which different decisions - or groups of decisions - are made by different decision-makers on the basis of different information" (Radner 1996).

Moreover, organizational dynamics turns out to depend again upon the size of firms (see again Table 5). Besides being centralized, small plants have partially delegated strategic decisions down the managerial hierarchy. The results of t-tests for matched pairs (see again Table A.9) show that for plants that had less than 100

[8] Indeed, only 3% of small plants is owned by a business group, while the same percentages are 41% and 76% for medium and large plants respectively.

employees in 1989, the difference between the values of DC for the 1997 and the previous organizations is statistically significant at the 95% level. A similar dynamic pattern applies to medium sized plants, which have significantly (at the 90% level) decentralized decision-making activities, starting from values of DC around the mean and becoming the most decentralized plant class. In contrast, as to large plants, the null hypothesis that the values of DC for previous and current organizations do not significantly differ cannot be rejected at conventional levels.

In order to gain further insights into organizational dynamics, I have computed the probabilities of transition, where each state is defined according to the value of the degree of centralization. In particular, I have divided plants in three categories: centralized, average and decentralized. Then I have calculated the transition probabilities from one category to another. Results are summarized in Table 6. We can infer that the allocation of decision-making power tends to be pretty stable over time. Again structural inertia seems to dominate organizational evolution. In addition, organizational changes are incremental rather than being radical. Indeed, the probabilities of changing the decision-making structure starting from either a centralized or a decentralized organization and turning to an average architecture are higher than those of adopting either a decentralized or a centralized organization (0.20 versus 0.11, and 0.16 versus 0.04, respectively).

Tab. 6 – Transition probabilities (p_{ij}), DC of strategic decisions

Previous organization	1997 organization		
	centralized	average	decentralized
centralized	0.69	0.20	0.11
average	0.06	0.81	0.13
decentralized	0.04	0.16	0.80

Moreover, in contrast to the suggestion by Hannan and Freeman (1984), the level of structural inertia does not increase with plant size. In particular, for small and large plants organizational inertia is much more pronounced than for medium sized plants. In fact, 63.9% of small plants and 64.7% of large plants have not changed any decision level for each of the strategic decisions considered, while the same percentage is 50.9% for medium sized plants. For small units, the unwillingness of a founder-leader to delegate responsibility is likely to be a main cause of organizational stability. Conversely, for large plants complexity of agent relations might undermine firm's stimulus towards changes (Schaefer 1998). Hence, organizational inertia appears to be a bell-shaped function of size. In any case, the allocation of authority is remarkably stable over time independently of size.

Tab. 7 – Number of strategic decisions (ND) taken by each level[a]

levels	Total	Plant class, number of employees <100	100-500	>500
1997 organization[b]				
1 – intermediate levels	0.12	0.08	0.17	0.21
2 – plant manager	0.98	1.14	0.81	0.59
3 – pm + aut.	1.48	1.19	1.88	1.76
4 – pm's proposals	2.18	1.83	2.57	2.94
5 – higher levels	1.24	1.76	0.57	0.50
previous organization[c]				
1 – intermediate levels	0.10	0.08	0.09	0.21
2 – plant manager	1.08	1.26	0.77	0.91
3 – pm + aut.	1.18	1.00	1.42	1.50
4 – pm's proposals	1.95	1.51	2.60	2.60
5 – higher levels	1.69	2.15	1.12	0.78

Legend:
[a] For each column, the sum equals 6, the number of strategic decisions considered.
[b] Plant size is defined as the number of employees in 1997.
[c] Plant size is defined as the number of employees in 1989.

So far, the analysis has considered the aggregate degree of centralization. How is authority allocated among hierarchical levels? The number of decisions taken by each tier (ND) helps us analyze this issue. Table 7 presents results relating to the ND variable for the 1997 and previous organizations. Intermediate levels (including blue collars and production middle managers) are totally excluded from plant strategic decision-making. There exists some minor diversity for plants of different size, but overall intermediate levels take almost no decision. The plant manager takes, either independently (real and formal authority, level 2) or subject to the superior's ultimate control (real but not formal authority, level 3), nearly two decisions, its authority changing little over time. Situations in which the plant manager and higher levels coordinate through a sharing of information (level 4) are now more likely. Conversely, authority of higher level management is decreasing, when is implemented in a very autocratic way (level 5).

Overall, decision-making has been reallocated within hierarchies. However such a change is not radical; instead it is characterized again by both inertial forces and incremental adjustments. In this sense, internal political constraints might have played a very important role. As long as authority is a fixed resource, structural changes involve its redistribution among firm agents. Such redistribution upsets the prevailing authority system, so that some agent or group of agents is likely to resist any proposed reorganization.

Another interesting aspect regards the relation between power allocation and plant size. From Table 7, it is evident that in small firms higher levels (very often the owner) take a considerably higher number of strategic decisions than the same levels in medium and large units.[9] This result has a straightforward interpretation: in small firms, ownership and actual control tend to coincide (or, by following

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[9] t-tests show that these differences are statistically significant at the 99% level. For the sake of simplicity I omit these tests.

Aghion and Tirole 1997, formal authority, the right to decide, and real authority, the effective control over decisions, are concentrated at the owner-principal level).

Tab. 8 - Degree of concentration of strategic decision-making

STD_CONC (means)	1997 organization[a]	previous organization[b]
Total	0.89	0.91
Small plants (n. of employees <100)	0.92	0.94
Medium plants (n. of employees: 100-500)	0.86	0.89
Large plants (n. of employees > 500)	0.82	0.85

Legend:
[a] Plant size is defined as the number of employees in 1997.
[b] Plant size is defined as the number of employees in 1989.

Finally, I have computed the standardized degree of concentration of decision-making (STD_CONC). The main objective is to investigate whether firms tend to diffuse authority in order to exploit specialized managerial capabilities (Geanakoplos and Milgrom 1991), or alternatively, concentrate decision-making to avoid coordination problems. From Table 8, we derive that strategic decisions are highly concentrated. Adding information on the allocation of decision-making, we are able to draw a comprehensive picture. Overall, authority is concentrated either at the plant manager level or at higher levels. Small firms have the highest degrees of concentration and centralization of decision-making. Differences between the value of STD_CONC of small plants and those of both medium and large plants are statistically significant at 99% both for the 1997 and previous organizations (see Table A.10). Medium and large firms tend to diffuse authority just slightly more; they also partially delegate decision-making downwards, as shown previously. In this respect, coordination seems to play a more important role than the exploitation of local specialized capabilities. There is no evidence of a radical shift towards multi-leader organizations, as predicted by some theory (Lindbeck and Snower 1996). However, the aggregate degree of concentration has significantly decreased (see Table A.11). The same holds true especially for small and medium size plants, with t-tests for matched pairs being statistically significant at conventional levels.

2.4.2 Operating Decisions

The analysis of operating decisions is based on indices analogous to those used for strategic decisions. For the sake of simplicity, in this paragraph I only synthesize the main results. However, descriptive statistics and statistical tests are reported exactly as in the case of strategic decisions. Overall, they clearly support the view that in the period under consideration Italian metalworking firms, especially of medium and large size, have increasingly adopted a "leaner" pattern of organization.

Tab. 9 – Degree of centralization of operating decision-making

DC (means)	1997 organization[a]	previous organization[b]
Total	- 0.13	0.13
Small plants (n. of employees < 100)	0.15	0.34
Medium plants (n. of employees: 100-500)	-0.45	-0.09
Large plants (n. of employees > 500)	-0.63	-0.45

Legend:
[a] Plant size is defined as the number of employees in 1997.
[b] Plant size is defined as the number of employees in 1989.

As is apparent in Table 9, operating decisions have been significantly decentralized over time for all categories of firms. The value of the variable DC has decreased from 0.13 to -0.13. Small (from 0.34 to 0.16), medium (from -0.09 to -0.46) and large plants (from -0.45 to -0.84) have all delegated operating decisions down the management hierarchy; the differences between the values of DC for the previous and the current organizations are significant at conventional levels (see Table A.13 in the Appendix). In particular, production middle managers are increasingly important for the implementation of strategic decisions. The ND variable shows that on average these hierarchical levels take three operating decisions out of 5, while the plant manager takes most of the remaining two (see Table 11). Authority has shifted marginally also towards blue collars, especially in large plants, but they do not play any significant role as to both the previous and the current organizations.

Tab.10 – Transition probabilities (p_{ij}), DC of operating decisions

Previous organization	1997 organization		
	centralized	average	decentralized
centralized	0.70	0.18	0.12
average	0.10	0.79	0.11
decentralized	0.08	0.14	0.78

Overall, the evolution of the distribution of authority of operating decisions shows that structural inertia again dominates organizational dynamic behavior (see Table 10). More than 75% of plants do not change class of DC, with medium sized units being the more inclined towards change. Thus, the allocation of operating decisions is quite stable over time, but when changes do occur they are towards a more decentralized structure.

Plant size influences the allocation of decision-making activities even for operating decisions. Small firms are the most centralized, and the differences in the degree of centralization between this category and medium and large sized plants are for both the previous and the current organizations statistically significant (at 99%, see Table A.12). Moreover, small plants tend to distribute responsibility between intermediate levels and the plant manager quite evenly, while large plants concentrate authority on intermediate levels (see Table 11).

Tab. 11 – Number of operating decisions (ND) taken by each level[a]

levels	Total	Plant class, number of employees <100	100-500	>500
1997 organization[b]				
1 – blue collars	0.25	0.21	0.30	0.32
2 – middle managers	3.07	2.84	3.32	3.56
3 – plant manager	1.68	1.95	1.38	1.12
previous organization[c]				
1 – blue collars	0.15	0.14	0.19	0.13
2 – middle managers	2.98	2.78	3.12	3.72
3 – plant manager	1.87	2.08	1.69	1.15

Legend:
[a] The sum for each column equals 5, the number of operating decisions considered.
[b] Plant size is defined as the number of employees in 1997.
[c] Plant size is defined as the number of employees in 1989.

Lastly, operating decisions are more diffused within layers of the hierarchy than are strategic ones; the average value of STD_CONC for current organizations is 0.51 significantly lower than 0.89, the standardized degree of concentration of strategic decisions. In addition, in 1997 differences between plant categories are not statistically significant, whereas as to the previous organization decision-making in small and large plants was considerably more concentrated than in medium sized plants, with t-tests being significant at conventional levels. Even more interestingly, in the 1980s and 1990s the level of concentration has substantially decreased for all categories of plants save large units (see Table A.15).

Tab. 12 – Degree of concentration of operating decision-making

STD_CONC (means)	1997 organization[a]	previous organization[b]
Total	0.51	0.59
Small plants (n. of employees < 100)	0.52	0.61
Medium plants (n. of employees: 100-500)	0.49	0.52
Large plants (n. of employees > 500)	0.55	0.63

Legend:
[a] Plant size is defined as the number of employees in 1997.
[b] Plant size is defined as the number of employees in 1989.

2.5 Conclusions

There is a large and growing interest in economic theory on the internal workings of firms. However, the theoretical literature is based on very little data and limited stylized facts. Indeed, most economists have traditionally relegated the study of organizations to business history or to case studies. The result is a complete lack of large scale quantitative empirical evidence on firm organization.

In this introductory part of the thesis, I have offered an empirical analysis of the internal organization of plants and its evolution over the 1980s and 1990s using a detailed data set of Italian metalworking plants. For this purpose, the metalworking sector is of great interest, as it is considered by the management literature as a pioneer in the adoption of the "lean production" model. In particular, I have focused attention on the hierarchical structure of plants and the allocation of decision-making activities as regards both strategic and operating decisions. I am aware that in this way I adopt a rather stylized view of organization. However, providing quantitative measures of these key aspects allows me to highlight rather interesting results.

First, the (static) choice of the organizational form can be explained by the 'loss of control phenomenon'. Plant's hierarchy expands with size, but bureaucratization seems to be partially avoided by higher values of the span of control and a higher degree of decentralization of decision-making. From one side, given the number of employees, firms can shrink their organization by increasing the number of subordinates under one manager. This, in turn, may lead to a decrease of failures in information transmission. From the other side, decentralization might be both a means of exploiting local and specialized capabilities and a way to speed up the implementation of decisions.

Second, the dynamics of plant organization turns out to depend crucially on size. In the 1980s and 1990s small Italian firms have been adopting a marginally more articulated organizational structure, characterized by a higher number of hierarchical levels. The average number of subordinates per manager has decreased quite substantially. In addition, they have been partially delegating strategic and operating decisions down the management hierarchy, even if they still remain very centralized in comparison to medium and large sized plants. Medium sized plants have been both reducing the span of control and decentralizing responsibility quite drastically. In contrast, large plants have followed a distinct evolutionary path from those of their small and medium counterparts, simplifying their organizational structure by reducing the number of hierarchical layers and increasing the average number of subordinates per manager. In addition, operating decisions have been increasingly delegated downwards, mainly to intermediate levels (such as production middle managers). This may be a result of the downsizing of large firms in the 1990s, which is evinced by the decrease of average plant size in this category. However, findings also provide quite robust evidence that large firms, in accordance with the scenario outlined by case studies in the managerial literature, have taken advantage of the greater monitoring and coordination capabilities offered by information technologies and of innovations in the managerial sphere, adopting a leaner kind of organization.

Third, the findings of the empirical analysis clearly show that organizational evolution is characterized by structural inertia. During the last twenty years most plants have not changed either hierarchical structure or decision-making allocation at all. In addition, when changes do occur, they tend to be incremental rather than radical, with the few exceptions being associated with the restructuring of more articulated units. Inertia is not related to size, as predicted by the population ecology theory of organizations.

Organizations of small and large plants are very stable over time, while medium plants seem to be more inclined to change.

I think that the results presented here shed new light on the organization of firms and its evolution. Nonetheless, I am aware that these results are to be viewed as a first step and that much remains to be done. Thus, two directions seem to me especially fruitful for further development in this thesis. First, whereas this chapter has focused on the role of firm size in influencing the choice of the organizational form and its dynamics, the variables capturing firm and industry-specific effects are also likely to have considerable explanatory power. I believe that, among them, the ownership structure and technology adoptions figure quite prominently. Second, the benefits coming from the use of a quantitative approximation of firm organization have only partially been exploited in this chapter. In particular, decisions concerning different aspects of organizations such as the choices of the number of managerial layers of a plant and of the degree of delegation of authority have never been subjects of a robust econometric analysis. The aim of the remaining part of the thesis is, thus, to develop a theoretical and empirical framework to look at the organization of firms and its evolution in a robust and comprehensive way.

Appendix

A.1 Results of Principal Component Analysis

Tab. A.1 - Coordinates of principal components of strategic decisions

	components					
decisions:	#1	#2	#3	#4	#5	#6
purchase of stand-alone machinery	**0.424**	0.381	0.004	0.464	0.016	0.678
purchase of large-scale equipment	**0.425**	0.402	0.002	0.349	-0.076	-0.728
adoption of new technology	**0.397**	0.417	0.054	-0.812	-0.018	0.074
hiring and dismissal	**0.401**	-0.352	-0.743	-0.045	0.401	-0.027
career paths of plant's personnel	**0.406**	-0.474	0.022	-0.022	-0.779	0.046
definition of incentive schemes	**0.397**	-0.414	0.667	0.012	0.475	-0.039

Tab. A.2 - Contribution to total variance of principal components, strategic decisions

	components:					
	#1	#2	#3	#4	#5	#6
standard deviation	2.12	0.88	0.53	0.48	0.36	0.24
proportion of variance	0.75	0.13	0.05	0.04	0.02	0.01
cumulative proportion	0.75	0.88	0.93	0.97	0.99	1.00

Tab. A.3 - Coordinates of principal components of operating decisions

	components:				
decisions	#1	#2	#3	#4	#5
daily production plan	**0.483**	0.345	0.304	0.135	0.732
weekly production plan	**0.428**	0.560	-0.248	-0.573	-0.337
definition of blue collars' tasks	**0.469**	-0.201	0.661	0.174	-0.522
control of results	**0.377**	-0.721	-0.158	-0.500	0.249
modification of production plan	**0.470**	-0.085	-0.619	0.610	-0.126

Tab. A.4 - Contribution to total variance of principal components, operating decisions

	components:				
	#1	#2	#3	#4	#5
standard deviation	1.54	0.96	0.81	0.74	0.70
proportion of variance	0.48	0.18	0.13	0.11	0.09
cumulative proportion	0.48	0.66	0.79	0.90	1.00

A.2 Results of Tests

1) Number of hierarchical levels (LEVEL)

Tab. A.5 - t-tests: differences between means of the number of employees of plants that have a hierarchy consisting of different levels

LEVEL	1997 organization average size	*t*	previous organization average size	*t*
2	34.41	-	43.95	-
3	121.03	6.26‡	104.63	4.32‡
4	217.06	3.77‡	238.50	4.43‡
5	569.45	2.51†	567.35	2.94‡
6	623.40	0.21	1023.52	1.53

Legend:
H_0: $SIZE_j = SIZE_{j-1}$, $j=3,4,5,6$, with $SIZE_j$ being the average number of employees of plants having a j-level hierarchy.
‡ Significance level greater than 99%.
† Significance level greater than 95%.

2) Span of control (SPAN)

Tab. A.6 - t-tests: differences between means of SPAN

test	1997 organization[a] means differences	1997 organization[a] t	previous organization[b] means differences	previous organization[b] t
small – medium	7.89 – 9.21	- 1.35	9.77 – 11.69	- 0.94
small – large	7.89 – 12.51	- 2.42†	9.77 – 8.74	0.70
medium – large	9.21 – 12.51	- 1.70	11.69 – 8.74	1.32

Legend:
Ho: $SPAN_j$=$SPAN_i$, i≠j, with *$SPAN_j$* being the average span of control of plants having less than 100 employees (small), between 100 and 500 employees (medium), and more than 500 employees (large).
[a] Plant size is defined as the number of employees in 1997.
[b] Plant size is defined as the number of employees in 1989.
† Significance level greater than 95%.

Tab. A.7 - t-tests: differences of SPAN between the 1997 and previous organizations (matched pairs)

plant class[a]	SPAN(1997)	SPAN(previous)	t
total	8.72	10.23	2.10†
small (n. of employees <100)	7.86	9.77	3.02‡
medium (n. of employees 100 - 500)	9.33	11.69	1.18
large (n. of employees >500)	11.20	8.74	-2.29†

Legend:
Ho: SPAN(1997) = SPAN(previous), with *SPAN (1997)* and *SPAN (previous)* being the average span of control for the present and the previous organizations respectively.
[a] Plant size is defined as the number of employees in 1989.
‡ Significance level greater than 99%.
† Significance level greater than 95%.

3) Degree of centralization of decision-making activities (DC), strategic decisions

Tab. A.8 - t-tests: differences between means of DC

test	1997 organization[a] means differences	t	previous organization[b] means differences	t
small – medium	0.13 – (- 0.45)	2.82‡	0.23 – 0.04	0.86
small – large	0.13 – (- 0.31)	1.60	0.23 – (-0.36)	2.00†
medium – large	- 0.45 – (- 0.31)	-0.54	0.04 – (-0.36)	1.34

Legend:
Ho: $DC_j = DC_i$, $i \neq j$, with DC_j being the average degree of centralization of plants having less than 100 employees (small), between 100 and 500 employees (medium), and more than 500 employees (large).
[a] Plant size is defined as the number of employees in 1997.
[b] Plant size is defined as the number of employees in 1989.
‡ Significance level greater than 99%.
† Significance level greater than 95%.

Tab. A.9 - t-tests: differences of DC between the 1997 and previous organizations (matched pairs)

plant class[a]	DC(1997)	DC(previous)	t
total	-0.12	0.12	3.08‡
small (n. of employees <100)	0.02	0.23	2.20†
medium (n. of employees 100-500)	-0.21	0.04	1.87§
large (n. of employees >500)	-0.59	-0.36	1.13

Legend:
Ho: DC(1997) = DC(previous), with *DC (1997)* and *DC (previous)* being the average degree of centralization for the present and the previous organizations respectively.
[a] Plant size is defined as the number of employees in 1989.
‡ Significance level greater than 99%.
† Significance level greater than 95%.
§ Significance level greater than 90%.

4) Degree of concentration of decision-making activities (STD_CONC), strategic decisions

Tab. A.10 - t-tests: differences between means of STD_CONC

test	1997 organization[a] means differences	1997 organization[a] t	previous organization[b] means differences	previous organization[b] t
small – medium	0.92 – 0.86	4.88‡	0.94 – 0.89	3.45‡
small – large	0.92 – 0.82	4.28‡	0.94 – 0.85	3.93‡
medium – large	0.86 – 0.82	1.57	0.89 – 0.85	1.66

Legend:
Ho: $STD\_CONC_j = STD\_CONC_i$, $i \neq j$, with STD_CONC_j being the average degree of concentration of plants having less than 100 employees (small), between 100 and 500 employees (medium), and more than 500 employees (large).

[a] Plant size is defined as the number of employees in 1997.

[b] Plant size is defined as the number of employees in 1989.

‡ Significance level greater than 99%.

Tab. A.11 - t-tests: differences of DC between the 1997 and previous organizations (matched pairs)

plant class[a]	STD_CONC(1997)	STD_CONC(previous)	t
total	0.89	0.91	3.90‡
small (n. of employees <100)	0.92	0.94	3.23‡
medium (n. of employees 100-500)	0.87	0.89	2.01†
large (n. of employees 500)	0.83	0.85	1.04

Legend:
Ho: STD_CONC(1997) = STD_CONC(previous), with *STD_CONC (1997)* and *STD_CONC (previous)* being the average degree of concentration for the present and the previous organizations respectively.

[a] Plant size is defined as the number of employees in 1989.

‡ Significance level greater than 99%.

† Significance level greater than 95%.

5) Degree of centralization of decision-making activities (DC), operating decisions

Tab. A.12 - t-tests: differences between means of DC

test	1997 organization[a]		previous organization[b]	
	means differences	*t*	means differences	*t*
small – medium	0.15 - (-0.45)	4.17‡	0.34 - (-0.09)	2.68‡
small – large	0.15 - (-0.63)	3.37‡	0.34 - (-0.45)	4.05‡
medium – large	-0.45 - (-0.63)	0.73	- 0.09 - (-0.45)	1.72§

Legend:
Ho: $DC_j = DC_i$, $i \neq j$, with DC_j being the average degree of centralization of plants having less than 100 employees (small), between 100 and 500 employees (medium), and more than 500 employees (large).
[a] Plant size is defined as the number of employees in 1997.
[b] Plant size is defined as the number of employees in 1989.
‡ Significance level greater than 99%.
† Significance level greater than 95%.
§ Significance level greater than 90%.

Tab. A.13 - t-tests: differences of DC between the 1997 and previous organizations (matched pairs)

plant class[a]	DC(1997)	DC(previous)	*t*
total	-0.13	0.13	3.98‡
small (n. of employees <100)	0.16	0.34	2.23†
medium (n. of employees 100-500)	-0.46	-0.09	2.82‡
large (n. of employees >500)	-0.84	-0.45	2.08†

Legend:
Ho: DC(1997) = DC(previous), with *DC (1997)* and *DC (previous)* being the average degree of centralization for the present and the previous organizations respectively.
[a] Plant size is defined as the number of employees in 1989.
‡ Significance level greater than 99%.
† Significance level greater than 95%.

6) Degree of concentration of decision-making activities (STD_CONC), operating decisions

Tab. A.14 - t-tests: differences between means of STD_CONC

test	1997 organization[a] means differences	t	previous organization[b] means differences	t
small – medium	0.52-0.49	1.23	0.61-0.52	2.65‡
small – large	0.52-0.55	-0.4	0.61-0.63	-0.43
medium – large	0.49-0.55	-0.97	0.52-0.63	-2.00†

Legend:
H₀: STD_CONC$_j$*=STD_CONC*$_i$*, i≠j,* with *STD_CONC*$_j$ being the average degree of concentration of plants having less than 100 employees (small), between 100 and 500 employees (medium), and more than 500 employees (large).

[a] Plant size is defined as the number of employees in 1997.

[b] Plant size is defined as the number of employees in 1989.

‡ Significance level greater than 99%.

† Significance level greater than 95%.

Tab. A.15 - t-tests: differences of STD_CONC between the 1997 and previous organizations (matched pairs)

plant class[a]	STD_CONC(1997)	STD_CONC(previous)	t
total	0.51	0.59	5.67‡
small (n. of employees <100)	0.52	0.61	5.26‡
medium (n. of employees 100-500)	0.47	0.52	2.35†
large (n. of employees 500)	0.60	0.63	0.94

Legend:
H₀: STD_CONC(1997) = STD_CONC(previous), with *STD_CONC (1997)* and *STD_CONC (previous)* being the average degree of concentration for the present and the previous organizations respectively.

[a] Plant size is defined as the number of employees in 1989.

‡ Significance level greater than 99%.

† Significance level greater than 95%.

Part III

Static Models

Chapter 3

Analysis of the Determinants of the Management Hierarchy

3.1 Introduction

In part I I presented anecdotal evidence that showed that the modern organization is characterized by having a deep management hierarchy. In sharp contrast with the pre-factory system, in the modern organization authority relations are organized vertically and agents are ranked hierarchically. Then in part II I provided quantitative evidence on the management hierarchy of plants and its evolution. In particular, I argued that one of the leading determinants for explaining sizable differences among organizations was (plant) size. Parts III and IV will aim at testing the determinants of the organization and its evolution through the estimates of econometric models.

Since the seminal work of Simon (1962) the firm has been defined by economists as a *complex system*, "a system made up of a large number of parts that interact in a non-simple way". More specifically, the firm is depicted as a *hierarchic system*, "a system that is composed of interrelated subsystems, each of the latter being, in turn, hierarchic in structure until we reach some lowest level of elementary subsystem". Williamson (1967) represents the first theoretical attempt to model the firm as a hierarchy. In his setting limitations of organizations strongly restrict the depth of the organization. The top manager (or peak coordinator) defines an optimal plan, but the implementation suffers from "organizational failures" due to the vertical and serial nature of organizations. The loss of control phenomenon is caused by information problems. These issues have been analyzed by two different approaches to the study of the hierarchic organization of firms: the *decentralization of incentives* and the *decentralization of information* (Radner 1992). The incentive stream (see Calvo and Wellisz 1978 and 1979, Qian 1994, and Rosen 1982) has focused on the issues that arise when information is asymmetric (e.g., agents' shirking). In this setting, the management hierarchy is analyzed as a network of multi principal-agent relations. The information stream (see Bolton and Dewatripont 1994, Keren and Levhari 1979 and 1983, Radner 1993, and van Zandt 1999) has studied bounded rationality within organizations due to information transmission failures (e.g., information overload, leaks in the transmission of information between firm's units).

In spite of the theoretical interest of economists on the organization of firms and the key contribution provided by business history, the empirical evidence on these issues is generally scarce. This chapter aims at testing (some of) the theoretical predictions of economic theory on the organizational architecture by looking at the relation between the depth of the management hierarchy of plants and plant and industry-specific variables. I test this relation through the estimates of an ordered logit econometric model. For this purpose, I use FLAUTO97 data set (see the empirical methodology chapter at the beginning of this thesis), which allows me to test econometrically the relation between the discrete choice of the depth of the organization and explanatory variables such as plant size, technology adoptions, ownership status and industry effects. It is my opinion that the findings extend our knowledge over the determinants of the organizational structure, and might be of some importance for the current theoretical debate.

The remainder of the chapter is organized as follows. Next section introduces recent theoretical literature in greater detail, identifying (some of the) crucial factors that influence the size of the management hierarchy. In section 3.3 the econometric model is specified. Given the (right) censored and categorical ordered nature of the dependent variable, I estimate an ordered logit model with censoring. In section 3.4 I illustrate the explanatory variables included into the econometric model and discuss their expected impact upon the likelihood of adopting hierarchies of different sizes. Section 3.5 describes the findings of the estimates of six ordered logit models. The chapter ends up with some concluding remarks in section 3.6.

3.2 A Review of Hierarchical Models of the Firm

There are mainly two kinds of models that analyze the determinants of the management hierarchy. The first is based upon information processing, the second on decentralization of incentives. In this section I review the contribution of these models and sketch out predictions of existing theoretical literature which I will test in the next sections.

Before considering hierarchical models of the firm in greater detail, some general definitions are in order. First, $t \in \{0,1,\dots,T\}$ is the index of corporate levels of a hierarchy, where *t=0* is the top manager level, and *t=T* is the level of operating units, hence the size of the management hierarchy. There is a neat difference between production workers (*t=T*) and other administrative employees (*t<T*). I assume that only blue collar workers are in charge of production activities, whilst the latter have administrative tasks, such as: monitoring and acquiring, storing, processing, and transmitting information. Second, x_t is the number of employees at level *t*. Assume that there is only one top manager (or top team) at the pinnacle of the managerial hierarchy, that is $x_0 = 1$. Assume further that the number of blue collars is given and equals *N*, that is $x_T = N$. Third, in accordance with theoretical models, which usually assume balanced hierarchies where the number of immediate subordinates under one manager is the same for all managers of the same level, s_t is the span of control of tier *t* given by $s_t = x_{t+1} / x_t$. Hence:[1]

$$x_{t+1} = s_0 s_1 \dots s_t \qquad (1)$$

[1] In fact, $s_0 = x_1/x_0$; and $x_1 = s_0$ (given that $x_0 = 1$). Moreover: $s_1 = x_2/x_1$, hence, $x_2 = s_0 s_1$. By iteration I obtain equation (1).

Since discrete formulations of hierarchical models of firms cannot be solved, at least in their more general versions, I shall employ continuous approximations.[2] Taking logarithm of x_t and considering a continuous formulation yields to:

$$\frac{dx_t}{dt} \equiv \dot{x}_t = x_t \log(s_t). \quad (2)$$

3.2.1 The Cost Function

Focusing only on labor, total cost is simply given by the remuneration of firm's personnel. Let the wage vary among corporate levels and assume a continuous formulation, total cost (TC) is given by,

$$TC = \int_0^T w_t x_t dt. \quad (3)$$

where $x_0 = 1$, $x_T = N$ and x_t satisfies equation (2). T is the endogenous size of the management hierarchy, and w_t is the wage of managers of layer t.

In the information approach, models generally assume the internal wage scale to be exogenous. Conversely, the incentive approach concentrates upon asymmetric information issues, so that the wage scale depends upon the level of effort of agents. To see this, let us

[2] Note however that van Zandt (1995) has recently pointed out that continuous formulations might not be good approximations of discrete hierarchies.

follow Qian (1994). Assume that the utility function of each agent of level t is given by:

$$u_t = w_t - g(a_t), \tag{4}$$

where $g(a_t)$ is the disutility from making an effort a_t, with $g(0)=0$.

The probability of being checked is for each agent a (negative) function of the span of control of his immediate superior. Suppose that this probability is simply given by $P=P(s)=1/s$. Then if the top manager wants to implement an $\tilde{a}_t$ level of effort, she will consider the following incentive scheme:

pay w_t if $a_t \geq \tilde{a}_t$ is known, or if a_t is not known; and

pay 0 if $a_t < \tilde{a}_t$ is known.

In this case the incentive compatibility condition is given by:

$$w_t - g(\tilde{a}_t) \geq [P \cdot 0 + (1-P) \cdot w_t] - g(a_t), \quad \forall a_t < \tilde{a}_t \tag{5}$$

Hence, the efficiency wage is $w_t = g(\tilde{a}_t)/P$, and the wage function is given by:

$$w_t = g(\tilde{a}_t)s_t. \tag{6}$$

If the span of control increases then the efficient wage increases as well.

3.2.2 *The Production Function*

Another key aspect that influences the internal working of the firm is the production technology. In particular, administrative work enters in the production technology as well as the other inputs (e.g., line operators). Let θ be a parameter of the production technology at the plant level and N the number of blue collars. Assume a Cobb-Douglas production function, then the total output Q is given by

$$Q = \theta N^{\alpha} y_{T}^{\phi} \tag{7}$$

where y_T is the total administrative output. Generally, hierarchical models of the firm assume α and ϕ to be individually equal to one.

One of the main features of the modern organization is its serial structure. This in turn implies that the production technology of administrative work is recursive (Beckman 1977). In any tier t, the administrative production (called "managerial effectiveness") depends on the efficiency of the manager of that level and of their superiors. That is, at every administrative layer managers use their immediate superiors' administrative output y_{t-1} as an intermediate input, and combined with their effort a_t ($0 \le a_t \le 1$) produce y_t for their immediate subordinates. Therefore,

$$y_t = F_t(y_{t-1}, a_t) \tag{8}$$

Suppose equation (8) to be simply given by $y_t = y_{t-1}a_t$, then, if I normalize in order to make y_0 equal to 1, I obtain

$$y_t = a_1 a_2 \cdots a_t. \tag{9}$$

The output of each fully effective blue collar (that is, $a_t=1$ at every tier t, hence $y_T=1$), is given by θ. From equation (9) it is possible to highlight a key characteristic of management hierarchies. The organization might suffer from administrative bottlenecks. In fact, if managers of level t are not effective then overall production declines. This might be due both to agents' shirking and to information and communication failures.

Just as in the incentive approach a_t represents the level of effort of employees of level t, so in the information stream a_t is the planning time of managers of level t. The total administrative output y_T is given again by a recursive function $y_T=f(a_1,\ldots,a_T)$, but in this case $\partial f / \partial a_t < 0$. If the time taken by each manager to perform his task increases, the total administrative output decreases. A plan that is efficient at period t-1, will probably need a revision at time t. Because the external economic environment changes very often, time matters. Thus, the productivity of blue collars clearly depends upon the efficiency of administrative workers in gathering, storing, and processing information. If we define efficiency in terms of speed in processing information then "efficiency can be achieved by hierarchical networks" (Radner 1992). In other words, the management hierarchy emerges as an optimal device of facing complexity of information (Bolton and Dewatripont 1994, and Radner 1993).

Following Keren and Levhari (1979)(1983) assume that each administrative employee receives from his immediate superior M items of information and, after having processed transmits them to his immediate subordinates. Further, suppose that the time to perform the task is a linear function of the number M of items to process and the number s_t of subordinates (i.e., the span of control). Then, I define a'_t, the time to perform the task of managers of level t, as:

$$a'_t = \overbrace{[\gamma_0 + \gamma_1 M]}^{\text{interaction time with the superior}} + \overbrace{[(\gamma_2 + \gamma_3 M)s_t]}^{\text{interaction time with subordinates}} + \overbrace{[\gamma_4 + \gamma_5 M + \gamma_6 s_t]}^{\text{calculation time}} \quad (10)$$

so that,

$$a'_t = \overbrace{[\gamma_0 + \gamma_4]}^{\text{fixed time}} + \overbrace{[(\gamma_1 + \gamma_5)M]}^{\text{fixed time for complexity}} + \overbrace{[(\gamma_2 + \gamma_3 M + \gamma_6)s_t]}^{\text{variable time (depends on the tier)}} \ . \quad (11)$$

If I normalize the unit of time in order to make the coefficient of the span of control unity, I obtain the following simple equation:

$$a_t = \beta + s_t. \tag{12}$$

where β is the ratio of fixed to variable (time) cost.

On the one hand, a decrease of the total time of processing the M items of information due, for instance, to improvements in information technology lowers, *ceteris paribus*, β. On the other hand, a decrease of the interaction time with other agents (or bureaus) due to improvements in network technology raises β.

An **example** might clarify this setting. Take the case of a firm with N blue collars, in which the management hierarchy is totally absent - there are only two layers: the top manager, who runs the firm, and blue collar workers, who implement her plan. In this case the total planning and implementation time is simply given by $\beta + N$. If the owner decides to add a tier then the span of control at the first and second levels are given by $s_0 = x_1$, and $s_1 = N / x_1 = N / s_0$ respectively, where x_1 is the number of administrative workers under the top manager. Thus, in the case of a three-layer hierarchy, the total planning time is given by:

$$a_1 + a_0 = \beta + s_1 + \beta + s_0 = 2\beta + s_0 + N / s_0.$$

If the top manager chooses $x_1(=s_0)$ in order to minimize the total planning time then it is straightforward to show that $s_0 = s_1 = \sqrt{N}$. Hence, the total planning time of a three-layer organization is given by $2\beta + 2\sqrt{N}$. This type of organization is more efficient than the two-tier structure if and only if $\beta + N > 2\beta + 2\sqrt{N}$, namely if:

$$\beta < N - 2\sqrt{N}.$$

So, if a firm decides to increase the number of blue collar workers, then an increase in the number of administrative layers is needed to minimize the total planning time.[3] Alternatively, if fixed time cost increases, or variable cost decreases, then a multi-layered organization becomes less efficient. That is, information technology that lowers fixed time of processing information increases the efficiency of a multi-layered organization. On the contrary, network technology that lowers the interaction time between different bureaus tends to reduce the need of adopting a deep organization.

[3] If this looks very odd business history may help understand. In fact, it is interesting to note that between 1890 and 1913 the total employment of Siemens grew from 3,000 to 57,000, whilst the ratio between non-manual to manual workers passed from 1:7.1 to 1:3.5. If I assume a constant span of control equal say to 7, then this expansion implies an increase in the number of hierarchic tiers from 4 (+1, manual workers) to 6 (+1) (elaboration from Kocha 1971).

3.2.3 The Determinants of the Management Hierarchy

There are two explanations of limitations of organizations, i.e., the loss of control phenomenon. First, a_t may reflect information processing and communication costs. Advances in communication technology reduce overload costs (higher a_t) and allow managers to increase the number of immediate subordinates, i.e., the span of control, avoiding information bottlenecks (Keren and Levhari 1979 and 1983). So, "a reduction of communication costs leads to a flatter and smaller organization" (Bolton and Dewatripont 1994). It is worth noticing, however, that the relation between the size of the management hierarchy and communication costs is still a puzzle in economic theory. Indeed, Lazear (1995) points out that since advances in network technology lower communication costs among firm's units, these promote both specialization of agents in specific tasks and reliance on large hierarchies. In his words "Technology-induced reductions in the cost of communication promote specialization and hierarchy" (p.125).

Second, a_t may reflect the effort of managers of level t. In this case the management hierarchy is depicted as a structure of multi principal-agent relations. For each agent the probability of being checked is a (negative) function of the span of control of his immediate superior, so that a_t is decreasing in the span. Advances in the monitoring technology allow the superior to increase the number of immediate subordinates avoiding agents' shirking at a time, and thus to reduce the optimal size of the organization (Qian 1994).

Also production technology might affect the optimal size of the management hierarchy. Williamson (1967) shows that if we assume the production function of equation (1), then, under certain conditions (i.e., constant span of control), an increase in the parameter θ raises the number of corporate levels. Lindbeck and Snower (1996) distinguish between technologies of different vintages. Single-purpose technologies that are associated with a Tayloristic approach to production are based upon specialization of line operators and hierarchy. Multi-purpose flexible technologies that are linked to a "holistic" approach are based on multiskilling and a sharp reduction of bureaucratization. Moreover, Milgrom and Roberts (1990) point to the importance of complementarities in the use of advanced manufacturing technologies: the impact on the organizational structure is strong only when flexible technologies work in cluster rather than in isolation.

Table 1 sums up the main theoretical predictions on the size of the management hierarchy. The number of corporate levels is positively related to the firm (plant) size. As to production technology, results are less robust. In Williamson, an increase in the productivity of blue collar workers raises the optimal size of the organization. In other models results depend on the features of the production technology (e.g., vintage and extent of use).

Tab. 1 - Determinants of the hierarchy, theoretical predictions

Determinants	*Impact on the optimal size of the hierarchy (T^*)*
Firm (plant) size	positive
Efficiency of production technology	positive in Williamson (1967), uncertain elsewhere
Efficiency of monitoring technology	negative in Qian (1994)
Efficiency of network technology	negative in Keren and Levhari (1979) and (1983), and Bolton and Dewatripont (1994); positive in Lazear (1995)

In the approach called *decentralization of incentives* the asymmetry of information and the related opportunistic behavior shape the form of the organization. In this context, the size of the management hierarchy is a negative function of the efficiency of the monitoring technology. Indeed, a better technology of monitoring allows the firm to increase the number of immediate subordinates under each manager, thus, to decrease the number of levels. As to the approach called *decentralization of information*, the focus is on the total planning time. In this case the size of the organization depends on communication costs.

3.3 The Econometric Model

Let us concentrate attention on the size of the plant's organization (i.e., the number of managerial levels). The optimal number of levels of plant j that operates in the industry i is given by

$$T_j^* = \arg\max_T(\pi_j) = F(N_j, x_j, y_j, z_i), \tag{14}$$

where π is the profit function, N is the number of plant's employees, x is a vector of production, network and monitoring technologies in use, y is a vector of other plant-specific characteristics such as the ownership status, and z is a vector of industry-specific characteristics such as market concentration and the industry technology base.

Above mentioned theoretical models have identified factors that influence the size of the management hierarchy. For instance, T^* should be a positive concave function of the number of plant employees. Moreover, production, network and monitoring technologies may affect the choice of the optimal size of the organization. I test these and other determinants through the estimates of a discrete choice model.

T^* is unobserved. What I observe is the real number of levels T that differs from its optimal value due, for instance, to adjustment costs. Schaefer (1998) has recently pointed out that influence costs may lead to delays in adjusting the organizational structure towards its efficient configuration. In any case, the relation between the optimal size of the organization and its actual value is

$$
\begin{aligned}
T &= 2 && \text{if } T^* \leq \mu_0 \\
T &= 3 && \text{if } \mu_0 < T^* \leq \mu_1 \\
T &= 4 && \text{if } \mu_1 < T^* \leq \mu_2 \\
T &= 5 && \text{if } \mu_2 < T^* \leq \mu_3 \\
T &= 6 && \text{if } T^* > \mu_3
\end{aligned}
$$

where μ_i are the thresholds that separate the different discrete categories of the number of corporate levels, $T=2$ represents the simplest two-layer organizational structure, and $T=6$ is the maximum observed level of organizational complexity, i.e., the data in FLAUTO97 allow me to know only if a plant has six or more managerial levels. Observations are, thus, censored on the right-end side of the distribution of T^*.

Given the (right) censored and categorical ordered nature of the dependent variable, I proceed to estimate an ordinal-level logit model with censoring (see Maddala 1983). Before proceeding further with the definition of the explanatory variables, a further remark is in order. In this chapter I focus on the optimal size of the management hierarchy. However, it is clear that this is but one element in a set of decisions the firms make. In other words, there is simultaneity between T^* and other variables. However, given the nature of the dependent variable the estimation of a simultaneous system lies beyond the scope of this research.

3.4 The Explanatory Variables

Table 2 presents explanatory variables of the econometric model and their description. Plant size is measured by the logarithm of the number of employees in 1997 (i.e., *Size*). In accordance with the results of above mentioned studies, I expect a positive impact of such variable on the probability of adopting a multi-layered organization. In order to account for declining marginal effects (i.e., a concave relation), plant size is introduced into the econometric model in a logarithmic form.

A second group of explanatory variables refers to technologies in use in sample plants in 1997 that pertain to the production sphere. I consider advanced manufacturing technologies (AMTs) and inflexible manufacturing systems (IMSs). *DAMT* is a dummy variable which is equal to 1 if a plant is among the adopters of one or more of the following AMTs: numerically (or computerized numerically) controlled stand-alone machine tools, programmable robots, machining centers, and flexible manufacturing systems. Further, I define four additional dummy variables *AMT1*, *AMT2*, *AMT3* and *AMT4*; they equal 1 if a plant has adopted 1, 2, 3 and 4 AMTs, respectively. These allow me to treat the intensity of use of AMTs as a categorical variable (see Dunne 1994). Finally, *IMS* is a dummy variable that is 1 when plants have adopted inflexible manufacturing systems. Overall, I expect production technology to have a significant impact on the choice of the organizational structure. However, I distinguish two types of technology. Inflexible manufacturing systems are tightly related to the Tayloristic approach to production based upon the specialization of blue collar workers and a sharp separation of tasks in production. IMSs are, therefore, likely to be linked to organizations in which the number of hierarchic layers is very high. Conversely, AMTs are last generation technologies, which have been devised to exploit complementarities in production. These aim at increasing the degree of flexibility in production through a holistic and decentralized form of organization based upon a loose definition of tasks. So, as to AMTs I would expect a negative impact on the probability of adopting very bureaucratic organizations.

Turning to network technology, I have considered two variables that capture advances in communication efficiency. *Intra-firm network* is a dummy variable that equals 1 for plants that by June 1997 had adopted local area network (LAN) and/or on-line connection with headquarters, whilst *Inter-firm network* is set to 1 for plants that by June 1997 had introduced electronic data interchange (EDI) with customers, suppliers and/or subcontractors. Whereas the former category accounts to advances in intra-firm communication technology, the latter relates to improvements in inter-firm communication system (i.e., shared databases between different firms, see Johnston and Vitale 1988 and Mukhopadhyay *et al.* 1995). Network technology increases the efficiency of both intra and inter-firm communication. In accordance with the above line of reasoning, the effect of advances in communication technology on the optimal number of corporate levels should be negative. Indeed, it reduces overload costs and thus allow the firm to increase the span of control and to shrink the management hierarchy. Moreover, advances in information technology enable managers to access to timely information about production (see Hubbard 1998). These increase the ability of managers to collect and process information on a plant's operations and decrease principal's costs of investigation. Therefore, advances in communication technology improve the efficiency of monitoring and lead to an increase in the span of control and to flatter management hierarchies. However, advances in communication by decreasing the costs of communication might induce specialization and hierarchy. As a consequence, the degree of bureaucratization may increase or decrease, depending on which effect prevails.

A fourth group of variables concerns adoptions of managerial innovations. *JIT* and *TQM* are dummies that equal one for plants that by June 1997 had adopted just-in-time manufacturing and total quality management, respectively. Management literature (see for instance Drucker 1988, Duimering *et al.* 1993, and Krafcik 1988) associates the introduction of such innovations to the adoption of a "lean" type of organization, characterized by a flat organizational structure.

Tab. 2 – The explanatory variables of plant organization

Variable	*Description*
Size	Logarithm of the number of plant's employees in June 1997
DAMT	1 for plants that by June 1997 had adopted one or more AMTs[a]; 0 otherwise
AMT1	1 for plants that by June 1997 had adopted one AMT[a], 0 otherwise
AMT2	1 for plants that by June 1997 had adopted two AMTs[a], 0 otherwise
AMT3	1 for plants that by June 1997 had adopted three AMTs[a], 0 otherwise
AMT4	1 for plants that by June 1997 had adopted four AMTs[a], 0 otherwise
IMS	1 for plants that by June 1997 had adopted inflexible manufacturing systems; 0 otherwise
Intra-firm network	1 for plants that by June 1997 had adopted advanced intra-firm network technology (i.e., LAN and on-line connection with headquarters); 0 otherwise
Inter-firm network	1 for plants that by June 1997 had adopted electronic data interchange with customers, suppliers and/or subcontractors; 0 otherwise
JIT	1 for plants that by June 1997 had adopted just-in-time manufacturing; 0 otherwise
TQM	1 for plants that by June 1997 had adopted total quality management; 0 otherwise
State owned group	1 for State-owned plants; 0 otherwise
Private group	1 for plants that belong to private business groups; 0 otherwise
Private Italian group	1 for plants that belong to private Italian business groups; 0 otherwise
European MNE	1 for plants that belong to European multinational enterprises; 0 otherwise
NA MNE	1 for plants that belong to North American multinational enterprises; 0 otherwise
R&D	Proportion of R&D employees to total sector employment (three-digit NACE-CLIO classification)
Herfindahl	Herfindahl concentration index (three-digit NACE-CLIO classification)

Legend:
a) AMTs (advanced manufacturing technologies): machining centers, programmable robots, numerically (or computerized numerically) controlled stand-alone machine tools, and flexible manufacturing systems (FMS).

Economists are introducing these features into theoretical models. However, there is no quantitative large-scale evidence that shows whether the relation between the lean type of organization and the adoption of such innovations holds or not (see also chapter 5). If these considerations hold true, then I would expect these routines to decrease the probability of adopting bureaucratic organizations (i.e., organization characterized by a large number of corporate levels).

Another group of variables relates to the plant's ownership status. I define the two dummy variables *State-owned* and *Private group* that denote whether in 1997 a plant belonged to a State-owned group or to a private multi-plant company, respectively. Moreover, I distinguish group's nationality by introducing three additional dummy variables *Private Italian group*, *European MNE* and *NA MNE*, indicating the Italian, European or North-American nationality of the private business group to which the plant eventually belonged. Above mentioned theoretical models do not take into account the effect of the ownership status on the organizational structure. However, I would expect organizations of plants that belong to a business group to be comparatively of smaller size, since administrative tasks are partially allocated at upper corporate levels outside the plant. On the contrary, in plants that belong to a single-plant firm the boundaries of the firm's management hierarchy coincide with those of the plant's organization. In addition, State-owned plants are expected to be comparatively more bureaucratic than private plants, since these do not have to respond in full to market pressures (see Shleifer 1998). Finally, differences in the nationality of business groups might lead to differences in organizational structures when corporate culture is an important feature (Kreps 1985).

Tab. 3 – Descriptive statistics of the explanatory variables

	Min	Max	Mean	Std. Dev.
Size	1.6094	8.4118	4.4818	1.1865
DAMT	0	1	0.8015	0.3994
AMT1	0	1	0.2215	0.4157
AMT2	0	1	0.3311	0.4711
AMT3	0	1	0.1530	0.3604
AMT4	0	1	0.0959	0.2948
IMS	0	1	0.3219	0.4677
Intra-firm network	0	1	0.5822	0.4938
Inter-firm network	0	1	0.1849	0.3887
JIT	0	1	0.4635	0.4992
TQM	0	1	0.5457	0.4985
State owned group	0	1	0.0320	0.1761
Private group	0	1	0.1963	0.3977
Private Italian group	0	1	0.0525	0.2233
European MNE	0	1	0.0890	0.2851
NA MNE	0	1	0.0548	0.2278
R&D	0	0.2204	0.0206	0.0375
Herfindahl	0.0001	0.2425	0.0177	0.0348

Industry-specific effects are captured by two variables. First, *R&D* is defined as the proportion of R&D to total industry employment (three-digit NACE-CLIO classification). Second, *Herfindahl* is the three-digit Herfindahl concentration index. These variables are introduced in order to control for industry effects. In particular, these give us information of the scientific base and market competition of industries in which plants operate.

Table 3 illustrates descriptive statistics of the explanatory variables. In June 1997, sample plants had on average 195 employees (*Size* = 4.48). As to AMTs, 80.1% of the sample establishments had adopted one or more AMTs by June 1997, with the average number of AMT types in use being 1.7. 32.2% of plants had adopted IMS, whilst the percentage of adopters was 58.2% and 18.5% for intra and inter-firm network technology, respectively. As concerned to managerial innovations, 46.3% and 54.6% of sample plants had adopted just-in-time manufacturing and total quality management. As to ownership status, 22.8% of plants were owned by a multi-plant organization; of these, 8.4% were owned by a national group, with the remaining 14.4% belonging to foreign multinational enterprises (either European or North-American).

To sum up, in this paper I estimate a series of ordered logit models with censoring, where the dependent variable "*Number of plant's managerial levels*" takes the value n=2,3,4,5,6 if in June 1997 the organization of the plant was compounded by n hierarchic levels. The explanatory variables are intended to capture the above-illustrated factors, which may influence the likelihood of choosing the number of layers.

3.5 Empirical Results

The results of three econometric models are reported in Table 4. Explanatory variables include plant size, adoption of production, network and managerial innovations, ownership by a business group, and industry-specific effects.

Generally speaking, the econometric results are quite robust. First, the positive, highly significant, coefficient of plant size comes as no surprise. *Size* is the individual variable, which exhibits the greatest explanatory power in all models, showing that the number of hierarchic levels is a positive and concave function of the number of plant employees.[4] So, the number of corporate levels increases with plant size, but at decreasing marginal rates. Obviously, span of control and depth of management hierarchy are closely entwined. In chapter 2 I showed that the span of control increases with the plant size. Thus, the (positive) concave relation between depth of the organization and plant size may be interpreted as the attempt of large plants to limit the expansion of the management hierarchy through an increase in the span of control, thus reducing the loss of control phenomenon.

Second, production technology plays a key role in influencing the choice of the organizational form. As predicted, there is a positive

[4] It is worth noticing that I have also introduced into the econometric model the number of employees in a linear form. However, the coefficient of the linear form turns out to be insignificant. More specifically, a LR test shows that I can drop out the linear form.

significant relation between the size of the organization and the use of IMSs. Such finding seems to confirm that single-purpose technologies linked to the Tayloristic approach to production need a rigid separation of tasks and ranks, hence a larger number of hierarchic layers.

In contrast, the use of AMTs tends to increase the probability of adoption of leaner forms of organization. However, the coefficient of *DAMT* is not significant. A further exploration to the extent of use of AMTs contributes to extend our understanding of such relation. Thus, in Model *II*, I have further distinguished the adoption of AMTs by introducing the categorical variables *AMT1*, *AMT2*, *AMT3*, and *AMT4*. Results show that the negative impact on the likelihood of adopting deep organizations is increasing in the number of AMTs, with *AMT4* being significant at the 95% level. This result confirms that the effect of the adoption of flexible technologies on the organizational structure is based upon complementarity effects. More than the use of an AMT in isolation, is the combination of different complementary technologies that leads to a "holistic organization", characterized by a loose definition of tasks, hence, by a flat management hierarchy.

Tab. 4 – The determinants of the hierarchy (ordered logit model with censoring)

	Variables	I	II	III
a_0	*Constant*	-0.8039 (0.4757)a	-1.0666 (0.4873)b	-0.9911 (0.4913) c
a_1	*Size*	0.7943 (0.1121) c	0.8510 (0.1140) c	0.8400 (0.1150) c
a_2	*DAMT*	-0.2447 (0.2819)	-	
a_3	*AMT1*	-	-0.1892 (0.3279)	-0.2159 (0.3316)
a_4	*AMT2*	-	-0.1790 (0.3014)	-0.1674 (0.3033)
a_5	*AMT3*	-	-0.2881 (0.3620)	-0.2310 (0.3705)
a_6	*AMT4*	-	-0.9568 (0.4152)b	-0.9106 (0.4200) b
a_7	*IMS*	0.5213 (0.1946) c	0.6178 (0.1963) c	0.6113 (0.2013) c
a_8	*Intra-firm network*	0.6548 (0.2427) c	0.6183 (0.2442) b	0.6438 (0.2467) c
a_9	*Inter-firm network*	-0.4974 (0.2452)b	-04576 (0.2509) a	-0.5282 (0.2636) b
a_{10}	*JIT*	0.2011 (0.2152)	0.2610 (0.2196)	0.2782 (0.2250)
a_{11}	*TQM*	0.1657 (0.2151)	0.1799 (0.2198)	0.1412 (0.2237)
a_{12}	*State owned group*	1.0798 (0.4449) b	1.0584 (0.4688) b	1.1316 (0.4697) b
a_{13}	*Private group*	-0.2553 (0.2420)	-0.1865 (0.2457)	-
a_{14}	*Private Italian group*	-	-	0.5017 (0.4014)
a_{15}	*European MNE*	-	-	-0.6884 (0.3131) b
a_{16}	*NA MNE*	-	-	-0.0054 (0.3585)
a_{17}	*R&D*	-1.1465 (2.4582)	-1.4780 (2.4392)	-1.6593 (2.6857)
a_{18}	*Herfindahl*	3.4768 (2.3236)	4.1121 (2.4468) a	3.5251 (2.6113)
	μ_1	3.7670 (0.3047) c	3.7918 (0.3072) c	3.7934 (0.3082) c
	μ_2	5.8158 (0.3458) c	5.8649 (0.3519) c	5.9167 (0.3519) c
	μ_3	7.8153 (0.4425) c	7.8719 (0.4518) c	7.9578 (0.4520) c
	Log-likelihood	-457.0385	-454.0520	-450.3609
	LR test	118.5546 (11) c	124.5275 (14) c	131.9097 (16) c
	N. of censored obs.	10	10	10
	N. of obs.	438	438	438

Legend
a) Significance level greater than 90%.
b) Significance level greater than 95%.
c) Significance level greater than 99%.
Standard errors and degrees of freedom in parentheses.

As to network technology results are rather articulated. First, the size of the organization is increasing in the use of intra-firm network technology. Since I cannot derive any robust conclusion on the causality link between organization and technology, I might also interpret this result on the other way round: plants characterized by a deep organizational structure are more likely to introduce network technology so as to improve the efficiency of intra-firm communication. Further, it is interesting to note that whilst advances in intra-firm communication increase the likelihood of choosing multi-layered structures, improvements in inter-firm communication (with customers, suppliers and/or subcontractors) decrease this probability. The coefficient of *Inter-firm network* is negative and significant at conventional levels. In particular, this result might be the outcome of a process of outsourcing: the integration of suppliers and subcontractors within the plant's network might capture a process of delegation of production activities outside the plant.

Turning then to managerial innovation variables, these overall display a very low explanatory power. Adoptions of just-in-time manufacturing and total quality management do not seem to influence the choice of the organizational structure of plants. It is interesting to note that in chapter 4 I will show that the use of JIT presses the firm to decentralize decision-making authority down the management hierarchy. So, whilst JIT affects the allocation of authority, it does not affect the size of the organization.

As to the ownership status, State-owned plants tend to be relatively more bureaucratic than private plants, with the coefficient of *State-owned group* being significant at 95%. Whereas in Models *I* and *II* I control for State versus private ownership, in Model *III* I further distinguish the nationality of the private multi-plant corporation to which the plant eventually belongs. It turns out that there is a great difference between plants owned by national private groups and those that belong to foreign multinationals. In particular, being owned by a European multinational enterprise (significantly) decreases the probability of plants of adopting deep organizational structures. Corporate culture might be a major determinant of differences in the organizational structure among firms of different nationality. This result might also point to the role played by the distance between the plant and its headquarters. Indeed, whilst plants that belong to European corporations are directly controlled by their headquarters, thus reducing the need of (some) intermediate levels, North-American multinationals whose headquarters is very far from the production unit may prefer to delegate activities completely at the plant level. As to Italian private business groups, they are in average of smaller size: 65% of them have less than 10,000 employees against 33% and 25% of European and North-American multinationals, respectively. So, plant and firm boundaries are more likely to overlap for a larger proportion.

Finally, there is no evidence of any relation between the size of the organizational architecture and the industry structure, with the coefficients of *R&D* and *Herfindahl* being insignificant in most regressions. Only in Model *II*, *Herfindahl* turns out to be significant at the 10% level, pointing to a (weak) positive relation between the level of plant bureaucratization and market concentration.

Tab. 5 - Determinants of the hierarchy, empirical facts

Determinants	LR tests (on the coefficients of Model *III*)	Results	Comments
size	$a_1=0$	51.30 (1) c	positive (concave) relation
production technology	$a_3= a_4= a_5= a_6= a_7=0$	12.54 (5) b	significant impact; the sign depends on the characteristics of production technology (i.e., vintage and extent of use/ complementarities in production)
network technology	$a_8=a_9=0$	10.27 (2) c	significant impact; the sign depends on the characteristics of network technology (i.e., intra versus inter-firm network technology)
managerial innovations	$a_{10}= a_{11}=0$	2.66 (2)	insignificant impact
ownership status	$a_{12}= a_{14}= a_{15}= a_{16}=0$	14.36 (4) c	significant impact, with State-owned plants being more bureaucratic than private plants; existence of national differences
industry effects	$a_{17}= a_{18}=0$	1.91 (2)	insignificant impact

Legend
b) Significance level greater than 95%.
c) Significance level greater than 99%.
Degrees of freedom in parentheses.

To sum up results, I have further proceeded to test the joint significance of different groups of explanatory variables by LR tests on Model *III* of Table 4. Table 5 presents results. Such findings may offer interesting indications to the theoretical literature. On the one hand, they confirm that the plant size and adoptions of (production and network) technology are key in explaining differences among organizational structures. On the other hand, results relating to the impact of the use of technological innovations upon the plant organization highlight the importance of the specific characteristics of such technologies. In particular, the magnitude and sign of these effects do depend on the vintage (i.e., IMS against AMT), the extent of use (number of AMTs in use) and the specific locus of (communications) innovations (intra against inter-firm network technology).

Conversely, managerial innovations display no explanatory power. This result points to the difference between innovations embedded and those not embedded in capital equipment. Technologies embedded in capital equipment incorporate specific and codified manufacturing methods (for instance, the new layouts of production linked to FMS). Thus, technological adoptions turn out to affect the structure of the organization. Instead, the implementation of managerial innovations follows more arbitrary rules: "Since TQM can fail if people in the organization expect it to fail, implementation details (e.g., whether widespread faith is cultivated effectively) will matter" (Camerer and Knez 1996). So, managerial techniques are not correlated with any specific form of organization. This might be due to differences in the implementation process among sample plants. In other words, business practices seem to be fads (see chapter 5 for further analysis).

3.5.1 A Further Inquiry on the Boundaries of the Firm

I have then proceeded to separate single-plant firms from plants owned by a multi-plant corporation. It is worth noticing that in both cases I have reduced the categories of the dependent variable (i.e., the number of managerial levels) from 5 to 4. As to single-plant firms, I have classified plants with 5 and 6 levels in one category, given that there are only three single-plant firms with 6 or more levels. As to plants owned by a multi-plant company, I have classified plants with 2 and 3 levels in one category, given that there are only two plants owned by a business group with the number of managerial levels that equals 2. Table 6 presents results of these estimates. At the end of the table LR tests on the overall contribution of size, production and network technology, managerial innovations, ownership status and industry effects, similar to those of Table 5, are reported.

Tab. 6 – Management hierarchy and boundaries of the firm

		Single-plant firm	Multi-plant firm	
	Variables	IV	V	VI
a_0	Constant	-0.8941 (0.5403)a	-5.7163 (1.871) c	-4.0630 (2.2523)a
a_1	Size	0.7819 (0.1332) c	0.8130 (0.3187) b	0.7546 (0.3288) b
a_2	AMT1	0.0119 (0.3539)	-1.2442 (0.9851)	-1.3159 (1.0519)
a_3	AMT2	-0.0450 (0.3280)	-0.6161 (0.9356)	-0.5016 (0.9643)
a_4	AMT3	0.1011 (0.4071)	-1.2356 (1.0407)	-0.9579 (1.1279)
a_5	AMT4	-0.2837 (0.6190)	-2.2005 (1.0407)b	-2.0073 (1.0589)a
a_6	IMS	0.3379 (0.2491)	1.3054 (0.4497) c	1.3548 (0.4855) c
a_7	Intra-firm network	0.5546 (0.2414) b	1.9844 (1.1365) a	2.3282 (1.3627) a
a_8	Inter-firm network	-0.5845 (0.3188)a	-0.4188 (0.5404)	-0.6176 (0.5866)
a_9	JIT	0.0500 (0.2424)	0.8849 (0.5856)	0.9322 (0.6700)
a_{10}	TQM	0.3601 (0.2357)	-0.3120 (0.6235)	-0.5884 (0.7440)
a_{11}	State owned group		1.3428 (0.6809) b	
a_{12}	Private Italian group			-0.7479 (0.8310)
a_{13}	European MNE			-2.1466 (0.7354)c
a_{14}	NA MNE			-1.0353 (0.8690)
a_{15}	R&D	-1.5638 (4.1634)	0.5200 (3.6709)	0.9313 (4.3933)
a_{16}	Herfindahl	3.9799 (2.5516)	3.5585 (6.4154)	2.0433 (8.4590)
	μ_1	3.6953 (0.3114) c	2.1681 (0.3432) c	2.3334 (0.3598) c
	μ_2	5.8058 (0.3628) c	4.1418 (0.5946) c	4.3727 (0.6225) c
	Log-likelihood	-325.6098	-103.3449	-99.7142
	LR test	68.1696 (12) c	37.8992 (13) c	45.1205 (15) c
	LR tests on groups of explanatory variables:			
	$a_1=0$	35.5822 (1) c	9.4722 (1) c	7.8780 (1) c
	$a_2= a_3= a_4= a_5= a_6=0$	2.5640 (5)	15.442 (5) c	15.233 (5) c
	$a_7=a_8=0$	6.9936 (2) b	5.1502 (2) a	7.1160 (2) b
	$a_9= a_{10}=0$	2.5682 (2)	3.6442 (2)	4.6760 (2) a
	$a_{11}=0$		5.4816 (1) b	
	$a_{12}= a_{13}= a_{14}=0$			12.7430 (3) c
	$a_{15}= a_{16}=0$	1.8720 (2)	0.4174 (2)	0.2088 (2)
	N. of censored obs.	26	7	7
	N. of obs.	338	100	100

Legend:
See Table 5

Generally speaking, results point to the difference between the determinants of the boundaries of the firm's organization and those of the plant's management hierarchy. In single-plant firms, the boundaries of the plant coincide with those of the firm. In this case administrative, financial and marketing activities are incorporated into the plant's organization as well as production operations. Thus, the impact of production technology vanishes, whereas the overall role of network technology remains key. Note also that the use of intercompany network technology is associated to flatter organizations only in single-plant firms, but not in plants owned by a business group. It is very likely that single-plant firms make use of such innovations to outsource part of the production to subcontractors, whilst the same does not apply to the other category of plants.

As to plants owned by a business group, the boundaries of a plant's organization relate only to the production unit. In this case, production technology is key in shaping the management hierarchy. In addition, we have a confirmation that State-owned plants are very bureaucratic compared to all the other categories of plants, and plants owned by private European corporations have adopted smaller organizations with respect to those owned by Italian and North American companies.

3.6 Concluding Remarks

This chapter is, as far as I know, the first attempt aimed at testing the determinants of the size of the management hierarchy. For this purpose, I have examined the decision to adopt an organizational form, in terms of the number of corporate levels for a sample of 438 Italian manufacturing plants. The characteristics of the plants were observed in 1997. Particular attention was devoted to variables usually considered in the theoretical literature, which I present in section 3.2, such as plant size and the use of production and network technology. In addition, I introduced into the econometric model the ownership status, which is traditionally considered in the theory of the firm, industry effects and managerial routines, upon which theoretical as well as empirical work starts to concentrate.

The findings of this chapter clearly show that managerial innovations do not significantly affect the organizational structure (chapter 5 provide further insights into this issue). This might suggest that, since these innovations are loosely defined, plants are not pressed to adjust the organization accordingly. In other words, even if, for instance, just in time manufacturing is diffused widespread, this does not preclude the existence of differences in the implementation process. This may point to the difficulty of codification, hence implementation, of innovations that are not embedded in capital equipment.

Conversely, (production and network) technology plays a central role in shaping the organization. However, the impact crucially depends on its type, vintage and extent of use. First, network technology shows two opposite (significant) effects on the organizational architecture depending on the specific locus of advances in communication efficiency. Whilst improvements in intra-firm network technology increase the likelihood of adopting organizations characterized by deep management hierarchies, the opposite applies to inter-firm network innovations. As to production technology, I have distinguished old vintage technologies (i.e., IMS) from AMTs. The former are linked to the Tayloristic approach to production, so that these need a high specialization of workers and a more hierarchic production structure. As to AMTs, these are intertwined with the flexible automation paradigm based on flexibility and job rotation, so that these are linked to a leaner kind of organization. In addition, I have also showed that the extent of use, and not the use, of AMTs affects the size of the organization of plants.

Finally, I provide evidence that the ownership status matters. State-owned plants adopt more bureaucratic forms of organization. More interestingly, my findings suggest that corporate culture might affect the choice of the organizational form. In particular, there are sizable differences according to whether a plant is owned by a private Italian group or by a foreign multinational enterprise, the latter being less hierarchic.

Chapter 4

Formal and Real Authority in Organizations: Testing the Determinants of the Allocation of Decision-Making

4.1 Introduction

> "While we all have personal experience with some determinants of real authority, it is harder to come up with more systematic evidence. The key issue is, of course, the *measurement* of real authority ... organizational characteristics such as the span of control, the concentration of ownership, and the number of principals and supervising layers are directly relevant for measuring (or assessing) real authority enjoyed by subordinates within a firm. In addition, one may use questionnaires, look ex post at the nature of decisions..., count the number of times the agents are overruled" (Aghion and Tirole 1997).

Economists are increasingly concerned about the internal working of firms and in particular about the determinants of the allocation of decision-making power. In spite of the fact that a reach stream of theoretical papers has recently addressed such issues, empirical studies are much less numerous and generally rely upon 'personal experience' as well as anecdotal evidence (see for instance the most cited works of Chandler 1962 and 1977). Probably, the most severe problem that economists find in addressing empirically these issues is collecting data which may be suitable to testing theoretical hypotheses. As far as I know, this chapter represents the first attempt to provide systematic quantitative evidence on the allocation of decision-making and its determinants. The aim of the chapter is to test (some of) the predictions of economic theory in a comprehensive and robust way through the estimates of an econometric model.

There are a number of determinants of the allocation of decision-making that have been analyzed in theoretical settings. I shall briefly look at some of them. In general, delegation implies benefits and costs for the firm. Assume a firm composed of two bureaus (teams or agents) hierarchically ranked, a superior and a subordinate. Furthermore, suppose that in each period the firm selects over N possible projects. Team theory (Marschak and Radner 1972) ignores the problem of conflicting objectives among bureaus and focuses upon the issue of coordination of imperfectly informed agents. Agents are boundedly rational *à la* Simon, in the sense that "the scarce resource is not information; it is processing capacity to attend to information" (Simon 1973). Thus, firm's screening over the projects is not perfect. Sah and Stiglitz (1986) (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. Keren and Levhari (1989) and Radner (1993) argue that if urgency is valuable for a firm, decentralization is an efficient means to achieve it. In other words, firms have strong incentives to decentralize decision-making activities when strategies must be taken in a short period of time and implemented shortly after. Now, suppose that the N projects are of m types. If we allow for increasing returns from task specialization (Bolton and Dewatripont 1994), then by delegating decision-making to the agent who has the best information over some type of decision, firms can fully exploit economies coming from local capabilities and tasks specialization

(Geanakoplos and Milgrom 1991). Finally, Aoki (1986) points out that if we extend theory of team dynamically decentralized organizations can exploit on-spot learning by doing and by using, whilst more centralized forms may show better ex ante specialized competencies.

Turning to a principal-agent context the transfer of authority to a subordinate may increase both his initiative to acquire information and his participation in the contractual relationship (Aghion and Tirole 1997). Laffont and Martimort (1998) argue that decentralization emerges whenever limits of communication and collusive behavior among agents are taken together into account. Otherwise, it follows from the revelation principle that centralization dominates decentralization.

The cost of delegating formal authority is the principal's loss of control over the choice of the project. Thus, loss of control assumes the form of deviation from principal's objectives. This concept can be approached from two different points of view: the decentralization of incentives and the decentralization of information (for this distinction see chapter 3). The information stream (see for instance Keren and Levhari 1979 and 1983, and Radner 1993) points out that organizational failures might be due to information transmission leaks. Since agents are organized serially within firm's organization, information transmission suffers from leaks between the pinnacle and the bottom of the hierarchy. Hence, general strategies defined by the superior (i.e., the top management) might differ from agents' implementation simply because of inefficiencies and delays in intra-firm communication. The incentive stream (see Calvo and Wellisz 1978 and 1979, and Qian 1994) underlines that limitations of organizations may be due to agents' shirking. As is natural in a context of asymmetric information, agents are tempted to hide valuable information to the principal in order to maximize their objectives that are in general different from those of their superior. This is obviously a major source of loss of control for the principal. To sum up, factors that influence these costs and benefits (principal's loss of control on the one hand, increase of agent's initiative and participation on the other) make delegation of decision-making more or less profitable, hence more or less likely.

The remaining part of the chapter is organized as follows. Next section introduces recent theoretical literature in greater detail, identifying (some of the) crucial factors that shape the allocation of decision power between an agent (i.e., the plant manager) and a principal (his corporate superior). I heavily draw upon the model of Aghion and Tirole (1997), which is close to the point of view of the present empirical research. Section 4.3 presents the design of the empirical analysis I have run in order to collect data on the allocation of authority within Italian manufacturing plants. In section 4.4 the econometric model is specified and the explanatory variables are illustrated. In section 4.5 I show the empirical results. Section 4.6 sums up conclusions.

4.2 Determinants of the Allocation of Decision-Making

In this section I illustrate some theoretical findings on the allocation of decision-making and their implications for the delegation of decision power to plant managers. Sections 4.2.1 and 4.2.2 are devoted to the delegation of real authority (i.e., the effective control over decision-making activity), with the principal conserving formal authority (i.e., the right to decide and thus to overrule the agent if needed). The analysis largely relies on Aghion and Tirole's (1997) (henceforth, A&T) basic model which is sketched out in section 4.2.1; some extensions of the model are briefly considered in section 4.2.2. In section 4.2.3 I turn to the determinants of the delegation of formal authority.

4.2.1 Delegation of Real Authority

Assume a hierarchy composed of a plant manager (the agent, *A*) and one superior (the principal, *P*). The agent is assigned the task of selecting and implementing one out of *N* projects (no project is project 0). For each project *k* define b_k as the agent's private benefit and B_k as the monetary gain for the principal (where $b_0=B_0=0$). For each party there is at least one project that gives a sufficiently negative pay-off (i.e., *k* and *k'* such that $b_k<<0$ and $B_{k'}<<0$), so both parties have no incentive to indicate a project when uninformed. Let *b* and *B* be the maximum gains that a project can yield for the agent and the principal respectively. If the principal's preferred project is chosen, the agent will have a private benefit given by βb. Alternatively, if the agent's preferred project is chosen then the principal will get αB, where α and β belong to (0,1] and are said, for obvious reasons, congruence parameters. Finally, with probability e the agent acquires all information about the pay-offs of the N projects at private cost $g_A(e)$. Instead, with probability $1 - e$ he does not learn anything and still judge all projects as identical. Similarly, the principal learns the pay-offs of all projects with probability E and is totally uninformed with probability $1 - E$; her disutility of being informed is given by $g_P(E)$. For the sake of simplicity, let us assume that principal and agent's disutility functions are given by $g_P(E)=pE^2/2$ and $g_A(e)=ae^2/2$ respectively, where a and p are two positive exogenous parameters.[1] Then, we obtain in equilibrium:

$$\frac{\hat{e}}{\hat{E}} = \frac{b(p - B)}{B(a - \alpha b)}. \tag{1}$$

Large values of the ratio $\hat{e}/\hat{E}$ indicate that real authority is increasingly transferred to the agent; in other words, the less informed the principal the more likely that he simply rubber-stamps the agent's proposal. According to expression (1), the assignment of real authority to the agent depends negatively on the agent's disutility

[1] A&T assume that $g_i(0)=0$, $g_i'(0)=0$, $g_i'(1)=\infty$, and g_i', $g_i''>0$, where $i=A,P$. Of course, when $g(\cdot)$ is a quadratic function we do have to introduce a discontinuity for $e=E=1$, sot that condition $g'(1)=\infty$ still holds.

parameter and the principal's maximum pay-off, and positively on the agent's maximum private gain, the principal's disutility parameter and the congruence of objectives between the parties. In what follows I am interested in the characteristics of a firm's organizational structure and procedures and other firm-specific variables that are likely to influence the relative allocation of real power between a plant manager and his corporate superior.

First, I expect the *complexity* of plant's operations to have a considerable impact on the distribution of decision-making power. In large plants characterized by an articulated multi-layer organizational structure the plant manager is likely to enjoy a substantial information advantage over the corporate headquarters, as he is closer to the plant's operations. In other words, the value of p rises more rapidly with a plant's complexity than that of a, thus favoring delegation of decision-making activity to the plant manager.

Second, use of *advanced communication technologies* is also likely to play a crucial role. By increasing the ability of the corporate headquarters to collect and process information on a plant's operations, improvements in communication technology decrease principal's costs of investigation, thus lowering p; *ceteris paribus*, assignment of real authority to the plant manager should be less frequent. Such reasoning especially applies to complex units which are relatively more exposed to information transmission problems. However, recourse to efficient communication technologies may also improve the plant manager's capability to collect information, resulting in a lower value for parameter a; therefore, the above mentioned negative effect on the delegation of real authority may possibly be reversed.[2]

Third, if strategic decisions relating to a plant's activity involve on average a greater amount of resources, their expected impact on the principal's monetary benefits is greater. In addition, a plant competes with the other organizational units of its parent firm (e.g., other functional departments, other manufacturing units in multi-plant firms) for the use of fixed corporate resources; the greater the financial resources required to implement the plant manager's preferred decisions, the less likely that locally optimal decisions will also be optimal for the firm as a whole, as there are substantial externalities on other units. Consequently, when decisions tend to involve considerable investments, B is large and α is small, other things being equal: less decentralization of decision-making follows. The above conditions do depend on the characteristics of a plant's production technology and organization of production activity; for instance, they generally hold true for plants that are involved in mass production of rather standardized goods and are characterized by

[2] In addition, note that communication technologies facilitate interaction between plant managers and their corporate superiors. Since the capabilities of the latter to monitor and control decisions by the former (and to reverse them if they turn out to be suboptimal) are enhanced, decision-making activity may well be more decentralized in organizations which have adopted such technologies, as far as real (but not formal) authority is concerned. This effect is not captured by A&T model, which is not a monitoring game.

large, highly indivisible investments in automated capital equipment, where strategic decisions relating to production factors basically are of discrete nature (i.e., adding or closing a production line).

4.2.2. More on the Delegation of Real Authority

According to the literature, there are a few additional variables which are among the main determinants of the relative allocation of real authority.

First, *urgency* might have a strong impact on the delegation of real authority to the plant manager. Accordingly, whenever a plant's organization is shaped by the desire to reduce "time to market" and assure prompt response to external stimuli, I expect responsibility for decision-making to be quite decentralized. Keren and Levahry (1989) show that if the implementation lag is valuable for the firm, than decentralization of authority may be an efficient outcome. Again, A&T 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). This result is quite straightforward from the framework considered in the previous section if one assumes that decision-making is sequential rather than simultaneous. For any level of principal's effort, urgency in decision-making results in an increase of her marginal disutility: the more she oversees, the slower the decision-making process, the lower the returns from implementing the selected project. Thus, an increase in urgency of decisions shifts downward the reaction curve of the principal, raising agent's real authority.

Another key aspect is the presence of *monetary incentives* aimed at aligning the agent's objectives with those of the principal. A&T (pp. 20-22) generalize the setting described in the previous section by allowing the agent to respond to monetary incentives. They show that there are two main reasons why an increase in agent's remuneration raises his real authority. First, for any level of effort of the principal agent's initiative increases with the amount of monetary incentives (that is, there is an upward shift of the reaction curve of the agent). Second, there is a reduction in the principal's incentive to monitor: for any level of agent's initiative the principal devotes less effort to investigate projects (i.e., principal's reaction curve shifts downward). Thus, the net effect of the introduction of monetary incentives is an increase of agent's real authority.

Let us now depart from the model considered in the previous section by assuming that the superior has authority over *m* identical subordinates, who run different independent tasks. The situation is identical to the previous one, except that the principal now has to distribute her effort over a plurality of agents, so that $g_p(E) = p(\sum_{i=1}^{m} E_i)^2 / 2$. The symmetric equilibrium (see equation 1) becomes

$$\frac{\hat{e}}{\hat{E}} = \frac{b(pm^2 - B)}{B(a - \alpha b)}. \qquad (2)$$

As the number m of subordinates increases, it becomes more costly for the superior to attend all activities; thus, the principal will delegate real authority downward the management hierarchy.

Conversely, a plant manager may have multiple principals. This has various implications, of opposite signs upon delegation of decision-making so that the net effect cannot be unambiguously predicted ex ante. First, due to the split of returns among several principals, there is a free rider problem in monitoring the agent's behavior which favors delegation.[3] Second, there is the effect of the split of authority among corporate superiors with imperfectly aligned objectives. On the one hand, the conflict of interests among them may raise each principal's incentive to monitor the agent's activity. On the other hand, it may also allow the agent to set the multiple principals against each other. Hence, the degree of centralization of real authority may increase or decrease, depending on which effect prevails.

The above mentioned variables (that is, the number of subordinates over which a plant manager's corporate superior has authority and the number of multiple principals of the plant

[3] Note however that depending on the characteristics of the principal's monitoring cost function, the multiplication of principals may induce more investigation in aggregate; in that case, the agent's initiative is reduced. See A&T (p. 23).

manager) are closely linked to organizational characteristics of a plant's parent firm such as its overall size, single-plant or multi-plant nature, and organizational structure (i.e., U-form or M-form, for a detailed description of these organizational forms see chapter 1). Accordingly, these factors are very likely to affect the distribution of real authority between the plant manager and his superior.

4.2.3 Delegation of Formal Authority

As a preliminary remark, one should acknowledge that formal responsibility for strategic decisions is quite rarely delegated to a plant manager. Superiors in the corporate hierarchy generally retain the formal right to overrule plant managers' choices if in their own view this is deemed necessary. This practice contrasts with the one concerning operating decisions, which are often (and increasingly) decentralized to plant managers and lower managerial layers (see chapter 2). Such evidence is in line with Geanakoplos and Milgrom (1991) which demonstrate that within firm's hierarchy the right to take a decision should be assigned to the manager who has the best information. That is, delegation emerges as an optimal outcome for exploiting local knowledge.

A&T also analyze the allocation of formal authority. They highlight that both incentive and individual rationality considerations are relevant for understanding why a principal gives up the right to reverse an agent's decisions. On the one hand, when the agent is also formally in charge of decision-making (that is, he has both real and formal authority), his initiative increases as he does not fear being overruled. The cost for the principal is the loss of control over agent's activity. On the other hand, delegating to the agent the formal right to decide raises his utility, thus relaxing his individual rationality constraint.

As to the allocation of formal authority over strategic decisions between the plant manager and his superior, the incentive considerations do not lead to directly testable hypotheses.[4] On the contrary, the participation view does. In particular, A&T suggest that the *specific nature of the strategic decision* should play a key role in assessing which decisions are delegated to the agent and which are retained by the principal. Decisions that have great impact on the principal's economic return (i.e., B assumes a large value) and little impact on the agent's private benefit (i.e., b is small) should be centralized. Conversely, decisions that affect only marginally principal's returns could be delegated to the agent. Furthermore, decisions for which the objectives pursued by the plant manager are likely to diverge from those of the firm as a whole (i.e., α is low) should be retained with the plant manager's superior, while those for

[4] Note that according to the incentive view, formal authority should be delegated to the agent when i) the principal's benefits are very sensitive to the agent's initiative, ii) the likelihood of the principal being informed is exogenous and iii) the principal is quite uninformed. On the contrary, the principal should retain it if she is very well informed. Such reasoning helps explain why operating decisions are frequently decentralized, while strategic decisions are not, as was indicated earlier.

which the superior's choices could badly hurt the plant manager's activity (i.e., β is low) should be relatively more decentralized. From the above line of reasoning I derive the following remarks.

- Decisions concerning *capital investments* should be kept more centralized than those concerning the *workforce* due to the greater amount of financial resources involved in each individual decision and the larger externalities they impose upon a firm's other units (higher B, lower α). In addition, control over the latter decisions is likely to be more important to the agent than control over the former, because his private benefit is likely to be greater (higher b) and the principal's choices may be very detrimental to him (lower β); such considerations reinforce the above mentioned tendency.
- As to decisions concerning investments in capital equipment, the larger the amount of the investments the less likely decentralization (higher B, lower α).
- As to decisions concerning a plant's labor force, formal authority should be kept centralized if decisions may affect other units (lower α) and be more frequently decentralized if they have a direct impact on the plant manager's activity (high b, low β). For instance, the former category includes decisions on the adoption of general schemes of payment of the labor force or, to a more limited extent, hiring and dismissal of plant's personnel, while to the latter one belong decisions on career paths within the plant.

4.3 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 thesis I use information on the organization of plants and their parent companies for a sample composed of 438 production units (see the empirical methodology chapter at the beginning of this thesis for further information). In particular, detailed data was provided by the questionnaire analysis on the decision-making structure of each sample plant. Data concern who within the firm (that is, which managerial level) takes strategic decisions related to plant's activity (see also chapter 2, and in particular section 2.2.2). I consider the following six plant's strategic decisions: (i) introduction of new technologies, (ii) purchase of large-scale capital equipment, (iii) purchase of stand-alone machinery, (iv) hiring and dismissal of plant's personnel, (v) career paths, and (vi) definition of individual and collective incentive schemes.

I 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 second 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. Instead, the first 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, I shall always use the term "plant manager".

In order to test the theoretical hypotheses illustrated in the previous sections, I have distinguished three distinct modes of allocating plant's strategic decisions.

1. Decisions are taken autonomously by the plant manager's corporate superior. In this case the plant manager can at most propose directives, but formal and real authority is a superior's matter (levels 4 and 5 of figure 1a in chapter 2).
2. The plant manager is in charge of the decision, but the superior can overrule him, as formal authorization is needed: the plant manager has real authority but formal authority still remains with the superior (level 3).
3. Finally, the plant manager has both formal and real authority. In this case decisions are taken autonomously by the plant manager and the superior is excluded from the decision-making activity (levels 1 and 2).

Thus, for each of the six aforementioned plant strategic decisions I know who (the plant manager or his corporate superior) is in charge and how the decision is taken. In other words, I know how real and formal authorities are allocated between the two parties.

4.4 The Econometric Model

4.4.1 The Specification of the Econometric Model

I test theory by analyzing the impact of some explanatory variables which will be illustrated in sections 4.4.2, on the allocation of decision-making. The choice faced by the parent firm of plant j (j=1,....,438) can be modeled as a discrete choice problem (see Maddala 1983). In particular, the firm can allocate every plant's strategic decision in three different ways. First, the superior retains formal and real authority over the strategic decision, whilst the plant manager can at most propose general directives (I call this situation *integration, I*). In the second case, formal authority is still a superior's matter, but the plant manager has real authority on the plant's strategic decision (*delegation of real authority, DR*). Finally, authority is completely delegated to the plant manager (*delegation of formal authority, DF*).[5] The choice of the decision mode reflects the maximization of the superior's utility, which is a random attribute of feasible choices. For each plant j and decision i the utility of choosing mode k (where $k = I, DR, DF$) is defined as

[5] Note that there exists, at least theoretically, a fourth situation, in which the plant manager holds formal authority whilst the superior possesses real power. In business organizations, where agents are ranked hierarchically, this situation is very unlikely. Moreover, A&T show that delegating formal authority increases the plant manager's initiative, so that the relative allocation of real authority to the plant manager under delegation (i.e., the equilibrium value $\hat{e}/\hat{E}$) is higher than under integration. Thus, the event in which the plant manager holds formal

$$U_{ij}^{k} = V_{ij}^{k} + \varepsilon_{ij}^{k}$$

where V_{ij}^{k} is a deterministic component, which depends on a set of explanatory variables X_{ij}, and ε_{ij}^{k} is a random disturbance. For instance, the superior will find convenient to delegate formal authority over a strategic decision to the plant manager whenever her expected utility under delegation of formal authority is higher than the utility under both delegation of real authority and integration, that is $U^{DF}>U^{DR}$ and $U^{DF}>U^{I}$. Utility maximization implies that the likelihood P_{ij}^{k} of mode k being chosen is given by

$$P_{ij}^{k} = \Pr(U_{ij}^{k} > U_{ij}^{t}, \quad \text{for all } t \neq k).$$

If disturbances ε_{ij}^{k} are independently and identically distributed by a Weibull distribution, then P_{ij}^{k} is given by the multinomial logit model (McFadden 1974). To test if these assumptions hold true, the McFadden, Train and Tye (1981) test has been performed.[6] The multinomial logit specification appears to be highly accepted in this context (see the results of the test in the Appendix, Table A.1).

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authority and the corporate superior possesses real authority is also theoretically very unlikely. In any case, in the empirical part I do not allow for this situation.

[6] Even if this test is biased toward accepting the null hypothesis, Brooks, Fry and Harris (1998) show that the test has very high power and recommend its use.

4.4.2. The Explanatory Variables

In order to test the predictions of economic theory as to the determinants of the allocation of decision-making power, I have considered a set of explanatory variables that are presented in what follows (see Table 1).

The complexity of the organization of plants is captured by two variables. *LEVEL* is the number of hierarchical levels of the plant. Since the superior is never included within the plant's hierarchy (either she is the owner or she is a salaried manager, but in no case is she part of plant organization), *LEVEL* is the number of levels under the superior. *SIZE* is the logarithm of the number of plant employees. As was stressed before, an increase of organizational complexity by increasing superior's marginal disutility, may press her to leave decision-making power to the plant manager who is closer to plant's operations and therefore enjoys an information advantage. Thus, I expect *LEVEL* and *SIZE* to have a positive impact on the likelihood of delegating decision-making down the firm's management hierarchy.

I define *NETWORK* as a dummy variable that equals one if the plant has adopted advanced intra-firm communication technologies (i.e., Local Area Network, on-line connection with the corporate headquarters). Since their adoption allows firms to improve the performance of data transmission within their organizations, I have introduced this variable as a proxy of intra-firm communication efficiency. We know that a better communication technology might allow the principal to centralize decision-making activities and reduce loss of control, so that *NETWORK* should be negatively related to the likelihood of delegating decision-making activities to the plant manager. Nonetheless, I noted earlier that with the use of sophisticated network technology, the cost incurred by the agent to collect information on plant's operations may decrease to a larger extent than those incurred by the principal; in that case *NETWORK* will have an opposite impact on the allocation of decision-making. The enhanced capabilities of the corporate headquarters to monitor agent's behavior may lead to the same result.

LARGE INVESTMENT is a dummy variable that is set at one for plants that have introduced large-scale capital equipment, such as inflexible and flexible manufacturing systems (IMS and FMS). This variable allows me to take into account situations in which plant's decisions become more important to the superior and are likely to engender larger externalities due both to budget constraints and indivisibility problems, thus leading to a more centralized decision structure. Further, *URGENCY* equals one whenever the plant makes use of "just-in-time" (JIT) production methods; otherwise its value is zero. I use this variable as a proxy of urgency of decisions. Indeed, firms that adopt JIT are pressed to deliver fast their products 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. From previous theoretical remarks, I would expect *URGENCY* to increase the probability of delegating real authority to the plant manager.

Tab. 1 – The explanatory variables of the econometric models

Variables	*Description*
Level	Number of hierarchic levels of plant organization
Size	Logarithm of the number of plant employees
Network	1 for plants that have adopted advanced network technologies (i.e., LAN and on-line connection with headquarters); 0 otherwise
Large investment	1 for plants that have invested in large scale capital equipment, such as inflexible and flexible manufacturing systems (IMS and FMS); 0 otherwise
Monetary incentives	1 for plants that use "non-traditional" pay incentive plans, 0 otherwise
Urgency	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 or business groups; 0 otherwise
Small group	1 for plants that belong to multi-plant parent companies or business groups with less than 100,000 employees; 0 otherwise
Large group	1 for plants that belong to multi-plant parent companies or business groups with more than 100,000 employees; 0 otherwise
M-form	1 for plants that belong to multi-plant parent companies or business groups with an M-form type of organization[a]; 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 & 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 introduction of general incentive schemes; 0 otherwise

Legend

a) M-form is equal to 1 whenever the parent company has more than 25,000 employees and no one of its product lines accounts for more than 70% of total sales (e.g., it is a "related business company").

MONETARY INCENTIVES is one for plants that have introduced "non-traditional" individual incentive schemes; otherwise it is equal to zero. Italian labor legislation allows firms to introduce individual and team monetary incentive plans. However, only a (small) proportion of them makes use of such payment plans. In particular, I focus on monetary incentives that link salaries to individual measures of performance. The introduction of monetary incentives should lead to more delegation of decision-making to the plant manager by both reducing superior's incentive to supervise and increasing the plant manager's propensity to recommend the superior's preferred project.

Lastly, let us turn to variables that reflect the structure and organization of plants' parent firms. I define *MULTI-PLANT* as a dummy variable that is one when the plant belongs to a multi-plant firm or a business group, and is zero when the plant is owned by a single-plant firm. As was suggested before, the position of the superior within firm's management hierarchy might influence the allocation of real and formal authority. Whilst *LEVEL* provides information on the position of the superior (and the plant manager) starting from the bottom of firm's hierarchy, *MULTI-PLANT* conveys information on the superior's position starting from the vertex of the organizational pyramid. Indeed, in plants that are owned by single-plant firms the superior often is the firm's owner, while in plants that are owned by a multi-unit organization she generally is an intermediate salaried executive. In this latter case, we also capture the effect of the size of the parent firm on the allocation of plant's strategic decisions by introducing two additional dummy variables. *LARGE GROUP* equals 1 for plants owned by business groups which have more than 100,000 employees and it is equal to 0 otherwise. *SMALL GROUP* equals 1 for plants owned by all remaining multi-plant organizations. In order to control for the organizational structure of the parent firm I have defined the variable *M-FORM,* which is a dummy variable that is one when the parent company is organized by a M-form type of organization. Since I do not have information regarding the organizational structure of all parent firms, I have proceeded as follows. The business history literature has highlighted that a M-form organization tends to be adopted especially by large-sized firms that have developed a diversification strategy (see chapter 1). For instance, in 1970 in France and Germany within the top 100 companies, 81% and 91% respectively of "single business" firms were functionally structured, whilst 59% and 50% of "dominant business" firms had a multidivisional organization; the same held true for 64% and 79% of "related business" firms (Dyas and Thanheiser 1976).[7] Similarly, in the 1970s within the top 500 American companies,

[7] "Single business" firms are defined as firms with 95% or more of total sales that lie within a single business. "Dominant business" firms are those firms which, in addition to their main product line, have diversified into other related or unrelated businesses to the extent of up to 30% of total sales. Finally, "related business" firms are firms which have diversified by entering into related markets or by using related technology, or have combined vertical integration with such diversification so that no one product line accounts for more than 70% of total sales.

100% of "single business" firms were functionally organized, whilst 64% and 95% of "dominant business" firms and "related business" firms respectively had a multidivisional structure (Scott 1973). Following this evidence, I have classified the organization of parent firms depending on their size and diversification of the product mix. In particular, I associate a M-form type of organization to the parent company whenever the latter has more than 25,000 employees and no one of its product lines accounts for more than 70% of total sales (e.g. it is a "related business" company).[8]

Table 2 shows descriptive statistics. The distribution of the number of plant's hierarchic levels is concentrated between 3 and 4, whilst the average number of employees is 195 (*SIZE*=4.48). Technological variables show that 58.2% and 71.7% of sample plants have adopted network technology and large-scale capital equipment respectively. 46.3% of them has introduced JIT techniques, 36.5% makes use of monetary incentive schemes. As to ownership status, more than 22% of sample plants belong to a multi-unit organization. Of them, 16% are owned by a firm or business group with less than 100,000 employees, whilst the remaining 6.8% are part of a very large corporation (i.e., total number of employees greater than 100,000). Lastly, in 10.5% of the cases the parent firm of sample plants can be considered as a M-form type of organization.

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[8] Data are derived from R&B (1998), the Hoovers's Handbook of World Business (1998), the Hoovers's Handbook of US Companies (1998), and Company Reports.

Tab. 2 – Descriptive statistics of the explanatory variables

	Mean	Max	Min	Std. Dev.
Level	3.473	6	2	0.838
Size	4.482	8.412	1.609	1.185
Network	0.582	1	0	0.494
Large investment	0.717	1	0	0.451
Monetary incentives	0.326	1	0	0.469
Urgency	0.463	1	0	0.499
Multi-plant	0.228	1	0	0.420
Small group	0.160	1	0	0.366
Large group	0.068	1	0	0.253
M-form	0.105	1	0	0.307
D-Technology	0.167	1	0	0.373
D-Capital equipment	0.167	1	0	0.373
D-Machinery	0.167	1	0	0.373
D-Hiring & dismissal	0.167	1	0	0.373
D-Career path	0.167	1	0	0.373
D-Incentive schemes	0.167	1	0	0.373

4.5 Empirical Results

Results of multinomial logit estimations are presented in Table 3. The baseline of the estimates is the situation in which the principal possesses both formal and real authority (i.e., integration). Columns 2 and 3 correspond to the estimates of the baseline against the delegation of real authority to the plant manager; hence I test the determinants of the allocation of real authority given that the superior holds formal authority (see sections 4.2.1 and 4.2.2). In columns 4 and 5 I compare the situation where the plant manager has real and formal authority with that where formal and real authority remains with the superior, so that I test the determinants of the allocation of formal authority (see section 4.2.3). Recall that the number of observations (2,628) is given by 438, the number of sample plants, time 6, the number of plant's strategic decisions I consider.

The number of coefficients of the econometric model has been reduced starting from the less significant ones. Both the initial unrestricted model and the final restricted model are reported in Table 3. In order to test for joint acceptance of all restrictions, a LR χ^2 test has been performed. The test is equal to 7.97 (95% critical value for χ^2_9 = 16.92), so that the restrictions are jointly accepted.

In order to provide further insights into the issues at hand, a simulation study has also been performed. The results are illustrated in Table 4. First, on the basis of the estimates of the restricted model, I have calculated the probabilities of integration of decision-making activity, delegation of only real authority to the plant manager, and delegation of formal (and also real) authority for the "average" sample plant, which represents the benchmark of the simulation. This latter is defined following the descriptive statistics of the explanatory variables reported in Table 2. In particular, the average plant is owned by a single-plant functionally organized firm and has adopted both advanced network technology and large-scale capital equipment but not monetary incentive schemes and JIT production methods.

Moreover, plant organization is composed of 195 employees (*SIZE*=4.48) and a three-layer hierarchy.

Second, I have computed changes of the above mentioned probabilities due to a variation of the value of each individual explanatory variable, with all remaining variables being kept constant. Indeed, since most explanatory variables are Boolean, this kind of exercise seems to offer more interesting evidence than simple calculation of marginal effects. Note also that as regards variations of continuous and discrete variables (i.e., *LEVEL* and *SIZE*), I have considered the lowest value of the first decile of sample plants in descending order (in this case the value assumed by the variable is defined as "large" or "high") and the highest value of the first decile in ascending order ("small" or "low" values), respectively.

Generally speaking, the evidence on the allocation of real and formal authority is rather robust and interesting. First, as to the complexity of the organization of plants, the number of hierarchic levels under the superior, captured by *LEVEL* significantly affects (at the 99% level) the allocation of both real and formal authority. In particular, more complex organizational structures are characterized by decentralization of real (and formal) authority to the plant manager. The results of the simulation study highlight that the likelihood of decision-making power being kept with the corporate superior is below 50% for a 5-layered plant, against 64.7% for the benchmark plant and 69.2% for a 2-layered plant.[9] Such findings confirm theoretical predictions relating to the alleged rapid increase of 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 for *SIZE* induces the superior to delegate real (but not formal) authority to the plant manager. However, in this case, I have to distinguish between plants that have adopted advanced network technologies and plants that have not. The estimates suggest that previous remark holds only for the latter category. Plants in which intra-firm communication is severely limited tend to decentralize real authority to the plant manager whenever the number of employees increases. Conversely, plants that have adopted network technologies do not seem to suffer from loss of control due to increasing complexity. In this case, the number of employees does not have any influence on the allocation of real authority: the value of the Wald test relating to the sum of the coefficients of *SIZE* and the interactive term *SIZExNETWORK* is not significant at conventional levels. However, quite surprisingly, it has a negative and significant (at the 95% level) impact upon the allocation of formal authority.

[9] In accordance with the criteria explained above, when *LEVEL* is "low" the plant is composed of a two-layer hierarchy, whilst a "high" value for *LEVEL* represents the case of an organization composed of five tiers.

Tab. 3 – Results of the multinomial logit models

	Variables	Delegation of real authority		Delegation of formal authority	
		Unrestricted	Restricted	Unrestricted	Restricted
a_0	*Constant*	-3.61 (0.39)c	-3.46 (0.37) c	-2.27 (0.43) c	-1.91 (0.29) c
a_1	*Level*	0.251 (0.07) c	0.26 (0.06) c	0.29 (0.07) c	0.30 (0.07) c
a_2	*Size*	0.40 (0.09) c	0.36 (0.08) c	0.10 (0.10)	-
a_3	*Network*	1.71 (0.47) c	1.63 (0.45) c	1.32 (0.53) b	0.99 (0.41) b
a_4	*Network * Size*	-0.40 (0.11) c	-0.37 (0.10) c	-0.34 (0.13) c	-0.25 (0.09) c
a_5	*Large investment*	-0.10 (0.12)	-	-0.49 (0.12) c	-0.43 (0.11) c
a_6	*Monetary incentives*	0.50 (0.10) c	0.48 (0.10) c	0.09 (0.12)	-
a_7	*Urgency*	0.08 (0.10)	-	0.25 (0.12) b	0.24 (0.11) b
a_8	*Small group*	0.30 (0.16) a	0.31 (0.15) b	0.17 (0.20)	0.20 (0.20)
a_9	*Large group*	1.27 (0.34) c	1.27 (0.34) c	1.589 (0.47) c	1.624 (0.46) c
a_{10}	*M-form*	-1.07 (0.28)c	-1.05 (0.28) c	-1.04 (0.41) c	-1.05 (0.40) c
a_{11}	*D-Capital equipment*	0.12 (0.16)	-	-0.50 (0.20) b	-0.54 (0.19) c
a_{12}	*D-Machinery*	0.20 (0.16)	-	-0.26 (0.19)	-0.33 (0.19) a
a_{13}	*D-Hiring & dismissal*	0.05 (0.17)	-	0.29 (0.18)	0.27 (0.17)
a_{14}	*D-Career path*	0.21 (0.17)	-	0.45 (0.18) c	0.39 (0.17) b
a_{15}	*D-Incentive schemes*	-0.08 (0.17)	-	0.01 (0.18)	0.03 (0.18)
	Log-likelihood	-2468.60	-2472.59		
	LR joint test	195.72 (30) c	187.74 (21) c		
	N. of observations	2628	2628	2628	2628

χ^2 tests (unrestricted model):	Del real authority	Del. formal authority	Joint model
$a_2 + a_4 = 0$	0.00 (1)	6.94 (1) c	-
$a_8 = a_9 = a_{10} = 0$	17.45 (3) c	15.57 (3) c	27.44 (6) c
$a_{11} = a_{12} = a_{13} = a_{14} = a_{15} = 0$	4.69 (5)	34.25 (5) c	42.01 (10) c

Legend

a) significance level greater than 90%;
b) significance level greater than 95%;
c) significance level greater than 99%.

Standard errors and degrees of freedom in parentheses.

Tab. 4 – Simulations

Variables	Del. of real authority	Del. of formal authority	Integration	Total
Benchmark plant	21.7%	13.6%	64.7%	100.0%
Level = low (=2)	18.6%	12.2%	69.2%	100.0%
Level = high (=5)	28.7%	21.6%	49.7%	100.0%
Size = small (21 employees)	20.7%	18.2%	61.1%	100.0%
Size = large (450 employees)	22.4%	9.6%	68.0%	100.0%
Network = 0, Size = small	14.4%	16.4%	69.2%	100.0%
Network = 0, Size = average	21.9%	15.0%	63.1%	100.0%
Network = 0, Size = large	33.2%	12.8%	54.0%	100.0%
Large investment =0	20.2%	21.4%	58.4%	100.0%
Monetary incentives =1	31.3%	13.2%	55.5%	100.0%
Urgency =1	21.0%	18.4%	60.6%	100.0%
Small group =1	26.7%	14.9%	58.4%	100.0%
Small group =1, M-form =1	12.8%	7.2%	80.0%	100.0%
Large group =1	36.5%	32.7%	30.8%	100.0%
Large group =1, M-form =1	23.2%	20.9%	55.9%	100.0%
D-Capital equipment =1	23.3%	9.4%	67.3%	100.0%
D-Machinery =1	22.8%	11.3%	65.9%	100.0%
D-Hiring & dismissal =1	20.9%	18.8%	60.3%	100.0%
D-Career path =1	20.4%	20.7%	58.9%	100.0%
D-Incentive schemes =1	21.8%	15.4%	62.8%	100.0%

Legend
Benchmark plant is defined as follows: (Large and Small) group = 0, Level =3, Size = 4.48 (195 employees), Network = 1, Large investment = 1, Monetary incentives = 0, Urgency = 0.
Small and *Large plant* are defined as the first and ninth deciles of the plant size distribution.
Low and *high level* are defined as the first and ninth deciles of the distribution of the number of hierarchic levels.

Note also the positive and significant (at the 99% and 95% levels for DR and DF, respectively) coefficients of *NETWORK*. Such result would seem to suggest that contrary to theoretical predictions, the adoption of sophisticated communication technologies might favor delegation of authority (real and/or formal) to the plant manager. Nonetheless, since the effects of the number of plant employees and the use of efficient intra-firm communication technology are tightly entwined, a more careful insight is possible only through the simulation analysis. Indeed, the findings of the simulations (see again Table 4) document the two opposite effects of the adoption of network technologies depending on plant size. In large plants[10] characterized by high intra-firm communication efficiency, decision-making is integrated at the superior level as is suggested by A&T, with the estimated likelihood of integration being as high as 68%. Conversely, when large plants do not adopt advanced intra-firm communication technologies such probability declines to 54%. The opposite pattern applies to smaller plants. Indeed, when the number of plant employees is low, integration at the superior level is more likely for plants that have not introduced sophisticated network technologies (69.2% versus 61.1%). In sum, delegation of decisions to the plant manager is positively (negatively) correlated to the number of employees for plants with low (high) intra-firm communication efficiency, with the allocation of decision-making of plants of average size being very similar for the two categories.

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[10] As was said earlier, "small" and "large" plants are defined by the first and ninth deciles of the size distribution of sample plants. In particular, a "small" plant has 21 employees, whilst a "large" plant has 450 employees.

In accordance with theoretical considerations, the introduction of monetary incentive schemes makes decentralization of real (but not formal) authority more likely, with the coefficient of *MONETARY INCENTIVES* being positive and significant at the 99% level for the delegation of real authority and insignificant for the delegation of formal authority. Accordingly, the likelihood of DR increases quite substantially when *MONETARY INCENTIVES* is set at 1 (from 21.7% up to 31.3%). As to the effect of *URGENCY*, its coefficient is positive and significant at 95% in the DF estimates but is insignificant in the DR estimates. In other words, plants that have adopted JIT are more likely to decentralize not only real but also formal authority to the plant manager; so, we may say that the plant manager is more likely to hold formal and real authority the more urgent the decision. *LARGE INVESTMENT* displays an opposite effect, with its coefficient being significantly (at 99%) negative for delegation of formal authority. Plants that do not invest in large-scale capital equipment are less likely to suffer from budget constraints or indivisibility problems, so that formal responsibility for strategic decisions is more likely to be decentralized at the plant manager level. Note from Table 4 the quite large increase of the probability of DF (from 13.6% to 21.4%) when *LARGE INVESTMENT* equals 0, with everything else being equal.

Turning to the effects of the characteristics of the parent firm of sample plants a preliminary remark is in order. If I introduce a variable which controls only for plant's belonging to a multi-unit organization (i.e., either a multi-plant independent firm or a business group), than the ownership status fails to register any impact on the likelihood of adopting different decision-making structures. The coefficient of this variable is indeed positive but insignificant.[11] Such finding would seem to suggest that infra-group mechanisms play no role in the allocation of plant's decision-making activities. Since I believe that two opposite forces are at work, one relating to the size of the parent firm and the other to its organizational form, I have addressed this issue in greater detail by distinguishing plants owned by a multi-unit company depending on both the size and the characteristics of the organization of the parent firm.

In particular, I control for the effect of the group's size by introducing the two dummy variables *SMALL GROUP* and *LARGE GROUP*, and the organizational form of the parent firm by introducing the dummy *M-FORM.*[12] In order to evaluate the joint significance of these variables I have computed LR χ^2 tests, which show that the size and the organizational form of the parent firm significantly (at 99%) affect delegation of both real and formal authority. Results for *SMALL GROUP* and *LARGE GROUP* confirm that the larger the group size, the

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[11] For the sake of synthesis, the estimates of such model are reported in the Appendix of the chapter (see Table A.2).

[12] Since *LARGE GROUP* and *M-FORM* are clearly (positively) correlated I have computed a LR χ^2 test in order to test for joint significance. The test is equal to 26.16 (99% critical value for χ^2_4 = 9.49), which shows that I cannot drop out the two variables.

higher the probability of delegating decision-making at the plant level. Conversely, when the parent firm adopts a multidivisional form decision-making is highly integrated at the corporate divisional level.

Simulations are again very illustrative. On the one hand, the size of the business group to which the plant belongs positively affects the likelihood of delegation of real and formal authority. Whilst the probability of complete centralization at the superior corporate level is 64.7% for an average independent plant (i.e., the benchmark case), it decreases to 58.4% for a plant owned by a small or medium-sized group and to 30.8% for one that belongs to a large corporation, with everything else being equal. On the other hand, with parent firm's size being kept constant, when the parent firm adopts a multidivisional form of organization instead of being functionally organized, the likelihood of delegation to the plant manager is sharply reduced. The results of the simulations highlight that the probability of integration is as high as 80% and 55.9% for plants owned by small-medium and large multidivisional corporations, respectively. Actually, multidivisional firms introduce an intermediate hierarchic level between the plant manager and the top management. From the point of view of high corporate officers, this process leads to decentralization of decision-making activities to division managers. Conversely, from the point of view of the plant manager, this type of organization decreases his authority in favor of his corporate superior.

Lastly, let us focus attention on the evidence about the effects of the dummy variables related to the different types of strategic decision. Note that the baseline is represented by the decision concerning the introduction of technological innovations (i.e., *D-TECHNOLOGY*=1). First, such variables overall display a significant impact on plants' decision-making structure. Indeed, we can reject the null hypothesis of joint equality to zero of their coefficients at the 99% level by a LR χ^2 test. However, second, whilst they significantly influence delegation of formal authority, the same does not hold true for delegation of only real power (see the values of the χ^2 tests at the bottom of Table 3). Third, there is a neat difference in the allocation of decisions concerning plant's capital equipment with respect to those concerning plant's workforce. Dummy variables relating to the former decisions display a negative impact on the likelihood of decentralization of formal authority, whilst those relating to the latter increase the probability of delegation. As to decisions concerning investment in capital equipment, the larger the amount of the investment (*D-CAPITAL EQUIPMENT* versus *D-MACHINERY*) the less likely the decentralization of decision-making to the plant manager. In particular, simulations show that for the benchmark plant, the probability of delegation of formal authority is 9.4% and 11.3% for decisions concerning the purchase of large capital equipment and individual machinery respectively, against 13.7% for the introduction of new technologies. As to decisions on plant's workforce, delegation from the corporate superior to the plant manager is more likely whenever decisions do not affect other units and have a direct impact on the plant manager's activity so as for decisions relating to the career of plant employees. The likelihood of DF in this latter case is estimated at 20.7% against 18.8% and 15.4% for decisions as to hiring and dismissal of plant's personnel and the introduction of general incentive schemes, respectively. Overall, these results provide support to the view expressed by A&T 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 exploitation of plant manager's specific knowledge about the characteristics of plant's workforce may have played a key role in shaping the plant's decision structure.

4.6 Conclusions

This chapter is a first step toward an empirically robust test of theoretical predictions on the allocation of decision-making. Aghion and Tirole (1997) have identified factors that influence the allocation of formal and real authority between a principal and an agent. I have tested these and other predictions of economic theory for a sample composed of 438 Italian manufacturing plants in the case of the relation between the plant manager (the agent) and his corporate superior (the principal). The results are quite interesting.

First, the complexity of a plant's organization strongly influences the allocation of decision-making activities. A higher number of managerial levels increases organizational complexity, hence, it also reduces the superior's information over the internal working of the plant. This process raises the stimulus toward delegation of both formal and real authority to the plant manager, who has greater knowledge of plant's activity. A similar reasoning, though confined to real authority, applies to the effect of an increase of the number of plant's employees if intra-firm communication efficiency is low. Conversely, plants that have adopted advanced intra-firm communication technology do not seem to suffer from loss of control due to an increase of size. Note also that use of such technologies seems to favor centralization of decision-making in large plants, in accordance with the predictions of A&T, whilst it stimulates delegation in smaller units. Such findings raise interesting questions on the role of technology in shaping firms' decision structure which wait for further theoretical developments.

Second, when decision is urgent the superior finds convenient to reallocate the right to decide downward the corporate ladder. Third, I find confirmation that the introduction of monetary incentives increases the likelihood of delegating real (but not formal) authority. Fourth, in accordance with the predictions of economic theory, authority over different types of plant's strategic decisions turns out to be allocated depending on a) the relative importance of them to the plant manager and to his corporate superior, b) the extent of intra-firm externalities, and c) the desire to take advantage of plant manager's local knowledge and specific capabilities. In particular, decisions concerning capital equipment are 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 machinery. Among the latter, decisions on career paths of plant's personnel are those that are most frequently delegated to the plant manager.

Lastly, for plants owned by a multi-plant firm, the size and the organizational form of the parent firm significantly affect the allocation of real and formal authority over decisions relating to plant's operations. Everything else being equal, the larger the parent company, the more frequently the superior is pressed to decentralize decision-making power, probably due to higher span of control and the associated greater overload cost. Conversely, when the parent firm adopts a multidivisional form, an intermediate level between the top management and the plant level is introduced. In this case, the span of control of the principal is reduced, with everything else being equal, so as the distance between plant manager's corporate superior and plant's operations. Thus, the adoption of a multidivisional form by the parent firm leads to a significant reduction of the plant manager's (real and formal) authority.

Appendix

Tab. A.1 – Results of the McFadden. Train and Tye Test (IIA Test): Test for the unrestricted model of Table 3

	Obs.	Full model	Restricted model	χ^2 tests
Integration and delegation of real authority	2147	-1262.62	-1262.50	0.25 (16)
Delegation of real authority and delegation of formal authority	1130	-730.16	-729.66	1.01 (16)
Integration and delegation of formal authority	1979	-1050.23	-1050.03	0.40 (16)

Legend

Degrees of freedom in parentheses.

Tab. A.2 – Results of the multinomial logit models with only the multi-plant ownership variable

		Delegation of real authority		Delegation of formal authority	
	Variables	Unrestricted	Restricted	Unrestricted	Restricted
a_0	*Constant*	-3.63 (0.39) c	-3.49 (0.36) c	-2.29 (0.43) c	-1.90 (0.29) c
a_1	*Level*	0.25 (0.07) c	0.26 (0.06) c	0.29 (0.07) c	0.31 (0.07) c
a_2	*Size*	0.41 (0.09) c	0.38 (0.08) c	0.11 (0.10)	-
a_3	*Network*	1.77 (0.46) c	1.56 (0.43) c	1.22 (0.51) b	0.73 (0.34) b
a_4	*Network * Size*	-0.41 (0.10) c	-0.36 (0.10) c	-0.32 (0.12) c	-0.19 (0.07) c
a_5	*Large investment*	-0.13 (0.11)	-	-0.50 (0.12) c	-0.44 (0.11) c
a_6	*Monetary incentives*	0.49 (0.10) c	0.47 (0.09) c	0.08 (0.12)	-
a_7	*Urgency*	0.05 (0.10)	-	0.22 (0.11) a	0.23 (0.11) b
$\mathbf{a_8}$	***Multi-plant***	**0.12 (0.14)**	-	**0.12 (0.18)**	-
a_9	*D-Capital equipment*	0.12 (0.16)	-	-0.50 (0.20) b	-0.53 (0.19) c
a_{10}	*D-Machinery*	0.20 (0.16)	-	-0.27 (0.19)	-0.33 (0.19) a
a_{11}	*D-Hiring & dismissal*	0.05 (0.17)	-	0.29 (0.18)	0.27 (0.17)
a_{12}	*D-Career path*	0.21 (0.17)	-	0.451 (0.17) c	0.39 (0.17) b
a_{13}	*D-Incentive schemes*	-0.08 (0.17)	-	0.01 (0.18)	0.03 (0.17)
	Log-likelihood	-2481.80	-2486.43		
	LR joint test	169.33 (26) c	160.07 (15) c		
	N. of observations	2628	2628	2628	2628

Tests	Del. of real authority	Del. of formal authority	Joint model
$a_2 + a_4 = 0$	0.00 (1)	5.87 (1) b	-
$a_9 = a_{10} = a_{11} = a_{12} = a_{13} = 0$	4.67 (5)	34.15 (5) c	41.87 (10) c

Legend
a) Significance level greater than 90%.
b) Significance level greater than 95%.
c) Significance level greater than 99%.
Standard errors and degrees of freedom in parentheses.

Chapter 5

A Note on the Measures of the Organization

5.1 Introduction

The theoretical literature on the organization of firms is extensive and articulated, ranging from the allocation of decision-making to the information structure. On the contrary, empirical evidence is limited and confined to particular issues such as the incentive schemes of (top) managers, the firm's ownership status and the financial structure. In the last few years, however, economists have started collecting firm (plant)-level data, capturing some missing features of the organization (see for instance Bresnahan *et. al* 1999, and Ichniowski *et. al* 1997). Nevertheless, empirical studies still do not look at some key aspects of organizations. For instance, there is a lack of large-scale quantitative evidence on the allocation of decision-making (chapters 2 and 4), on the size of the management hierarchy (chapters 2 and 3) and on the span of control (chapter 2). Empirical work on the organization concentrates on the adoption of innovations such as human resource managerial procedures (e.g., quality circles, job rotation, incentive schemes) and other management routines (e.g., just-in-time, total quality management). These are of course very important features of the internal working of the firm, which might significantly affect firm's productivity, even though these innovations often relate only indirectly to the aspects over which economic theory has been puzzled in the last 20 years.

Since above mentioned features of business organizations are quite difficult to observe economists have started to use managerial innovations as proxies of these characteristics. Chapter 2 tackles the issue of exploring empirical methods to investigate directly the latter. This short note aims instead at analyzing the relations between managerial innovations and variables that measure the organizational structure, showing that economists might be wrong in linking the two.

5.2 Measures of Organizational Structure

In this paragraph I shall look very briefly at some empirical measures of the organizational structure developed in chapter 2. For reader's convenience, I re-define some of the measures described in that chapter which I analyze in this note. For further details see of course chapter 2.

As to the allocation of decision-making, I have information on the corporate level that takes each of the following six plant's strategic decisions: (i) purchase of stand-alone machinery, (ii) purchase of large-scale capital equipment, (iii) introduction of new technologies, (iv) hiring and dismissal, (v) definition of individual and collective incentive schemes, and (vi) plant's employees career paths. Similarly, I know what level of a hierarchy is assigned responsibility for the following five operating activities: (a) daily production plan, (b) weekly production plan, (c) definition of blue collars' tasks, (d) control of blue collars' operations, and (e) change of production plan after sudden external shocks. In particular, for operating (strategic) decision-making I allow for three (five) corporate levels ranging from blue collars, maximum degree of decentralization, to the plant manager (the plant manager corporate superior for strategic decisions), maximum degree of centralization (see figures 1a and 1b in chapter 2). Table 1 illustrates descriptive statistics.

I have thus defined for each plant *j* (*j* =1,..,438) a measure of the degree of centralization of decision-making (DC), in the following way:

$$DC(j) = \sum_{i=1}^{5} a_{1i} x_i(j),$$

where a_{1i} ($i=1,..,5$) are the five coordinates of the first component of the principal component analysis and $x_i(j)$ ($i=1,..,5$) are the values of the decision variables for plant *j* once linearly ranked; recall that such variables range from 1 (1), maximum decentralization, to 3 (5), maximum centralization, for operating (strategic) decisions. Thus DC will be large if plant decision-making is highly centralized.

Second, I use the Euclidean distance as a measure of concentration of decision-making power. For each plant *j* (*j* =1,..,438),

$$CONC(j) = (y_{1j}^2 + y_{2j}^2 + y_{3j}^2)^{1/2}$$

where y_{ij} is the number of type of operating decisions, out of 5 (6 for strategic decisions), taken by level *i*. Clearly, *CONC* reaches its maximum when all decision-making is concentrated at one level. I have then recalculate *CONC* in the following way

$$STD\_CONC(j) = \frac{CONC(j) - \min(CONC)}{\max(CONC) - \min(CONC)},$$

so that $0 \leq STD\_CONC \leq 1$, and higher values represent higher concentrations of decision-making. If $STD\_CONC = 1$, then all decisions are concentrated at one hierarchic level.

Tab. 1 – Decision-making structure

	Range	Mean	Std. dev.
Strategic decisions (1=blue collars, 5=plant manager's corporate superior)			
Introduction of new technologies	1-5	3.57	1.04
Purchase of large scale capital equipment	1-5	3.67	.94
Purchase of stand-alone machinery	1-5	3.60	.98
Hiring and dismissal	1-5	3.53	1.12
Career paths	1-5	3.42	1.09
Definition of general incentive schemes	1-5	3.65	1.09
Operating decisions (1=blue collars, 3=plant manager)			
Weekly production plan	1-3	2.61	.50
Daily production plan	1-3	2.16	.49
Monitoring of blue collars' operations	1-3	2.21	.61
Definition of blue collars' tasks	1-3	2.03	.39
Change of production plan	1-3	2.41	.55

Finally, *LEVEL* is the number of hierarchic tiers that compound a plant's organizational structure.

5.3 Relation between Measures of Plant's Organization

Table 2 shows definitions and descriptive statistics for variables measuring the organizational structure and for human resource practices. It is worth noticing that the variable STD_CONC has been re-defined as ST_C.ST and ST_C.OP for strategic and operating decisions, respectively.

I test two different but related hypotheses on the introduction of human resource practices:

Hypothesis 1: human resource practices covary in cross-sectional data (Holmstrom and Milgrom 1994).

Hypothesis 2: such instruments are correlated to a new organizational form characterized by decentralization of decision-making, diffusion of power among hierarchical layers, and reduced bureaucratization.

In order to assess correlation, I have proceeded to calculate Spearman rank correlations between aforementioned variables controlling for industry sector (through nine two-digit dummies), plant's size (in terms of the number of plant's employees), ownership status (single versus multi-plant ownership), and production structure (layout of production: job shop versus line). Table 3 reports results.

Tab. 2 – Organization variables

	Type	Variable	Mean	Std. dev.
Variables measuring the organizational structure				
Degree of concentration of strategic dec.	continuous	ST_C.ST	0.894	0.154
Degree of concentration of operating dec.	continuous	ST_C.OP	0.513	0.297
Degree of centralization of strategic dec.	continuous	DC.ST	-0.115	2.008
Degree of centralization of operating dec.	continuous	DC.OP	-0.128	1.500
Number of hierarchic levels	ordered	LEVEL	3.473	0.838
Human resource management practices variables				
Job rotation	dummy	JOB	0.605	0.489
Quality circles	dummy	CIRC	0.372	0.483
Individual pay incentive plans	dummy	INC	0.326	0.469
Management innovations variables				
Just-in-time	dummy	JIT	0.463	0.499
Total quality management	dummy	TQM	0.546	0.498
Firm-specific controlling variables				
Number of employees	discrete	EMPL	195.34	373.73
Ownership status (multi-plant=1)	dummy	MULTI	0.228	0.420
Layout of production (line=1)	dummy	PROD	0.518	0.500

As both theoretical and empirical work suggests, human resource practices covary in cross-sectional data. The significant and positive correlations among the various human resource management variables point to the presence of a cluster of complementary innovations. This may be the result of the adoption by profit-maximizing firms of a coherent business strategy that exploits complementarities. Alternatively, there might be the same underlying cause that drives all of them. One explanation is the presence of fads (Bikchandani *et. al* 1992): "Think of all the manufacturing firms in the United States that have attempted to imitate Japanese manufacturing techniques over the past decade without a very clear understanding of why or how those techniques work" Kreps (1990).

Tab. 3 - Correlations between measures of plant's organization and new management practices

Measure	ST_C.ST	ST_C.OP	DC.ST	DC.OP	LEVEL	JOB	CIRC	INC	JIT	TQM
ST_C.ST	1	.021	-.22 c	.08	-.00	.03	-.06	.07	.05	-.05
ST.C.OP	-	1	.06	-.03	-.15 c	.16 c	-.06	-.05	-.18 c	-.05
DC.ST	-	-	1	.18 c	-.17 c	-.04	.04	-.07	-.10 b	.01
DC.OP	-	-	-	1	-.17 c	-.02	.02	-.05	.00	-.06
LEVEL	-	-	-	-	1	.07	.13 c	-.00	.07	.11 b
JOB	-	-	-	-	-	1	.07	.19 c	.27 c	.14 c
CIRC	-	-	-	-	-	-	1	.13 c	.18 c	.34 c
INC	-	-	-	-	-	-	-	1	.18 c	.06
JIT	-	-	-	-	-	-	-	-	1	.28 c
TQM	-	-	-	-	-	-	-	-	-	1

Spearman partial rank order correlations controlling for industry (nine 2-digit industry dummies), employment (EMPL), ownership status (MULTI) and production structure (PROD). Number of observations = 438.
Legend:
a) Significance level greater than 90%.
b) Significance level greater than 95%.
c) Significance level greater than 99%.

Turning to the focus of the chapter, *i.e.*, testing hypothesis 2, results of Table 3 strongly point to the absence of any relation between measures of the plant's organizational structure and human resource management practices. Only just-in-time is correlated with a more diffused and decentralized form of organization. Contrary to common arguments, total quality management and quality circles are instead correlated with more bureaucratic structures. The other results do not show any significant correlation at all.

Finally, I define a variable that measures how "lean" is the organization of sample plants:

$$LEAN(j) = -S[S(DC.ST) + S(DC.OP) + S(ST\_C.ST) + S(ST\_C.OP) + S(LEVEL)]$$

where S(x) means standardization of x.

By following existing literature, a lean type of organization is defined as characterized by: decentralization of (some) decision-making activities, diffusion of centers of power (in order to exploit local knowledge) and sharp reduction of bureaucratization (very low number of corporate levels). Thus, I would expect *LEAN* to be highly correlated with the adoption of new management practices.

Table 4 shows that this is not the case. Again, only just-in-time is (weakly) correlated with the lean type of organization. There is no evidence, at least for Italian plants, of any relation between the adoption of flat and decentralized organizations and the introduction of new managerial practices. In sum, such findings suggest that economists should be more careful in using the latter as proxies of the former.

Tab. 4 – Correlations between LEAN and management practices

Measure	JOB	CIRC	INC	JIT	TQM
LEAN	.068	-.037	.050	.085 a	.022

Spearman partial rank order correlations controlling for industry (nine 2-digit industry dummies), employment (EMPL), ownership status (MULTI) and production structure (PROD). Number of observations = 438.
Legend:
a) Significance level greater than 90%.

Part IV

Dynamic Models

Chapter 6

The Determinants of Structural Inertia: Technological and Organizational Factors

6.1 Some Preliminary Remarks on Structural Inertia

There are wide anecdotal evidence and a few large-scale empirical studies supporting the view that business firms quite rarely change their organizational structure, a phenomenon usually referred to in the literature as "structural inertia".

Both the economic press and studies in business history suggest that powerful conservative forces are at work preventing firms from implementing organizational changes, even if such changes would overtly improve performances. There are well known examples of companies in which internal reorganization lasted for many years, being obstructed by high corporate officers; in the end a drastic change of top management was needed for the restructuring to take place (see for instance the cases of Du Pont in Chandler *et al.* 1996, of General Motors in Chandler 1962, of Mitsubishi in Moriwaka 1970, and of Siemens in Kocha 1971 reported in chapter 1). In other instances, organizational changes were only implemented when a crisis threatened the very survival of the firm (see for instance Baker and Wruck 1989 and Wruck 1994, mentioned in Schaefer 1998). In addition, econometric works on the diffusion of the M-form highlight that large enterprises have been extremely slow in adopting such organizational innovation when compared to the adoption of technological innovations, thus suggesting the existence of structural inertia (see for instance Teece 1980).

Why are firms so reticent to modify their organizational structure? In other words, what are the determinants of structural inertia?

Various explanations of such phenomenon have been offered by the economic literature.

Behavioralist theorists of organizations (see March and Simon 1958, Cyert and March 1963) point to the bounded rationality of economic agents and the costs involved by decision-making activity under uncertainty to have access to, store, process, and transmit information. As there is no guarantee that a decision to modify the organization be optimal, firms prefer to stay with their structure unless abnormally poor performances trigger change.

The literature on population ecology contends that structural inertia is the outcome of an ecological-evolutionary process, as selection processes tend to favor stable organizations, that is organizations whose structure is difficult to change (see Hannan and Freeman 1984). Namely, in comparison with other institutions, business firms enjoy the advantage of a high level of reliability and accountability (*i.e.*, the capacity to collectively produce a product of given quality repeatedly and to document the sequence of decisions and related outcome, see Hannan and Freeman 1984, p. 153). But in order to assure reliability and accountability, a firm's organizational structure needs to be reproducible over time. This is obtained by processes of institutionalization and by the creation of standardized routines, two factors which make firms highly resistant to change.

Evolutionary theories of technical change (see Nelson and Winter 1982) help understand why organizational routines are a source of structural inertia. According to such stream of literature, routines are the repertoire of idiosyncratic collective actions that inform a firm's behavior; they are built through a cumulative process based on the experience of firm's problem solving activity and involve automatic coordinated responses to specified signals from the environment.[1] So, due their very nature, they can only be modified incrementally and at considerable costs, with this leading to lock-in effects which extend to firm's entire organization.

Two further bodies of theoretical literature are relevant for understanding the sources of structural inertia. The literature concerned with the investment behavior of firms under uncertainty in the framework of real option theory (Dixit and Pindyck 1994) has argued that when an investment decision entails sunk costs and future market conditions are uncertain, there is an additional opportunity cost of implementing the decision which stems from the lost option value of delaying it until new information is available. Any change of a firm's organization implies sunk costs, caused by the re-definition of authority relations, task assignment, information flows, and administrative procedures, and its returns are uncertain by

[1] Routines are the memory of the organization, being responsible for the preservation of distinctive capabilities in spite of the fact that individual employees come and go (Winter 1988). See also the analysis by Nelson and Winter (1982). For a critical review of the concept of routines and its relation to firms' distinctive capabilities, see Cohen *et al.* (1996).

nature. So, it might be optimal for a firm to wait and postpone any change of the organizational structure until new information is collected.

Lastly, there are political forces within organizations that hinder organizational change (see Milgrom 1988 and Milgrom and Roberts 1990a). The reason is that adoption by a firm of a particular organizational design leads to a particular distribution of quasi-rents among firms' employees. Therefore, if a firm is going to change its organizational structure, a change which is likely to have considerable distributional implications, individual employees will try to influence the nature of the change so as to protect or augment their own quasi-rents. As such influence activities absorb employees' time and attention, which otherwise could be used in directly productive activities, they engender substantial costs. Their extent will depend among other things on the nature of decision-making power within the organization: the more discretionary decision-making, the higher influence costs, with everything else being equal. In order to avoid them, a firm may refrain from implementing organizational changes that would improve productive efficiency, unless failure to do so threatens survival (Schaefer 1998).

The aim of the present chapter is to analyze empirically the determinants of structural inertia. As far as I know, this work constitutes the first attempt to directly address such issue through econometric estimates based on a large, longitudinal data set at plant level. For this purpose, I specify and test a survival data analysis model of the likelihood of an individual plant changing the number of hierarchical tiers at time *t*, provided that no change has occurred up to *t*. I consider a set of plant- and industry-specific explanatory variables which are expected to induce or oppose organizational change.

I am especially interested in three aspects. First, I adhere to the view that technological and managerial innovations are the main driver of organizational change. It has been argued by previous studies that have analyzed in the early 1990s the emergence of a new manufacturing paradigm (see for instance Milgrom and Roberts 1990, Holmström and Milgrom 1994) that adoption of advanced technologies, use of new human resource management practices and organizational change are characterized by strong complementarities and non-convexities. Therefore, if they even occur, they do so contextually.[2] In accordance with such argument, I devote particular attention to the impact upon organizational change of the adoption of process innovations and new management practices that are germane to the "flexible firm" paradigm. Second, I consider the role of sunk costs associated with the organization of plants' production process. In plants that adopt a Tayloristic organization of production, based

[2] Colombo and Mosconi (1995) analyze the diffusion of advanced manufacturing and design technologies among Italian metalworking plants. They provide evidence that consistently with the above argument, the adoption of anyone of the two technologies positively influences subsequent adoption of the other; in addition,

on rigid division of labor among plant employees and the specialization of tasks, there are quite substantial sunk costs, so, I expect inertial forces to be strong. Lastly, I focus on variables which are likely to mirror the extent of influence activities by plants' employees. The incentives to indulge in such activities depend on the marginal benefits and costs to individual employees. Incentives will be large if i) the decision to change the organizational structure is likely to have considerable distributional implications and to negatively affect an employee's rent (for instance, because it implies the elimination of some managerial positions), ii) there is room for influencing the decision (for instance, because the decision-maker has discretionary power) and iii) the attempt to influence the decision is not very costly to the employee (for instance, due to his closeness to the decision-maker). In line with such reasoning, I expect the allocation of responsibility for decisions relating to a plant's organizational chart to figure prominently in explaining structural inertia.

The remainder of the chapter is structured as follows. Section 6.2 is devoted to the specification of the empirical model. The explanatory variables are introduced in Section 6.3. Section 6.4 provides results of the estimates of the econometric model. Finally, in Section 6.5 I

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adoption of both technologies is positively associated with use of innovative management techniques such as just-in-time and total quality management.

present some concluding remarks based upon simulations of the estimated model.

6.2 A Survival Model for the Analysis of Structural Inertia

Table 1 shows transition probabilities for the size of plant's organization. In other words, p_{ij} is the probability that a plant characterized by an *i-level* hierarchy in 1975 turned its organization to a *j-layered* structure by 1997. In what follows, I shall focus on the determinants of structural inertia of organizations (*i.e.*, staying on the diagonal). I collapse a choice problem where, at any time, management decides the plant either to stay on the diagonal of a transition probabilities model or to move off-diagonal to any other organizational structure, into a simpler dynamic problem with a binary choice of either to stay on the diagonal or to move off-diagonal.

Tab. 1 – Transition probabilities, p_{ij}, of management hierarchy

N. of levels of the previous organization	N. of levels of the 1997 organization				
	2	3	4	5	6
2	0.57	0.32	0.07	0.04	0.00
3	0.01	0.79	0.17	0.03	0.00
4	0.01	0.36	0.57	0.06	0.00
5	0.00	0.21	0.44	0.28	0.07
6	0.00	0.00	0.26	0.48	0.26

The econometric model is specified in terms of duration τ of not changing the management hierarchy: that is, the time elapsed between two consecutive organizational changes. Since I have detailed information only on the last two organizational structures (in terms of size of the management hierarchy, allocation of decision-making activities, and line or job shop nature of production operations), I focus on the period that starts in the year following the organizational change before the last one and ends in 1997 (the survey date). More specifically, as for the duration origin, which is not the same for each plant, I have proceeded in the following manner. For plants that have not changed their structure during the last 20 years the origin is given by the maximum (say t_0) between the plant's year of foundation and 1975, which is the first date of observation of the empirical survey. Observations of plants that have changed once have been divided into two intervals: the first period of observation goes from t_0 to the date of the first organizational change (t_1), while the time span of the second interval is delimited by t_1+1 and 1997. Lastly, observations of plants that have changed two (or more) times have been divided into two intervals: the first period starts with the year following the organizational change before the last one and ends with the date of the last change (t_2); the time spell of the second interval is delimited by t_2+1 and 1997. In the appendix I illustrate in greater detail these cases.

At τ, the dependent variable of the econometric model equals one if after τ years from the last change a plant switches to another organizational structure, either decreasing or increasing the size of the management hierarchy (*i.e.*, leaving the diagonal). By following the recent literature on technological change (see in particular Colombo and Mosconi 1995, Karshenas and Stoneman 1993, and Stoneman and Kwon 1994) I employ a duration model. The basic tool for modeling duration data is the hazard function, which may be viewed as the "instantaneous probability" of leaving the present state (*i.e.*, turning to a different management hierarchy), indeed:

$$h_i(\tau, x_i, \theta) = \lim_{\Delta \downarrow 0} \frac{P[\tau_i < T \le \tau_i + \Delta | T \ge \tau_i, x_i, \theta]}{\Delta}, \qquad (1)$$

so that the hazard function is the probability density of changing the organizational structure by plant i at τ, conditional on not having changed up to τ. It depends on duration τ and a set of explanatory variables x_i. Finally, $h_i()$ includes the unknown parameter vector θ, which is supposed to be the same for all individuals.

The likelihood function can be written in terms of the hazard function, as follows (Cox and Oakes 1984):

$$L(\theta) = \prod_i \exp\left\{-\int_0^{\tau_i} h_i(u, x_i, \theta) du\right\} \prod_{i \in U} h_i(\tau, x_i, \theta), \qquad (2)$$

where U is the set of all uncensored individuals (*i.e.*, plants that have changed organizational structure before the survey date).

In order to estimate equation (2) I have to choose a functional form for the hazard function. Following previous work, I assume *h()* to be Weibull:[3]

$$h_i[\tau, x_i, \theta \equiv (p, \beta)] = hp(h\tau)^{p-1}, \qquad h = e^{x_{it}\beta} \tag{3}$$

where p is the parameter that rules duration dependence. When $p=1$, there is no duration dependence; when it is greater than one there is positive duration dependence, while a negative duration dependence arises when p is smaller than 1. The effects of covariates x (*i.e.*, explanatory variables) are accounted for by the parameter vector β.

6.3 The Determinants of Structural Inertia

In this paragraph I concentrate on the explanatory variables, which are presented in Table 2. All time varying variables have a subscript t.

I have divided explanatory variables into three sets. The first set refers to variables regarding the characteristics of the organization: allocation of decision-making, hierarchy's size and type of production operations. These variables are intended to capture the effect of

[3] Karshenas and Stoneman (1993) estimate both exponential and Weibull models, and argue that the latter explains in greater detail the diffusion of technological adoptions, because it allows for epidemic effects (*i.e.*, positive time dependence).

influence activities and sunk costs on structural inertia. The second group includes variables concerning technology adoptions of advanced manufacturing technologies (AMTs) and introduction of human resource management practices (HRMPs). These variables measure the impact on organizational evolution of technological change. Finally, the third group concerns other plant-specific variables such as plant size, ownership status, and growth, and industry-specific variables such as industry R&D, market growth rate and concentration.

6.3.1 Variables Regarding the Organizational Structure

If we consider theoretical work, probably the most important determinant of organizational change is the organization itself. In other words, the organization changes according to its current structure. Thus, for instance case studies document that very centralized firms, where the owner holds most of decision-making power, have often suffered from structural inertia. In this section I present variables regarding the characteristics of the organization.

First, I define variables that control for the allocation of decision-making activities within the firm's organization. $PM\ SUP_t$ is a time-varying dummy variable that equals 1 if the plant manager's corporate superior has at time t responsibility for decisions concerning the plant's organization. More specifically, I set *PM SUP* to

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Colombo and Mosconi (1995) employ a Weibull model and find positive time and duration dependence.

1 when authority over at least one of the decisions regarding plant's workforce is assigned to a plant manager's superior (*i.e.*, hiring and dismissal, definition of individual and collective incentive schemes, and decisions on plant's employees career paths). Given that I do not have specific information of the corporate level that takes the decision on organizational change, I assume that the likelihood of such decision being taken by a superior of the plant manager is greater if he is in charge of (some of the) decisions concerning the plant's personnel. Indeed, this decision presents high externalities with all the other strategies; thus it is usually assigned to higher corporate levels.

Further, I distinguish between situations in which the corporate superior of the plant manager is the owner of a single-plant firm and those in which she is a middle manager within a large multi-plant corporation. In single-plant firms the owner operates both inside and outside the plant. Agents have thus great incentive to try to affect directly and/or indirectly decisions of the owner, who possesses power over a very large spectrum of decisions. Thus, in this case influence activities are very high, due to both the proximity between plant's agents and the owner and the large discretionary power of the decision-maker. Moreover, case studies reveal that the owner is often unwilling to change the organization. In (small) single-plant firms changing the structure means both introducing new corporate levels and delegating some power downwards the management hierarchy (see chapter 2). Due to moral hazard problems and psychological explanations, owners are often adverse to this change.

Tab. 2 – The explanatory variables of structural inertia

Variables	*Description*
SIZE	Logarithm of the number of plant's employees in 1989
ΔSIZE	Positive value of plant's growth rate (employment), period 1989-96
GROWTH	Plant's growth rate, for plants with positive growth rate; 0 otherwise
DECLINE	Positive value of plant's growth rate, for plants with negative growth rate; 0 otherwise
GROUP	1 for plants that belong to a multi-plant company; 0 otherwise
AGE_t	Plant's age at time t;
$LINE_t$	1 for plants involved in line production of a limited number of standardized designs; 0 for plants characterized by job-shop kinds of operations;
$LEVEL_t$	Number of hierarchic levels of plant's organization
$EXTERNAL_t$	1 for plants owned by a multi-plant company in which the decision on the plant's organizational structure is taken by corporate officers outside the plant; 0 otherwise
$OWNER_t$	1 for plants owned by a single-plant firm in which the decision on the plant's organizational structure is taken by the firm's owner; 0 otherwise
$AMT1,2,3,4_t$	1 for plants that by year t-1 have adopted 1,2,3,4 AMTs[a] respectively; 0 otherwise
QC_t	1 for plants that by year t-1 have adopted formal team practices (*i.e.*, quality circles); 0 otherwise
INC_t	1 for plants that by year t-1 have adopted individual line incentives; 0 otherwise
ROT_t	1 for plants that by year t-1 have adopted job rotation; 0 otherwise
I-GROWTH	Positive value of industry growth rate (three digit NACE-CLIO classification)
R&D	Proportion of R&D employees to total sector employment (two-digit NACE-CLIO classification)
HERF	Herfindahl concentration index (three-digit NACE-CLIO classification)

Legend
(a) AMTs (advanced manufacturing technologies): machining centers, programmable robots, numerically (or computerized numerically) controlled stand-alone machine tools, and flexible manufacturing systems (FMS).

Conversely, in multinational corporations where decision-making on plant's organization is assigned to a salaried executive who works outside the production unit, influence activities are strongly limited by the distance between the decision-maker and the agents who are affected by her decisions.

In order to take into account these situations, I have defined three time-varying dummy variables: $OWNER_t$, PM_t, and $EXTERNAL_t$.[4] *OWNER* equals one if at time *t* decisions on plant's organization are assigned to the plant manager's corporate superior (*i.e.*, *PM SUP* =1) and the plant is owned by a single-plant firm. In this case it is very likely that there are no intermediate levels between the plant manager and the owner. Thus, *OWNER* captures situations where the firm's owner detains decision-making power on plant's organization, and is set to zero otherwise. *PM* equals one if at time *t* the plant manager is assigned responsibility for the decision on the change of the plant's management hierarchy independently on the single or multi-plant ownership status (*PM SUP* =0). *EXTERNAL* equals one when *PM SUP* is one (*i.e.*, authority is centralized at the plant manager's corporate superior level) and the plant is owned by a multi-plant corporation. In this latter case the plant manager's corporate superior is a high corporate officer who works outside the plant. On the basis of the aforementioned theoretical considerations

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[4] Note that these variables are mutually exclusive and exhaustive, thus one has to be chosen as the baseline of the estimates. In particular, I choose *PM*, which thus does not appear in the estimates of the econometric model.

on influence activities, I expect the following order as to the impact of the allocation of decision-making power upon organizational change: *OWNER*<*PM*<0<*EXTERNAL*.

I define the variable $LEVEL_t$ as the number of the plant's corporate levels at time *t*. This variable provides information on the complexity of the structure of agents' relations. On the one hand, managerial literature suggests that during the 1980s and 1990s plants characterized by very bureaucratic structures have changed their organizations turning to "leaner forms" (see Baharami 1992, Drucker 1988, Krafcik 1988). On the other, organizational ecology theory (Hannan and Freeman 1977 and 1984) predicts just an opposite relation: complexity of organizations causes structural inertia. As a consequence, the likelihood of inertia may increase or decrease, depending on which effect prevails.

Finally, I also consider the characteristics of the production process to considerably affect the likelihood of changing the organization. Their impact is examined through the time-varying dummy variable denoted $LINE_t$. *LINE* indicates that at time *t* plants are involved in line production, whilst equals 0 with plants characterized by job-shop kinds of operations. We should consider that line production is associated to specialization of blue collars in specific tasks, whilst job shop operations are linked to a more flexible multitask organization. Thus, plants involved in line production are less likely to change their organization, due to the higher sunk costs associated with a change of the management hierarchy (e.g., re-definition of tasks and procedural routines).

6.3.2 Technology Adoptions and HRMPs

I divide explanatory variables on adoption of innovations into two sets. The first concerns technology adoptions, whereas the second set includes managerial innovations.

I consider advanced production technologies which are at the core of the analysis of recent empirical literature on technological change (see Dunne 1994). In particular I focus attention on AMTs which are defined as one of the following category of technology: flexible manufacturing systems (FMS), machining centers, CN/CNC stand alone machine tools, and programmable robots. Generally speaking, both theoretical (see Milgrom and Roberts 1990) and empirical (see Bresnahan *et al.* 1999) literature suggests advanced technologies to be positively related to organizational change. In addition, I expect the existence of a "cluster effect": AMTs may affect the organizational change when introduced together, rather than in isolation. Thus, I define four time-varying dummy variables: $AMT1_t$, $AMT2_t$, $AMT3_t$, and $AMT4_t$ equal 1 for plants which by year *t-1* have adopted 1,2,3 and 4 AMTs, respectively. It is worth mentioning that Doms *et al.* (1997), using a similar technology count for US manufacturing plants, find that the intensity of use of AMTs is positively related with the use of multiple technologies. So, in accordance with previous line of reasoning, I expect plants that have adopted a great number of AMTs to be more innovative hence more inclined towards organizational change.

The second set consists of time dependent dummy variables regarding the introduction of human resource management practices (HRMPs). QC_t, INC_t, and ROT_t equal 0 for plants that by year t have not adopted quality circles, individual incentive schemes and job rotation, respectively. In the year following the adoption they are switched to 1. These work policies are at the core of recent empirical and theoretical research on the organization of firms (see for instance Holmstrom and Milgrom 1994, Kandel and Lazear 1992, and Ichniowski *et al.* 1997 for empirical support). This work suggests that the introduction of managerial innovations is part of a new organizational structure characterized by decentralization of (some) decision-making activities, multitasking (rather than specialization of tasks), and reduced bureaucratization. As Lindbeck and Snower (1996) point out "the organizational structure of firms is becoming flatter: the new structure is built around teams that report to the central management, with few if any intermediaries". In this respect, job rotation, team work (*i.e.*, quality circles), and incentive schemes appear to be complementary to a new "holistic" form of organization. Hence, I predict a positive impact as to the effect of the introduction of HRMPs to the organizational change of plants.

6.3.3 Plant and Industry-specific Variables

Previous empirical work on organizational change have mainly concentrated on firm and industry-specific characteristics, such as firm size, growth and ownership status, product differentiation, and industry concentration and growth.

SIZE is the logarithm of the number of plant's employees at the end of the 1980s (June 1989). On the one hand, Thompson (1983) shows that organizational change (*i.e.*, the passage from a functional form to an M-form in large multi-plant companies) is positively related to firm size. On the other hand, more recent studies (see for instance Palmer *et al.* 1993) find that once we control for (product and geographic) diversification the effect of size vanishes.

DSIZE is the positive value of the plant's growth rate (in terms of employment) between 1989 and 1996. I expect a change in the number of employees to strongly affect the likelihood of changing the organizational structure. In fact, since the size of the organization is a positive function of the number of employees, a change in the latter should end up in a change in the former. In order to control for eventual asymmetric effects two additional variables *GROWTH* and *DECLINE* are defined. They are equal to the (positive) value of the growth rate for plants with positive and negative growth respectively, and are set to 0 otherwise. I would expect the effect of the change in plant size to be quite symmetric. Descriptive evidence of chapter 2 would seem to confirm this impression. Indeed, during the last two decades very complex and large plants have been both downsizing and reducing their number of levels, whilst small and simple plants have increased their number of employees and adopted more complex structures.

GROUP is a dummy variable that is one when the plant is owned by a business group and is set to 0 otherwise. In multi-plant firms, the change of the organizational structure of plants may imply higher sunk costs due to the large extent of externalities associated with this decision. Thus, I would expect the organization of plants that are owned by a business group to be comparatively more stable over time. AGE_t is a time-varying variable that conveys information on plant's age at time *t*. Young firms have less consolidated hierarchic structures (in terms of procedural routines, definition of tasks), hence enjoy gains coming from a more flexible and less bureaucratic organization. In accordance with such line of reasoning, I expect *AGE* to negatively affect the likelihood of changing the organization.

The second set of explanatory variables refers to industry-specific characteristics. *I-GROWTH* is the positive value of the industry growth rate (three-digit NACE-CLIO classification) in the period 1981-1991. To examine the impact of industry concentration on the likelihood of changing plant's organization, I calculated the Herfindahl index at the three digit NACE-CLIO classification in 1991 (*HERF*). Finally, I include the variable *R&D*, which is the ratio of R&D expenses to industry turnover (two-digit NACE-CLIO classification). Overall, I would expect plants in high-tech, fast-growing and more competitive industries to change more frequently their organizations, due to the need of adapting quickly their production structure to an unstable and competitive environment.

6.4 Empirical Evidence

Table 3 presents the results of two Weibull duration models. Before addressing the core issues which this paper is concerned with, *i.e.*, the impact of organizational variables and technology adoptions on structural inertia, let us consider the role of "more classical" firm and industry-specific explanatory variables.

First, *SIZE* fails to register any additional significant impact upon the likelihood of changing the organizational structure once I consider the characteristics of plant's organization (notably, the number of levels of the management hierarchy). In contrast, plant's employment growth (*i.e.*, *DSIZE*) turns out to play a crucial role in positively influencing the likelihood of changing the organizational structure. In chapter 3, I demonstrated that organizational depth is positively related to plant size; therefore the negative impact of *DSIZE* on inertia would seem to mimic the static link: plants that are growing introduce new corporate layers, whereas those that are downsizing decrease the depth of the management hierarchy.

In model II I investigate whether such effects are symmetric by replacing *DSIZE* with two variables: *GROWTH* and *DECLINE*. Results are somewhat surprising: they show the existence of an asymmetric relation between changes of size and structure. Whilst growing plants do change their architecture, declining plants do not. This evidence may point to the role played by influence activities: these activities are indeed very high when the firm is downsizing, when changing the management hierarchy implies shrinking its size and re-allocating tasks. In this process many agents are likely to be (negatively) affected by the organizational change. In contrast, when a firm is growing the amount of resources is growing as well, thus a re-allocation of power will damage only few (if any) agents. The impact of influence costs, however, will be analyzed in greater detail later in this section.

Contrary to prior expectations, *AGE* displays a negative effect on structural inertia, even if it fails to register any significant explanatory power. The ownership status seems to play a role in the evolution of plants' organization, with *GROUP* being negative and significant at 90%. Thus, we have a confirmation that plants that are owned by a multi-plant company are, other things being equal (notably the allocation of decision-making), less likely to change their organization, due to the larger externalities involved in this decision: a change of the organization of this category of plants very often implies a contextual change of the organization of other firm's units.

Tab. 3 – The econometric model of organizational change

	Variables	*I*	*II*
	p	1.2563 (0.1156) c	1.2587 (0.1161) b
a_0	*Constant*	-5.1897 (0.4335) c	-5.1901 (0.4327) c
a_1	*SIZE*	-0.0666 (0.0829)	-0.0577 (0.0827)
a_2	*ΔSIZE*	0.4249 (0.1657) b	-
a_3	*GROWTH*	-	0.4375 (0.1658) c
a_4	*DECLINE*	-	0.2365 (0.3869)
a_5	AGE_t	0.0038 (0.0030)	0.0042 (0.0031)
a_6	*GROUP*	-0.6670 (0.4001) a	-0.6843 (0.4135) a
a_7	$LINE_t$	-0.3526 (0.1451) b	-0.3511 (0.1448) b
a_8	$LEVEL_t$	0.3424 (0.0777) c	0.3382 (0.0787) c
a_9	$OWNER_t$	-0.4544 (0.1974) b	-0.4566 (0.1971) b
a_{10}	$EXTERNAL_t$	0.2625 (0.4039)	0.2915 (0.4037)
a_{11}	$AMT1_t$	0.6178 (0.2084) c	0.6094 (0.2082) c
a_{12}	$AMT2_t$	0.9294 (0.2075) c	0.9204 (0.2079) c
a_{13}	$AMT3_t$	1.1133 (0.2589) c	1.1050 (0.2589) c
a_{14}	$AMT4_t$	1.6964 (0.3065) c	1.6913 (0.3059) c
a_{15}	QC_t	0.5773 (0.1759) c	0.5656 (0.1779) c
a_{16}	INC_t	0.1475 (0.1550)	0.1408 (0.1592)
a_{17}	ROT_t	0.3576 (0.1455) b	0.3546 (0.1454) b
a_{18}	*I-GROWTH*	0.3776 (0.2271) a	0.3767 (0.2269) a
a_{19}	*R&D*	2.3280 (2.0550)	2.3430 (2.0550)
a_{20}	*HERF*	-4.4463 (2.2562) b	-4.5060 (2.2550) b
Log-likelihood		-703.1834	-703.0019
LR χ^2-tests on groups of explanatory variables:			
Organization: $a_7 = a_8 = a_9 = a_{10} = 0$		33.3408 (4) c	32.984 (4) c
- bureaucratization: $a_7 = a_8 = 0$		26.0636 (2) c	25.4504 (2) c
- decision-making: $a_9 = a_{10} = 0$		5.8794 (2) a	6.0274 (2) b
Technology: $a_{11} = a_{12} = a_{13} = a_{14} = 0$		49.1928 (4) c	48.7988 (4) c
HRMPs: $a_{15} = a_{16} = a_{17} = 0$		24.6986 (3) c	23.6454 (3) c
Industry: $a_{18} = a_{19} = a_{20} = 0$		10.1742 (3) b	10.3292 (3) b
Number of plants		438	438
Number of records		8,169	8,169

Legend: Usual t-tests, except for *p*, where $H_0: p=1$.
a) Significance level greater than 90%.
b) Significance level greater than 95%.
c) Significance level greater than 99%.
Standard errors and degrees of freedom in parentheses.

Turning to industry-specific variables, they overall display a significant impact on structural inertia, with the coefficient of *I-GROWTH*, *R&D* and *HERF* being jointly significant at conventional levels (see the LR tests at the bottom of Table 3). In particular, the greater the turbulence of an industry, the more likely the change of plants' organization, with *I-GROWTH* positive and significant at 90%. In addition, the negative significant (at the 95% level) effect of *HERF* illustrates that industry concentration favors structural inertia, whilst the positive though insignificant coefficient of *R&D* would seem to show that a higher scientific base induces more change.

Next, let us focus on variables regarding plant's organization. They overall display a significant impact on structural inertia (see again the LR tests of Table 3). As to the complexity of a plant's organization, this turns out to be positively related to organizational change, with the coefficient of *LEVEL* being positive and significant at the 99% level. This result contrasts with predictions of organizational ecology theory, confirming instead case studies evidence of managerial literature. It is worth noticing that the reduction of hierarchical layers of very complex organizations is not the result of a process of downsizing, which was particularly pronounced in the 1990s.[5] Indeed, as stressed before, the variable *DECLINE* has not been found to play any role in organizational change. Instead, it may be due to a

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[5] For instance, between the end of the 1980s and 1996 the average plant's size had declined from 233 employees to 195.

new method of organizing production in a mutated, more uncertain environment. In this context, operative decisions have to be taken just in time, so that a new flatter form of organization is needed, confirming in some way predictions of computer science models (see in particular van Zandt 1999).

The result of the variable *LINE*, which has a negative and significant (at 95%) coefficient, shows that sunk costs are key in explaining structural inertia. Given that a) plants whose layout of production is in line incur in high sunk costs when changing their organizational structure and b) the decision on organizational change implies uncertain returns, then in accordance with option theory (Dixit and Pyndick 1994) for a plant's management may be rational to postpone any change until new information is collected. This in turn leads to the detected inertial process.

Let us now turn to variables reflecting the allocation of decision-making. Plants owned by a single-plant firm where the owner holds large discretionary power are more likely to be characterized by structural inertia: the coefficient of *OWNER* is negative and significant at the 95% level. Conversely, plants owned by multi-plant corporations in which decision making power on a plant's organization is assigned to a corporate officer outside the production unit, are marginally more likely to change. *EXTERNAL* has a positive though statistically insignificant coefficient. In an intermediate position are those situations in which the plant manager is assigned responsibility on plant's organizational structure (*i.e.*, the baseline of the estimates). Such evidence provides support to the key role played by influence activities in inhibiting organizational change. Agents are very likely to try to influence the decisions of the principal so as to defend their personal power, especially when a) the principal is physically close to them, as is the case of single-plant firms independently of whether decision activity is allocated to the plant manager or to its superior and b) if the principal is entitled with considerable decision power, a condition which distinguishes situations where the owner-manager is in charge from those where responsibility on some plant's strategic decisions is partially delegated to the plant manager. Actually, such result is also consistent with previous evidence on the aversion of owner-manager of very autocratic organizations towards organizational change which often implies a delegation of decision-making authority to salaried managers.

Next, let us focus attention on technology adoptions of AMTs. They overall display a great explanatory power, with the LR test of joint significance showing the key role played by technological innovations on organizational change. The coefficients of the categorical variables *AMT1*, *AMT2*, *AMT3*, and *AMT4* are all positive and statistically significant at 99%. Even more interestingly, these results show that the higher the intensity of use of AMTs, the larger the impact on organizational change. This evidence is further confirmed by the Wald tests of Table 4, which demonstrate that the increasing magnitude on organizational change of the effect of multiple technology adoptions is statistically significant in almost all cases: the larger the number of technologies in use, the higher the probability of changing the management hierarchy. Such result points to the complementarity between the adoption of technologies related to the Flexible Automation paradigm and consequent changes in organization. In this sense, they are consistent with both theory (Milgrom and Roberts 1990) and previous empirical evidence (Colombo and Mosconi 1995).

Tab. 4 - The impact of technological complementarity

Intensity in the use of AMTs	Walt tests on Model II of Table 3
AMT4 > AMT3	4.28 (1) c
AMT4 > AMT2	8.72 (1) c
AMT4 > AMT1	14.70 (1) c
AMT3 > AMT2	0.73 (1)
AMT3 > AMT1	4.42 (1) b
AMT2 > AMT1	2.66 (1)

Legend
b) Significance level greater than 95%.
c) Significance level greater than 99%.
Degrees of freedom in parentheses.

Before turning to the results of managerial innovations, a last remark on technology adoptions is in order. As said, the detected impact of AMTs on structural inertia may point to a causal relationship between complementarity in advanced production technologies and organizational change. Yet this may also reflect unobserved plants heterogeneity: plants that adopt multiple technologies are more likely to change the organization due to differences in plants' employees skills (see Di Nardo and Pischke 1997 for a similar issue but in another empirical context). In particular, the larger the intensity in the use of AMTs, the higher the skill of employees working inside the plant (Bartel and Lichtenberg 1987). Plants with operators with higher skill are in turn more likely to change their organization, due to the lower costs of re-organizing the production process, *i.e.*, tasks, information flows, and administrative procedures.

Lastly, the results on human resource management practices (HRMPs) confirm prediction of aforementioned theoretical work: the management hierarchy changes with the introduction of managerial innovations. The coefficients of *INC, QC* and *ROT* are positive, with the last two being significant at conventional levels. In the 1980s and 1990s, the use of such innovations has forced Italian plants to change their organization. It is worth mentioning however that in chapter 5 I found that, unlike technology adoptions, the use of HRMPs was not associated to any particular form of organization. So, whilst managerial innovations influence the likelihood of changing the organization, they do not influence the direction of this dynamic path.

6.5 Concluding Remarks through Simulations

The coefficients of previous econometric models are not derivatives in the estimations, thus assessing the magnitude of the impact of the different explanatory variables is difficult. For this purpose, I have proceeded to simulate the model. The basic idea is to use the estimated parameters for calculating the distribution function $F(\tau,x,\theta)$. For any plant, F gives the probability to change the organization after τ years from the last organizational change. As a benchmark, I have firstly calculated the value of F when the explanatory variables in the vector x take on values that describe the "representative plant". The probability of the representative plant is then compared to those calculated for different values of x, in order to analyze the estimated effects of the variable(s) which have been modified.

The characteristics of the representative plant are described in Table 5. All non-dummy variables have been set at (or around) the mean, while dummies have set to zero for the whole period with the exception of *LINE*, which equals 1. So, the benchmark case is represented by a plant founded in 1957, with a constant number of employees equal to 233, and characterized by a four-level hierarchy in which decisions on plant's organizational structure are assigned to the plant manager.

Tab. 5 – Description of the 'representative plant'

Variable	Value
Plant's employees	233
DSIZE	0
$LINE_t$	1 for all t
$LEVEL_t$	4 for all t
Year of establishment	1957
$OWNER_t$ *and* $EXTERNAL_t$	0 for all t
$AMT1_t$	0 for all t
$AMT2_t$	0 for all t
$AMT3_t$	0 for all t
$AMT4_t$	0 for all t
QC_t	0 for all t
INC_t	0 for all t
ROT_t	0 for all t
I-GROWTH	0.0614
R&D	0.0198
HERF	0.0177

Tables 6, 7 and 8 illustrate the predicted probability of changing the organization by 1997 when the explanatory variables are changed one at a time, to give an idea of the impact of each variable on structural inertia. Whenever a variable is changed, it is set either to a value representative of the lowest values observed in our sample, or to a value representative of the highest ones. This with the exceptions of *SIZE* and *DSIZE*, for which intermediate (more interesting) values have been chosen. As for the time varying dummies that capture characteristics of the organization, when they are changed they are set to 1 from the period considered (*i.e.*, from 1975). For the time varying dummies of technology and HRMPs adoptions, when they are changed they are set to 1 from 1979 (I call this as the case of a *pioneer*), 1984 (*early adopter*), 1989 (*average adopter*), or 1995 (*late adopter*).

Table 6 presents simulations of the effects on structural inertia of change in organization and other plant-specific variables with respect to the representative plant. In order to evaluate the effect of the allocation of decision-making, I have considered two benchmark cases depending on the plant's ownership status: single or multi-plant ownership. The two benchmarks differ quite remarkably in the likelihood of changing the organization by 1997: for single-plant firms this probability is as high as 18.1%, whilst it drops to 8.1% for plants owned by a business group, confirming that when the decision on the plant's management hierarchy might extend to other firm's units sunk costs are higher. The sunk costs explanation of structural inertia is also supported by the effect of the type of production operations: single-plant firms that are involved in line production operations are far less likely to change their structure than plants characterized by job shop kinds of operations (18.1% versus 26.6%). As to organizational complexity, the probability of changing the organization of plants increases with the size of the management hierarchy: 8.1% in 2-layered organizations (3.5% when the plant is owned by a business group), 18.1% (8.1%) when the number of levels is 4, up to 37.3% (17.9%) with 6 managerial layers.

Tab. 6 - Simulation of the effect on organizational change of change in one variable at a time with respect to the representative plant: organization and plant-specific variables

	Probability of changing the management hierarchy by 1997	
	single-plant	multi-plant
Representative plant	*18.06%*	*8.07%*
Level = 2	8.15%	3.53%
Level = 6	37.30%	17.90%
Job shop (Line =0)	26.65%	12.28%
Owner = 1	10.61%	-
External = 1	-	11.44%
Size = 100	19.09%	8.56%
Size = 1,000	16.41%	7.29%
Decline = 50%	20.64%	9.31%
Growth = 50%	23.08%	10.50%
Large, complex and downsizing	38.57%	18.61%
- and driven by an external manager	-	25,71%
Small, simple and growing	11,23%	4,91%
- and driven by the owner	6,48%	-

Influence activities strongly inhibit the stimulus towards change. For single-plants firms where decision-making is (partially) delegated to the plant manager, the likelihood of changing the organization is as high as 18.1%. This probability drops to 10.6%, in an autocratic (owner driven) single-plant firm where power is highly concentrated and agents have more incentive to influence the principal's behavior. In plants owned by a business group, where the decision-maker is physically far from the production unit, influence activities of plant's employees are reduced, thus organizational change is more likely (11.4% versus 8.1% of the benchmark case).

At the bottom of Table 6, I present results for two important categories of plants: large (number of employees=1,000), complex (number of levels=6) and declining (growth rate=-50%) units and small (100), simple (2) and growing (+50%) plants. The former tend to change their organization quite often, specially when they are managed by an external executive, whilst the latter follow an inertial process, particularly pronounced in very autocratic single-plant firms where ownership and control are not separated.

Tab. 7 - Simulation of the effect on organizational change of change in one variable at a time with respect to the representative plant: industry effects

	Probability of changing the management hierarchy by 1997
Representative plant (single-plant)	*18.06%*
Low scientific base (R&D=0.002)	17.24%
High scientific base (R&D=0.139)	24.68%
Low concentration (Herf=0.000)	19.75%
High concentration (Herf=0.242)	5.42%
Low turbulence (I-growth=0.003)	17.62%
High turbulence (I-growth=0.992)	26.63%

In Table 7 I have proceeded to simulate the effects on organizational change of different industry environments. The scientific base of an industry, in terms of proportion of resources devoted to R&D, raises the likelihood of changing frequently the organization of plants. In addition, industries with low market concentration and high turbulence are not only characterized by a changing environment, but are also populated by changing organizations.

Tab. 8 – Simulation of the effect on organizational change of change in one variable at a time with respect to the representative plant: technology adoptions and HRMPs

	Probability of changing the management hierarchy by 1997				
	Pioneer	*Early adopter*	*Average adopter*	*Late adopter*	*No adoption*
AMT1	32.52%	29.19%	25.09%	19.16%	*18.06%*
AMT2	43.27%	37.85%	30.86%	20.14%	*18.06%*
AMT3	50.70%	44.07%	35.20%	20.91%	*18.06%*
AMT4	72.59%	64.02%	50.59%	24.08%	*18.06%*
INC	20.70%	20.05%	19.29%	18.25%	*18.06%*
JROT	25.47%	23.69%	21.57%	18.60%	*18.06%*
QC	31.20%	28.15%	24.42%	19.06%	*18.06%*

Legend
Pioneer: adoption in 1979;
Early adopter: adoption in 1984;
Average adopter: adoption in 1989;
Late adopter: adoption in 1995.

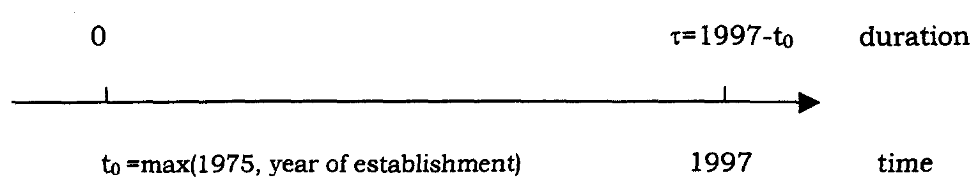
Lastly, Table 8 shows the results of the simulated effects on structural inertia of technology adoptions and HRMPs. First, the likelihood of inertia increases with the adoption time: the earlier the adoption, the more likely organizational change. This result derives from the significantly positive duration dependence of the estimates (see the result of the parameter *p* reported in Table 3). Second, the impact of technology adoptions on organizational change seems to be greater than that of HRMPs: a plant that by 1979 had adopted one AMT has a probability of changing its structure by 1997 equal to 32.5%, which is greater than the impact of the most influent category of HRMPs (Quality Circles with 31.2%). Third, it is now more manifest the increasing effect of technological complementarity. The higher the number of flexible technologies adopted, the larger the impact on organizational change, with a 'pioneer plant' that by 1979 had adopted four AMTs being almost sure to change its management hierarchy by 1997 (73% versus 18% of the no adoption case).

Appendix

I have classified plants depending on the evolution of their organizational structure. In particular there are three possible cases, which are graphically presented in what follows: a) plants that have not changed their organization in the last 20 years (*i.e.*, from 1975 to 1997), b) plants that have changed once, and c) plants that have changed two (or more) times.

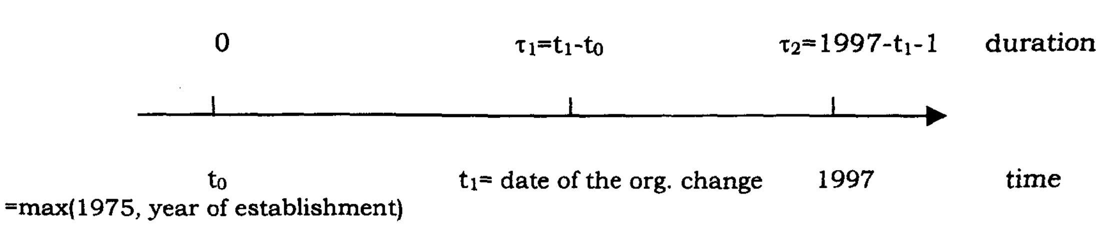
a) No organizational change:

In this case I impose a starting date which is the maximum (t_0) between 1975 (the first year of observation of the empirical survey) and the date of plant's foundation. Also, observations are right-censored, since I impose a closing date given by 1997 (the survey date).



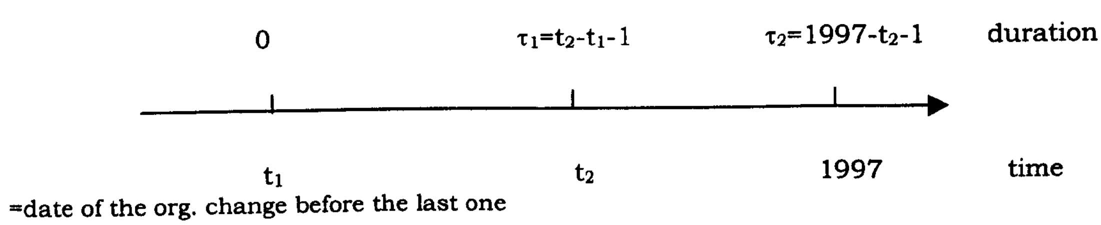
b) 1 organizational change:

In this case I divide the period under observation into two intervals. The first starts from t_0 and ends at the date of the last organizational change (t_1). The second is delimited by t_1+1 and 1997.



c) 2 (or more) organizational changes:

In this case I divide the period under observation into two intervals. The first starts from the year after the date of the organizational change before the last one and ends at the date of the last change (t_2). The second interval is delimited by t_2+1 and 1997.



Summing Up

The Central Theme: Coordination through Hierarchies

The unifying viewpoint of this study relates to the notion of the firm. So far, the firm has been depicted as a nexus of contracts (Jensen and Meckling 1976), in which information is asymmetric and agents tend to exploit informational gains opportunistically. In this context, the main issue is to design an efficient incentive system so as to align agents' objectives to those of the firm. The firm and the market are (alternative) contractual arrangements, which do not differ much. Indeed, the firm "has no power of fiat, no authority, no disciplinary action any different in the slightest degree from ordinary market contracting between any two people" (Alchian and Demsetz 1972).

Alternatively, the firm derives from transaction costs analysis (Coase 1937). Firms are efficient institutions when transaction costs of market relations are high. More generally, you can think of a continuum of institutional arrangements each of them minimizes transaction costs under certain conditions. Since transaction costs are inter-linked with asymmetric information issues, contractual relations re-emerge as key in the notion of the firm.

I do not deny that these are important aspects of the firm. However, I depart from these and reject the view that depicts the firm uniquely (or even mainly) in terms of contractual relations. Indeed, market relations and intra-firm agents' relations are very different institutional arrangements. We cannot look at these as different sides of the same coin or as a continuum of ordered contractual structures. In particular, it is my opinion that we should analyze the organization in greater detail.

More specifically, hierarchic organizations are a strong means of ranking and coordinating agents within companies. By following Radner (1992), a hierarchy can be defined as a ranked tree, where a tree is a collection of members of the firm (either single agents or teams) together with a binary relation, called "superior to", that satisfies the following properties: 1) *transitivity*: if the agent A is superior to B, and B is superior to C, then A is superior to C; 2) *antisymmetry*: if the agent A is superior to B, then B is not superior to A (A is subordinate to B); 3) there is exactly one agent that is superior to all other agents, called the *top manager*; 4) except the top manager, agents have exactly one immediate superior (if the agent A is an immediate superior of B, then there is no agent between them in the relation). In order to rank a tree, that is to obtain a hierarchy, we add two further properties: 5) if the agent A is superior to B, then A has a higher rank; 6) if the agents A and B have the same rank, then they are not comparable in terms of the relation "superior to". It follows that within hierarchies agents are (partially) ordered. Roughly speaking, the hierarchic organization allows companies to set up a system of relations where the equilibrium is not reached through the market mechanism but by the hierarchic allocation of authority. In other words, firms “attempt to supersede the price mechanism by direct hierarchical coordination” (Miller 1992, pg.4).

In this context aspects such as the span of control, the size of the management hierarchy, the allocation and concentration of decision-making, the adoption of human resource management practices and managerial innovations are key. These are means of stimulating agents, monitoring activities, coordinating resources, defining information flows, exploiting local knowledge. Within this more general framework monetary incentive schemes play an important role. However, they are neither unique nor the most exploited means of aligning agents' objectives to those of the firm.

Indeed, part of the most recent theoretical work on the firm has been devoted to the study of these characteristics of the organization. Thus, decentralization or *empowerment* is now recognized as a means of stimulating motivation, exploiting local knowledge, testing agents' qualification (Aghion and Tirole 1995, 1997, Aoki 1986, Geanakoplos and Milgrom 1991 and Sah and Stiglitz 1986 and 1988). Human resource management practices and managerial innovations aim at coordinating agents', defining a network of information (Holmstrom and Milgrom 1994, Kandel and Lazear 1992, Ichniowski *et al.* 1997). The size of the management hierarchy and the span of control are inter-linked to the monitoring activity of managers and communication costs (Bolton and Dewatripont 1994, Calvo and

Wellisz 1978 and 1979, Keren and Levhari 1979 and 1983, Qian 1994, Radner 1993, and van Zandt 1999).

The Empirical Survey

I started this thesis with some anecdotal evidence on the organization and its evolution derived from case studies of both business history and managerial literature. It was noted in Chapter 1 that these studies are based on qualitative definitions of organization variables. Also, they often concentrate on few case studies of very large corporations. The aim of this thesis was instead to provide evidence on key aspects of the management hierarchy by defining quantitative measures of the organization on a sample of plants of different sizes. The result is the empirical survey and the related FLAUTO97 database.

In the empirical survey, I focused attention on the organization of plants. This was due to two reasons. First, in order to study aforementioned aspects of hierarchies I had to delimit the unit of observation. Consider for instance the study of the decision-making allocation, the span of control and the size of the organization in large multi-plant corporations. Given the complexity of information to gather and the unwillingness of large corporations to provide such data, it is very likely to end up, as for business history and managerial studies, with qualitative taxonomies of organizations. However, my aim was to develop objective quantitative indices of organizational variables. Second, the study of technology adoptions is mainly based on plant-level evidence. As long as I wanted to analyze the relation between technology and organization, the choice of the plant came out as the most appropriate.

Therefore I designed and conducted a questionnaire analysis on Italian manufacturing plants aimed at collecting quantitative information on the above mentioned aspects of business organizations. The main pay-off from building the empirical survey upon this approach to organization relates to the alleged potentialities of testing quantitatively economic theory. So far, economists have left aspects such as leadership and power within organizations to sociologists or business schools. A large-scale data set has allowed me to test quantitatively economic models. It is my opinion that the findings shed new light on the organization.

Substantive Findings

At the end of a work one is pressed to sum up substantive findings. This is the place in my thesis. I do not want to summarize results of all Chapters here. I just want to highlight a few findings that seem to me particularly important in the present theoretical debate.

First, the size of the management hierarchy increases with the complexity of a firm's (production and administrative) operations due to economies of scale in gathering and processing items of information. However, given the distance between the pinnacle and the bottom of the hierarchy, large organizations may incur in the loss of control phenomenon. So, the management of firms characterized by very large organizations tends to increase the number of subordinates under one manager (*i.e.*, the span of control) so as to shrink the size of the hierarchy and to limit communication and information failures (see Chapter 2). In other words,

Finding 1. The loss of control phenomenon shapes the organization of firms: both the size of the management hierarchy and the span of control increase with the complexity of a firm's operations.

Another means of reducing the distance between decision-making and implementation is decentralization. In large organizations, strategic and operating decisions are decentralized more often than in small sized firms were the owner usually holds most of power. Overall,

Finding 2. Also decentralization of strategic and operating decision-making is positively correlated with the complexity of a firm's operations.

Decentralization of decision confers power on an individual agent, who may be able to use it to purse its own interest at the owner's expense. Given the existence of conflicting goals in organization, decentralization may be a considerable source of loss of control. In this situation, monetary incentives are introduced as a means of aligning agent's objectives to those of the firm.

However, delegation of (real and formal) authority can be itself a mechanism to motivate agents and increase their participation in the contractual relationship. In Chapter 4 I showed that authority is allocated depending on the importance of the decision to the agent and to the principal. The exploitation of local knowledge and capabilities, the extent of intra-firm externalities and the urgency of decision also turned out to play a remarkable role in influencing the allocation of real and formal authority. To sum up,

Finding 3. Management introduces individual incentive schemes as a means of aligning agent's objectives to those of the firm when authority is (partially) delegated to the agent. In addition, authority is allocated depending on the importance of the decision to the agent and to the principal, the desire to exploit local knowledge and capabilities, the extent of intra-firm externalities and the urgency of decision.

Another aspect of interest is the relation between organization and technology. Just as the second industrial revolution changed the configuration of business organizations, so the information technology (IT) and flexible automation (FA) paradigms are shaping the organization again. In particular, in Chapter 3 I maintained that advances in communication and production technology strongly influence the organizational architecture of firms and plants. I have also argued that this relation deserves a careful analysis. Indeed, the sign and the magnitude of the impact of technology on the organization depend on the characteristics of technological innovations. In particular, I found that adoptions of different technologies that pertain to the production and communication spheres affect the organization in rather distinct and (sometimes) opposite ways.

First, whereas advances in communication technology have an impact both on the plant and overall on the firm's organization, production technology influences only the architecture of the production unit.

Second, both the vintage and the extent of use of production technologies play a key role in assessing the way in which technology shapes the organization of plants. Plants that use technologies linked to the Tayloristic approach to production (*i.e*, inflexible manufacturing systems) have a hierarchy composed of many layers, whilst plants that have introduced a cluster of technologies linked to the Flexible Automation (*i.e*, flexible manufacturing systems, robots, CNC machine tools, machining centers) are characterized by leaner kinds of organization. As to network technology, it is the locus of advances in communication - *i.e.*, intra versus inter-firm network - that matters in the relation between technology and organization:

advances in intra-firm communication promote specialization and hierarchy, technology-induced reductions in communication costs between firms encourage outsourcing, hence a smaller type of organization. Thus, overall

Finding 4. Advances in communication and production technology shape the organizational structure. The way in which technology affects organization crucially depends on its type, vintage and extent of use.

In contrast, the use of new management practices does not affect the organizational architecture of firms (and plants). In particular, in Chapter 5 I found that neither human resource management practices nor other managerial innovations are associated with the lean type of organization. Nevertheless, the use of such instruments covary in cross-sectional data; that is, they generally diffuse in cluster rather than in isolation. Given the lack of correlation with other important aspects of the organization (e.g., decentralization, reduced bureaucratization), it is hard to maintain that this is the result of the adoption by profit-maximizing firms of a coherent business strategy that exploits complementarities. I rather adhere to the view expressed by some theory that can be summarized as follows:

Finding 5. Adoption of new management practices is driven by fads.

Another fundamental theme, which has been investigated in Chapter 6 (and Chapter 2), concerns the evolution of organizations. In this respect, I have provided robust evidence on the existence of an inertial process. Both the allocation of decision-making activities and the structure of the management hierarchy are very stable over time. Indeed,

Finding 6. The evolution of business organizations is characterized by structural inertia.

This is not the effect of organizational complexity as some sociological theory suggests (*i.e.*, the organizational ecology approach). Inertia seems to be determined by influence activities (and sunk costs). Since authority is a fixed resource, re-organization implies a change in the allocation of power that favors some agents and damages some others. Thus, there always exist agents who oppose any change and embark in costly influence activities.

Finding 7. Influence activities inhibit organizational change.

Just as technology influences the static choice of an organizational structure, so also it affects the evolution of organizations. In particular, the (extent of) use of flexible technologies linked to FA is associated to flatter and smaller organizations. Since the introduction of multiple technologies signals a more skilled workforce, plants that adopt technological innovations are also more inclined towards change due to the lower costs of changing frequently tasks and ranks. More generally, Chapter 6 shows that

Finding 8: Technological change induces organizational change.

Further, it is my opinion that *organization and technology co-evolve.* However this is not a finding of the present work, but it is a suggestion for further economic research.

References

Abernathy, W.J. and Wayne, K., 1974, "Limits of the learning curve," *Harvard Business Review*, 52, pp.109-119.

Abernathy, W.J., 1978. *The Productivity Dilemma*, (John Hopkins University Press, Baltimore).

Aghion, P. and Tirole, J., 1995, "Some implications of growth for organizational form and ownership structure," *European Economic Review*, 39, pp.440-455.

Aghion, P. and Tirole, J., 1997, "Formal and real authority in organizations," *Journal of Political Economy*, 105, 1-29.

Alchian A., and Demsetz, H., 1972, "Production, information costs, and economic organization," *American Economic Review*, 62, pp.777-795.

Alford, B.W., 1994, "Chandlerism, the new orthodoxy of US and European corporate development?," *Journal of European Economic History*, 23, pp.631-643.

Aoki, M., 1986, "Horizontal vs. vertical information structure of the firm," *American Economic Review*, 76, pp.971-983.

Aoki, M., 1988. *Information Incentives and Bargaining in the Japanese Economy*, (Cambridge University Press, Cambridge).

Aoki, M., 1990, "Toward an economic model of the Japanese firm," *Journal of Economic Literature*, 88, pp.1-27.

Arrow, K., 1974. *The Limits of Organization*, (Norton, New York).

Arthur, W.B., 1985, "Competing technologies, increasing returns, and lock-in by historical small events," *CEPR Working Paper*, 43, Stanford.

Arthur, W.B., 1988, "Self-reinforcing mechanisms in economics," in Arrows, K. and Pines, D., (eds.). *The Economy as an Evolving Complex System*, Addison Wesley.

Baharami, H, 1992, "The emerging flexible company," *California Management Review*, 34, pp.33-52.

Baker, G., Gibbs, M. and Holmstrom, B., 1994, "The internal economics of the firm: evidence from personnel data," *Quarterly Journal of Economics*, 109, pp.881-919.

Bartel, A.P., and Lichtenberg, F.R., 1987, "The comparative advantage of educated workers in implementing new technology," *Review of Economics and Statistics*, 69, pp.1-11.

Beckmann, M.J., 1977, "Management production functions and the theory of the firm," *Journal of Economic Theory,* 14, pp.1-18.

Bikchandani, S., Hirshleifer, D. and Welch, I., 1992, "Learning from the behavior of others: conformity, fads, and informational cascades," *Journal of Economic Perspectives,* 12, pp.151-170.

Bolton, P. and Dewatripont, M., 1994, "The firm as a communication network," *Quarterly Journal of Economics,* 109, pp.809-839.

Bresnahan, T., Brynjolfsson, E. and Hitt, L., 1999, "Information technology, workplace organization and the demand for skilled labor: firm-level evidence," *NBER Working Paper,* 7136.

Bresnahan, T., and Trajtenberg, M., 1995, "General purpose technologies: 'engines of growth'?," *Journal of Econometrics,* 65, pp.83-108.

Brooks, R.D., Fry, T.R. and Harris, M.N., 1998, "The size and power properties of combining choice set partition tests for the IIA property in the logit model," Royal Melbourne Institute of Technology.

Cainarca, G.C., Colombo, M.G. and Mariotti, S., 1989, "An evolutionary pattern of innovation diffusion. The case of flexible automation," *Research policy,* 18, pp. 59-86.

Calvo, G., and Wellisz, S., 1978, "Supervision, loss of control, and the optimal size of the firm," *Journal of Political Economy,* 86, pp.943-952.

Calvo, G., and Wellisz, S., 1979, "Hierarchy, ability and income distribution," *Journal of Political Economy,* 87, pp.991-1010.

Camerer, C. and Knez, M., 1996, "Coordination, organizational boundaries and fads in business practices," *Industrial and Corporate Change,* 5, pp.89-112.

Carlos, A.M. and Nicholas, S., 1988, "Giants on a earlier capitalism: the chartered trading companies as modern multinationals," *Business History Review,* 62, pp.398-419.

Carlsson, B., 1984, "The development and use of machine tools in historical perspective," *Journal of Economic Behavior and Organization,* 5, pp.91-114.

Carlsson, B., 1989, "Flexibility and the theory of the firm," *International Journal of Industrial Economics,* 7, pp.179-203.

Carrol, G., (1994), "Organizations...the smaller they get," *California Management Review,* 37, pp-28-41.

Chandler, A.D., 1956, "Management decentralization: an historical analysis," *Business History Review,* 30, pp.111-174.

Chandler, A.D., 1962. *Strategy and Structure*, (The MIT Press, Cambridge MA).

Chandler, A.D., 1977. *The Visible Hand: the Managerial Revolution in American Business*, (Harvard University Press, Cambridge MA).

Chandler, A.D., 1990. *Scale and Scope*, (Harvard University Press, Cambridge MA).

Chandler, A.D., 1992, "Organizational capabilities and the economic history of the industrial enterprise," *Journal of Economic Perspectives*, 6, pp.79-100.

Chandler, A.D., McCrow, T.K. and Tedlow, R.S., 1996. *Management Past and Present*, (South-Western College Publishing, Cincinnati).

Channon D., 1973. *The Strategy and Structure of British Enterprise*, (Macmillan, Boston).

Coase, R.H., 1937, "The nature of the firm," *Economica*, 4, pp.386-405.

Cohen, Y., 1991, "The modernization of production in the French automobile industry between the wars," *Business History Review*, 65, pp.754-780.

Cohen, M.D., Burkhart, R., Dosi, G., Egidi, M., Marengo, L., Warglien, M., and Winter, S., 1996, "Routines and other recurring actions patterns of organizations," Santa Fê Institute Working Paper, Santa Fé.

Colombo, M. and Delmastro, M., 1999, "Technology use and plat closure," *Research Policy*, forthcoming.

Colombo, M. and Mosconi, R., 1995, "Complementarity and cumulative learning effects in the early diffusion of multiple technologies," *Journal of Industrial Economics*, XLIII, pp.13-48.

Coriat, B., 1979. *L'Atelier et le Chronometre*, (Chirstian Bourgois Èditeur, Paris).

Coriat, B., 1991. *Penser à l'envers*, (Chirstian Bourgois Èditeur, Paris).

Cox, D.R. and Oakes, D., 1984. *Analysis of Survival Data*, (Chapman and Hall, London).

Cyert, R. and March J., 1963. *A Behavioral Theory of the Firm*, (Prentice-Hall, Englewood Cliff, N.J.).

Davies, S., 1979. *The Diffusion of Process Innovations*, (Cambridge University Press, Cambridge).

Delmastro, M., 1996, "Organizational forms and firm decision-making in a bounded rational context," paper presented at the E.A.R.I.E. Conference, Vienna, September 1996.

Di Nardo, J. and Pischke, J.S., 1997, "The returns to computers use revisited: have pencils changed the wage structure too?," *Quarterly Journal of Economics*, 112, pp.291-311.

Dixit, A. and Pindyck, R., 1994. *Investment under Uncertainty*, (Princeton University Press, Princeton).

Doms, M., Dunne, T. and Troske, K., 1997, "Workers, wages and technology," *Quarterly Journal of Economics*, 112, pp.253-290.

Drucker, P.F., 1988, "The coming of the new organization," *Harvard Business Review*, 66, pp. 45-55.

Duimering, P.R., Safayeni, F. and Purdy, L., 1993, "Integrated manufacturing: redesign the organization before implementing flexible technology," *Sloan Management Review*, summer, pp. 47-56.

Dunne, T., 1994, "Plant age and technology use in U.S. manufacturing industries," *RAND Journal of Economic*, 25, pp.488-499.

Dunne, T., Roberts, M.J. and Samuelson, L., 1988, "Pattern of firm entry and exit in U.S. manufacturing industries," *RAND Journal of Economics*, 19, pp. 495-515.

Dunne, T., Roberts, M.J. and Samuelson, L., 1989, "The growth and failure of U.S. manufacturing plants," *Quarterly Journal of Economics*, 104, pp. 671-98.

Dyas, G.P. and Thanheiser, H.T., 1976. *The Emerging European Enterprise*, (Mcmillan, London).

Fauri, F., 1996, "The role of FIAT in the development of the Italian car industry in the 1950s," *Business History Review*, 70, pp.167-206.

Ford, H., 1923. *My Life and Work*, (William Heinemann).

Ford, H., 1926. *Today and Tomorrow*, (Associated Bookbuyers).

Geanakoplos, J. and Milgrom, P., 1991, "A theory based on limited managerial attention," *Journal of the Japanese and International Economies*, 5, pp.205-225.

Hannah, L., 1976. *Management Strategy and Business Development*, (Macmillan, London).

Hannah, L., 1996, "Marshall's 'trees' and the 'global forest'," Paper presented at the NBER Conference.

Hannan, M.T. and Freeman, J., 1977, "The population ecology of organizations," *American Journal of Sociology*, 89, pp.929-964.

Hannan, M.T. and Freeman, J., 1984, "Structural inertia and organizational change," *American Sociological Review*, 49, pp.149-164.

Hitt, L., and Brynjolfsson, E., 1997, "Information technology and internal firm organization: an exploratory analysis," *Journal of Management and Information Systems*, 14, pp.81-101.

Holmstrom B., and Milgrom, P., 1994, "The firm as an incentive system," *American Economic Review*, 84, pp.972-991.

Hoover, G., Campbell, A. and Spain, P.J., 1998a. *Profiles of over 500 Major Corporations*, (Austin, Reference Press).

Hoover, G., Campbell, A. and Spain, P.J., 1998b. *Profiles of over 500 Major U.S. Corporations*, (Austin, Reference Press).

Hubbard, T., 1998, "Why are process monitoring technologies valuable? The use of on-board information technology in the trucking industry," *NBER Working Paper*, 6482.

Ichniowski, C., Shaw, K. and Prennushi, G., 1997, "The effects of human resource management practices on productivity: a study of steel finishing lines," *American Economic Review*, 87, pp.291-313.

Jaikumar, R., 1986, "Postindustrial manufacturing," *Harvard Business Review*, 64, pp.69-76.

Jenks, L.J., 1961, "Early history of a railway organization," *Business History Review*, 35, pp.153-179.

Jensen, M.C., and Meckling, W.H., 1976, "Theory of the firm: managerial behavior, agency costs, and ownership structure," *Journal of Financial Economics*, 3, pp.304-360.

Johnson, H.T., 1975, "Management accounting in an early integrated industrial," *Business History Review*, 49, pp.184-204.

Johnson, H.T., 1978, "Management accounting in an early multidivisional structure," *Business History Review*, 52, 490-517.

Johnston, R. and Vitale, M., 1988, "Creating competitive advantage with interorganizational systems," *MIS Quarterly*, 12, pp.153-165.

Kandel, E. and Lazear, E., 1992, "Peer pressure and partnership," *Journal of Political Economy*, 100, pp.801-817.

Karshenas, M. and Stoneman P., 1993, "Rank, stock, order, and epidemic effects in the diffusion of new process technologies: an empirical model," *RAND Journal of Economics*, pp.503-528.

Kelley, M., 1994, "Productivity and information technology: the elusive connection," *Management Science*, 40, pp. 1406-1425.

Kenney, M. and Florida, R., 1988. *Beyond Mass Production*, (Oxford University Press, New York).

Keren, M. and Levhari, D., 1979, "The optimum span of control in a pure hierarchy," *Management Science*, 25, pp.1162-1172.

Keren, M. and Levhari, D., 1983, "The internal organization of the firm and the shape of average costs," *Bell Journal of Economics*, 41, pp.474-486.

Keren, M. and Levhari, D., 1989, "Decentralization, aggregation, control loss and costs in a hierarchical model of the firm," *Journal of Economic Behavior and Organization*, 11, pp.213-236.

Kocha, J., 1971, "Family and bureaucracy in German industrial management 1850-1914," *Business History Review*, 45, pp.133-156.

Koike, K., 1984, "Skill formation system in the US and Japan," in Aoki, M (ed.). *The Economic Analysis of the Japanese Firm*, (North-Holland, Amsterdam).

Koike, K., 1990, "Internal labor markets," in Shirai, T. (ed.). *Contemporary Industrial Relations in Japan*, (University of Wisconsin Press, Madison).

Kogut, B. and Parkinson, D., 1998, "Adoption of the multidivisional structure: analyzing history from the start," *Industrial and Corporate Change*, 7, pp. 249-273.

Krafcik, J.F., 1988, "Triumph of the lean production system," *Sloan Management Review*, fall, pp.41-51.

Kreps, D., 1985, "Corporate culture and economic theory," mimeo, University of Stanford.

Kreps, D., 1990. *A Course in Microeconomic Analysis*, (Princeton University Press, Princeton).

Kwon, M.J. and Stoneman, P., 1995, "The impact of technology adoption on firm productivity," *Economics of Innovation and New Technology*, 3, pp.219-233.

Laffont, J.J. and Martimort, D., 1998, "Collusion and delegation," *RAND Journal of Economics*, 29, pp.280-305.

Lanlgois, R.N. and Robertson, P.L., 1989, "Explaining vertical integration: lessons from the American automobile industry," *Journal of Economic History*, 49, pp. 361-375.

Lazear, E., 1995. *Personnel Economics*, (MIT Press, Cambridge MA).

Lazonick, W., 1990a. *Competitive Advantage at the Shop Floor*, (Harvard University Press, Cambridge MA).

Lazonick, W., 1990b, "Organizational capabilities in American industry," *Business and Economic History*, 19, pp.35-54.

Leijohnuhvud, A., 1986, "Capitalism and the factory system," in Langlois, R.N. (ed.). *Economics as a Process*, (Cambridge University Press, Cambridge).

Levin, R.C., Klevorick, A.K., Nelson, R.R. and Winter S.G., 1987, "Appropriating the returns from industrial R&D," *Brookings Papers of Economic Activity*, 3, pp.783-820.

Lindbeck, A. and Snower, D.J., 1996, "Reorganization of firms and labor-market inequality," *American Economic Review Paper and Proceedings*, 86, pp.315-321.

McFadden, D., 1974, "Conditional logit analysis of qualitative choice behavior," in P. Zarembka (ed.). *Frontiers in Econometrics*, (New York, Academic Press).

McFadden, D., 1977, "Econometrics models of probabilistic choice," in C.F. Manski and D. McFadden (eds.). *Structural Analysis of Discrete Data with Econometric Applications*, (Cambridge MA, MIT Press).

McFadden, D., Train, K.E and Tye, W., 1981, "An application of diagnostic tests for the independence of irrelevant alternatives property of the multinomial logit model," *Transportation Research Record*, 637, pp.39-46.

Maddala, G.S., 1983. *Limited-dependent and Qualitative Variables in Econometrics*, (Cambridge, Cambridge University Press).

Mahajan, V., Sharma S. and Bettis R., 1988, "The adoption of the M-form organizational structure: a test of imitation hypothesis," *Management Science*, 34, pp.1188-1201.

Mansfield, E., 1968. *Industrial Research and Technological Innovation*, (Norton, New York).

March, J.G., 1981, "Footnotes to organizational change," *Administrative Science Quarterly*, 26, pp.563-577.

March, J.G. and Simon, H., 1958. *Organizations*, (Wiley & Sons, New York).

Marglin, S., 1974, "What do bosses do? The origin and functions of hierarchy in capitalist production," *Review of Radical Political Economy*, 6, pp. 60-112.

Marschak, J. and Radner, R., 1972. *Economic Theory of Teams*, (Yale University Press, New Haven).

Mata, J., Portugal, P. and Guimaraes, P., 1995, "The survival of new plants: Start-up conditions and post-entry evolution," *International Journal of Industrial Organization*, 13, pp. 459-81.

Meyer, M., Milgrom, M. and Roberts, J., 1992, "Organizational prospects, influence costs and ownership changes," *Journal of Economics and Management Strategy*, 1, pp.9-35.

Milgrom, P., 1988, "Employment contracts, influence activities and efficient organization design," *Journal of Political Economy*, 96, pp.46-60.

Milgrom, P. and Roberts, J., 1990, "The economics of modern manufacturing: technology, strategy, and organization," *American Economic Review*, 80, pp.511-528.

Milgrom, P. and Roberts, J., 1990a, "Bargaining costs, influence costs, and the organization of economic activity," in Alt, J. and Shepsle, K. *Perspectives on Positive Political Economy*, (Cambridge University Press, Cambridge).

Milgrom, P. and Roberts, J., 1992. *Economics, Organization and Management*, (Prentice-Hall International, London).

Milgrom, P. and Roberts, J., 1995, "Complementarities and fit strategy, structure and organizational change in manufacturing," *Journal of Accounting and Finance*, 19, pp.179-208.

Miller, G., 1992. *Managerial Dilemmas: the Political Economy of Hierarchy*, (Cambridge University Press, Cambridge).

Montgomery, D., 1979. *Workers' Control in America*, (Cambridge University Press, Cambridge).

Montgomery, D., 1987. *The Fall of the House of Labor*, (Cambridge University Press, Cambridge).

Moriwaka, H., 1970, "The organizational structure of the Mitsubishi and Mitsui zaibatsu," *Business History Review*, 44, pp.62-83.

Mukhopadhyay, T., Lerch, J. and Mangal, V., 1995, "Business value of information technology: a study of electronic data interchange," *MIS Quarterly*, 19, pp.137-156.

Nelson, R. and Winter, S., 1982. *An Evolutionary Theory of Economic Change*, (Harvard University Press, Cambridge MA).

O'Donnel, C., 1952, "Origins of corporate executive," *Business History Review*, 26, pp.55-72.

Palmer, D., Friedland, R., Devereaux Jennings, P. and Powers, M., 1987, "The economics and politics of structure: the multidivisional form and the large U.S. corporation," *Administrative Science Quarterly*, 32, pp.25-48.

Palmer, D., Devereaux Jennings, P. and Zhou, X., 1993, "Late adoption of the multidivisional form by large U.S. corporations," *Administrative Science Quarterly*, 38, pp.100-131.

Qian, Y., 1994, "Incentives and loss of control in an optimal hierarchy," *Review of Economic Studies*, 61, pp.527-544.

Radner, R., 1992, "Hierarchy: the economics of managing," *Journal of Economic Literature*, 30, pp.1382-1415.

Radner, R., 1993, "The organization in decentralized information processing," *Econometrica*, 61, pp.1109-1146.

Radner, R., 1996, "Bounded rationality, indeterminacy and the theory of the firm," *Economic Journal*, 106, pp.1360-1373.

Raff, D.M., 1991, "Making cars and making money in the interwar automobile industry," *Business History Review*, 65, pp. 721-753.

Rosen, S., 1982, "Authority, control and the distribution of earnings," *Bell Journal of Economics*, 13, pp.311-323.

Sah, R.K. and Stiglitz, J.E., 1986, "The architecture of economic systems: hierarchies and polyarchies," *American Economic Review*, 76, pp.716-727.

Sah, R.K. and Stiglitz, J.E., 1988, "Committees, hierarchies and polyarchies," *Economic Journal*, 98, pp.451-470.

Schaefer, S., 1998, "Influence costs, structural inertia, and organizational change," *Journal of Economics and Management Strategy*, 7, pp.237-263.

Scott, B.R., 1973, "The industrial state: old myths and new realities," *Harvard Business Review*, 51, pp.133-148.

Shleifer, A., 1998, "State versus private ownership," *Journal of Economic Perspectives*, 12, pp.133-150.

Simon, H., 1959, "Theories of decision making in economics," *American Economic Review*, 49, pp.245-263.

Simon, H., 1962, "The architecture of complexity," *Proceedings of the American Philosophical Society*, 106, pp.467-482.

Simon, H., 1973. *Administrative Behavior*, (New York, Macmillan).

Sloan, A.P., 1963. *My Years with General Motors*, (Macfadden-Bartel, New York).

Starbuck, W.H., 1971. *Organizational Growth and Development*, (Penguin, Harmondsworth).

Stoneman, P. and Kwon, M.J., 1994, "The diffusion of multiple process technologies," *Economic Journal*, 104, pp.420-431.

Stoneman, P. and Kwon, M.J., 1996, "Technology adoption and firm profitability," *Economic Journal*, 106, pp.952-962.

Sugden, R., 1989, "Spontaneous order," *Journal of Economic Perspectives*, 3, pp.85-97.

Suzuki, Y., 1991. *Japanese Management Structures*, (Macmillan, London).

Taylor, F.W., 1967. *Principles of Scientific Management*, (Norton, New York).

Teece, D.J., 1980, "The diffusion of administrative innovation," *Management Science*, 26, pp.464-470.

Teece, D.J., 1994, "The dynamics of industrial capitalism," *Journal of Economic Literature*, 31, pp.199-225.

Thompson, R., 1983, "Diffusion of the M-form structure in the UK," *International Journal of Industrial Organization*, 1, pp.297-315.

Venkatraman, N., Loh, L. and Koh, J., 1994, "The adoption of corporate governance mechanisms: a test of competing diffusion models," *Management Science*, 40, pp.496-507.

Williamson, O.E., 1967, "Hierarchical control and optimum firm size," *Journal of Political Economy*, 75, pp.123-138.

Williamson, O.E. and Bhargava, N., 1972, "Assessing and classifying the internal structure and control apparatus of the modern corporation," in Cowling, K. (ed.). *Market Structure and Corporate Behaviour*, (Gray-Mills, London).

Winter, S., 1971, "Satisficing, selection, and the innovating remnant," *Quarterly Journal of Economics*, 85, pp.237-261.

Womack, J., Jones, D.T. and Ross, D., 1990. *The Machine that Changed the World*, (Macmillan, New York).

Young, P., 1996, "The economics of convention," *Journal of Economic Perspectives*, 10, pp.105-122.

van Zandt, T., 1995, "Continuous approximations in the study of hierarchies," *RAND Journal of Economics*, 26, pp.575-590.

van Zandt, T., 1999, "Real-time decentralized information processing as a model of organizations with boundedly rational agents," *Review of Economic Studies*, 66, pp.633-658.