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The structural and spatial adjustments of the automobile industry in Spain: 1975–1990

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THE STRUCTURAL AND SPATIAL ADJUSTMENTS OF THE AUTOMOBILE INDUSTRY IN SPAIN: 1975-1990

by

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THE STRUCTURAL AND SPATIAL ADJUSTMENTS OF THE AUTOMOBILE INDUSTRY IN SPAIN, 1975 - 1990

(Order No.)

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Abstract

Globalization of the production and consumption processes in the automobile industry is increasing competitiveness among firms. Some firms adjust to this by shifting from the Mass Production System (MPS) to the Lean Production System (LPS), where the LPS refers to the use of flexible manufacturing and Just-in-Time inventory. This dissertation focuses on the structural and spatial changes brought about by the shift from the MPS to the LPS in the automobile industry in Spain.

The analysis is at several scales. Trends in total production, exports, industrial structure, employment in assembly and component firms are documented for the 1975 - 1990 period using time series data. These trends are compared to those of other countries of Europe, USA, and Japan. The spatial evolution of the industry in Spain is shown in a series of maps. Cobb-Douglas production functions are estimated for the industry as a whole and for three firms -Nissan Motor Ibérica, Fasa Renault, and Seat Volkswagen. A critical path dispersion model is applied to flows of components such as windows, glasses, and batteries from the suppliers to Nissan Motor Ibérica and Fasa Renault. This illustrates the usefulness of this method for analyzing the concentration or dispersion of the material networks.

The results document that the industry is still in a state of transition as the LPS is replacing the MPS since 1986, and there are characteristics of both systems. The production functions show high elasticities of output with respect to materials. The value added by labor and capital is low, reflecting the increasing trends of roundaboutness and outsourcing in the industry leading to larger numbers of components which have labor and capital embodied in them. Little empirical support was found for spatial clustering commonly postulated in the theoretical literature regarding the shift from the MPS to the LPS. The insignificance of clustering could, however, be a result of the recency of the introduction of the LPS in Spain.

TABLE OF CONTENTS

LIST OF TABLES

Table number

LIST OF FIGURES

Figure number

CHAPTER 1 INTRODUCTION

The maintenance of industrial competitiveness is one of the major concerns of the private and public sectors in most advanced economies. Faced with overproduction of industrial goods, shrinking demand due to recessionary pressures and the possibility of production efficiencies due to knowledge technologies, analysts are focusing on the explanatory factors that govern the competitive success of specific firms, regions, and nations. To what extent do inventions, technological and organizational innovations, R&D expenditures, infrastructure investments, improved management, government support of industry and trade affect the efficiency of firms? Answers to such questions are of critical importance for the economic health of industrial sectors and of nations states in which such sectors are important.

As a result, there is analytical focus on new production strategies that can increase competitiveness in a global production and consumption system. Industries are undergoing structural changes in advanced economies and restructuring has led to modifications, mainly in the management and structure of production, in industries where there is strong international competition. One of the most significant changes is the flexibility of production permitted by the introduction of the Lean Production System (LPS). The LPS first appeared in the automobile industry in Japan; subsequently, it spread to the automobile industry and other industries of several countries.

This dissertation, focussing on the industrial structure of the automobile industry, has two objectives. First, at a theoretical level, the structural and spatial manifestations resulting from the ongoing industrial restructuring are explored. The analysis of the structural and the spatial adjustments of the automobile industry (AI), due to the introduction of LPS, is done using qualitative models. Three models describe alternative production systems: the Mass Production System (MPS), the Lean Production System

(LPS), the Cellular Production System (CPS). While the MPS and the LPS have been discussed by industrial geographers and other analysts of production systems (Monden 1984; Altshuler 1985; Oliver and Wilkenson 1988; Abbeglen and Stalk 1986; Schoenberger 1987; Mair, Florida and Kenney 1988; Womack, Jones and Roos 1990; Law 1991; Linge 1991), the CPS is described for the first time in this dissertation. The emergence of the CPS can be observed in its embryonic form in Japan and it is a response to the problems created by the maturity of the LPS system in Japan.

Second, at the empirical level, this dissertation analyzes the restructuring of the AI in Spain, particularly the structural and spatial transition from the MPS to the LPS system of production. The structural trends in the AI are analyzed using time series data for the period 1975 - 1990. This is followed by an econometric analysis, using a Cobb-Douglas production function, of three automobile firms in Spain -Fasa Renault, Nissan Motor Ibérica, and Seat Volkswagen.

The spatial relationships between the assembly and the component firms are analyzed through a network model as the AI consists of component firms that supply parts to the assembly plants. A car contains more than 10,000 discrete parts in 100 major components, such as transmissions, gear, brakes and so forth (Womack, Jones and Roos 1990, 58). The assembly plants producing the finished car for the market account for approximately 15% of the total manufacturing process. In this study, the assembly plants are considered as first-order nodes. The major component firms form the second-order nodes as they assemble the components from discrete parts produced by third-order supplier firms. Interfirm linkages are analyzed in this study using the minimal path dispersion algorithm of graph theory. However, the minimal path could not be ascertained for the full list of suppliers of the assembly plant, due to data limitations. The automobile firms were able to provide information about only major components. While, only a partial network structure is provided, the analysis illustrates the utility of this method. A more

complete picture of the spatial linkages is provided in this study through the use of data, from the census of manufacturers, on the geographical locations of supplier firms. A series of maps describing these linkages are shown.

1.1 MASS PRODUCTION AND LEAN PRODUCTION: TENDENCIES IN THE AUTOMOBILE INDUSTRY

In the last three decades the automobile industry is undergoing pressures for change. Changes occurring in the industry are, primarily, a result of external pressures. New competitors entering into the market, globalization of the production, and changing demand are the relevant factors affecting the structure of the AI. Actions taken within the firm in order to cope with this external pressures, and to maintain a competitive advantage are the following: replacement of standard production by flexible production with differentiated output, capital investments in information technology and increase in labor skills to get more technically prepared labor force. Actions taken *outside* the firms are the following: flexible specialization -subdividing and subcontracting the different functions-, sharing R&D between a group of firms and developing network linkages to share information and raise quality standards.

The introduction of the LPS to the production system in the AI incorporates most of the actions taken within and outside the firm to attain the flexibility. In addition, the Just-in-Time (JIT) method of production and distribution of components is embodied in the LPS. One of the main characteristics of the JIT is the coordination between assembler and supplier firms in order to receive the components in a short period of time, at the quantity demanded, and with appropriate sequentiality. Some specific results of the adoption of the LPS have been postulated in the theoretical literature. For example, the number of suppliers of assembly firms decline because: 1) in order to decrease the assembly's firms cost of monitoring of quality standards of components at the supplier firm; and 2) due to rationalization of the organization of component suppliers by the assembly firm, the assembler systematizes its relations with the suppliers in different tiers (Womack, Jones and Roos 1990; Wells and Rawlinson 1992; Linge 1991). A notable reduction of component inventories in the assembly plant is expected to occur (Sugimori, Kusunoki and Uchikawa 1977; Hay 1988). There is a change in the role of managers, in which the flexible specialization drives the organization of the firm outside of the firm's walls (Jaikumar 1986; Chandler 1990). These issues are empirically addressed in the dissertation.

The automobile industry has been chosen as it is significant for several reasons. First, it is a major industry of the industrial economies, controlled by multinational firms, with global annual production of more than 39.3 million cars (Automotive News, 1991 Market Book Issue). It employs more than 3.0 million workers (OECD. Industrial Structure Statistics). Second, the AI has large economic multipliers due to its backward linkages with other industries such as glass, steel, rubber, plastics and so on. Consequently, it has enormous impacts on the economic health of a nation, for a downturn in the AI has recessionary impacts on a number of industries. Third, the AI has pioneered manufacturing systems which have expanded to other industries. In fact, in the 20 century the two most significant revolutions in production systems -the Mass production system and the Lean production system- were initiated in the automobile industry.

The history of the automobile industry in the US and Japan is a history of innovation -new ideas introduced in the industrial structures produced notable changes in production systems. First, in the US the Mass production system was invented in the 1910s. Second, in Japan the Lean production system started functioning in the 1970s. Both systems influenced the industry and became the prevalent system due to their efficiency. In the early part of this century, automobile production changed from a craft

system to a mass production system in the US. As a result the US dominated the automobile industry and the global industrial economy. In the second half of the century, automobile production changed from mass production to a lean production system in Japan. As a result Japan began its dominance of the automobile industry and its competitive position in the global industrial economy. Firms in both countries benefited from the competitive advantage provided by the first stage of the product cycle model. First the US, then Japan received monopolistic profits and Japanese firms are currently continuing to benefit from this competitive advantage. For instance, the major force generating structural change in the European AI is the increasing competitive threat from the Japanese manufacturers (Dicken 1992).

Changes in the industrial production system also have an impact on the spatial structure of industrial regions. Holmes (1983) notes that spatial restructuring is a manifestation of reorganization of the production system. For instance, Glasmeier and McCluskey (1987, 142) have reported that changes in production by the AI in the USA have resulted in spatial restructuring of the overall industry, specifically in the spatial re-concentration of employment and the spatial reorganization of component production plants. Furthermore, Mair et al. (1988, 353) argue that "While the trend in late Fordism was towards geographical dispersal of automobile production at local, regional, and international scales, the predominant trend among the transplants is towards geographical concentration internationally and regionally combined with dispersal at the local scale". Currently, the automobile industry in the world which is largely concentrated in three producer regions -Europe, Japan, and the US, also has plants located in other parts of the globe, such as East and South-East Asia and Latin America.

1.2 EVOLUTION OF THE AUTOMOBILE INDUSTRY IN SPAIN

The automobile industry is an important manufacturing industry in Spain. It produces two million of cars a year (Automotive News, 1991 Market Data Book Issue), with more than 140 thousand employees (OECD. Industrial Structure Statistics), and it's export share accounts for more than 30 percent of the Spain's total exports (U N International Trade Yearbook). In addition, Spain is the fourth largest car producer in Europe and the sixth in the world. Its market is divided between local and foreign consumption. Foreign exports are predominantly to other European countries.

Most of the main producers in the automobile industry are joint ventures with European, Japanese, and US firms. Even though Spain started producing cars in the 1920s, it was in the 1980s, with the location of large multinationals -like Ford (1973), and General Motors (1979)- in addition of other firms already located in the country -Fasa Renault and Seat Volkswagen-, that Spain has become a large motor vehicle producer country. Seat Volkswagen, the most important Spanish car producer (20,000 workers, and a market share of 20.3% in 1990), is located in Barcelona (1950). Seat started in 1950 and was critical for the development of the AI in Spain, not only for the direct and indirect employment and externalities it generated, but because it helped to create the network of kindred firms which constituted a major factor in the subsequent growth of the AI.

One of the general hypothesis of this dissertation is that the automobile firms in Spain, in common with Europe and the rest of the world, are changing their production system from the MPS to the LPS. While in general, this hypothesis was supported, there were differences between the firms based on the length of adoption of the LPS. Nissan Motor Ibérica introduced the LPS in 1986, Seat Volkswagen, and Fasa Renault introduced the LPS in 1990; General Motors España in 1991. Thus, the changes are quite recent. Seat Volkswagen, Nissan Motor Ibérica and Fasa Renault have all introduced a complete

new system of distribution of components and parts flowing from subcontractors to the assembly plant.

1.3 STRUCTURE OF THIS DISSERTATION

This dissertation is organized as follows. Chapter 2 contains the review of the theoretical literature and a discussion of the characteristics of the automobile industry including a brief highlighting of the attributes of the MPS and the LPS. Chapter 3 discusses the data the methodology, and hypotheses tested in this dissertation. Descriptive statistics highlight the attributes of Spain's motor vehicle industry. Econometric modeling is used to determine the structural changes of the industry, and a graph theoretic model is used to test for spatial restructuration. Chapter 4 discusses the network structure of the AI for the three types of production systems.

Chapters 5, 6, and 7 provide the empirical analysis of the structure of the AI in Spain. In Chapter 5, the AI is analyzed from a macro perspective in the context of the nation, the rest of Europe, and other automobile producer countries of the world. Chapter 6 provides the analysis of the structural adjustments, particularly the shift from the MPS to the LPS. The structure of the AI is compared with other industries, the manufacturing industry, and some other automobile producer countries. In Chapter 7 the spatial analysis is done at descriptive level, with illustrations of the application of the minimum path dispersion model for two firms. In Chapter 8 the major findings of the dissertation are summarized and suggestions are made for future research.

CHAPTER 2 INDUSTRIAL AND SPATIAL RESTRUCTURATION: A REVIEW OF THE LITERATURE

This study focuses on the structural and spatial changes brought about by the shift from the Mass Production System (MPS) to the Lean Production System (LPS) of manufacturing. While these terms are defined below, the transition from the earlier MPS to the LPS, often termed industrial restructuration, has far-reaching consequences on the competitive advantage of nations, regions within nations, and firms within an industrial sector. Industrial restructuring not only affects industries and firms, but also countries and regions (Tödtling 1992). In this chapter prior research the structural and spatial characteristics of this shift in production systems are discussed.

2.1 INDUSTRIAL RESTRUCTURING

Industrial structures underwent rapid change in the advanced economies in the 1980s. These changes in the industrial structure were a result of the adaptation of firms to the new market conditions resulting from the globalization of production and consumption processes. Globalization increased competitiveness among firms, particularly under conditions of market saturation. Market saturation was endemic in many industries (Piore 1986; Piore and Sabel 1984), particularly the automobile, steel and related manufacturing industries. Other contextual characteristics of the contemporary manufacturing industries were fragmented demand (Harvey and Scott 1988; Gertler 1988; Schoenberger 1989; Gibbs and Jenkins 1991), entry of new firms into the manufacturing and related service sectors, rapid rates of innovation, increased investment in new technology and rapid obsolescence of existing technology (Rotwell 1983; MacLachlan 1992; Scott 1992).

Many of these characteristics were also found in the automobile industry, particularly fragmented demand, rapid rates of innovation and economic obsolescence of technologies. Industrial restructuring in the automobile industry was an efficiency-based response to global competition (Business Week 12 June 1982; Hoffman and Kapinsky 1988; Hudson and Sadler 1989). In order to adjust to the dynamics of new global competition (Berry 1989), firms were compelled to adopt various strategies in order to maintain their competitiveness. Some of these were

- production restructuring and adoption of flexible technologies,
- flexible specialization, vertical disintegration, and strengthening of the network economy,
- labor shedding, job rescaling, and new definition of management roles,
- decentralization of production,
- de-industrialization of old industrial areas.

Each is discussed below.

2.1.1 Production Restructuring and Flexible Technology

A major attribute of LPS is its emphasis on flexibility. Flexibility in production has manifested itself in several manufacturing industries and in the service sector, among which the automobile industry is one of the pioneers (Christopherson 1989; Schoenberger 1989; Gibbs and Jenkins 1991). Different forms of flexibility can be identified: flexible technologies, flexible integration, flexible specialization, and flexible accumulation and growth of the flexible firm (Sayer 1989; Gibbs and Jenkins 1991). In this chapter these several forms of flexibility are grouped into two broad categories: internal and external flexibility of a firm. Flexibility related to the labor tasks and job development, as well as to the technology of production occurs *inside* the firm and is discussed here in its relation to production restructuring. Flexibility of a firm in its relation to subcontractors and supplier firms occurs *outside* the firm, and is called flexible specialization. This is discussed in section 2.1.2.

The introduction of any innovation changes the input structure in an industry. For instance, introduction of new technology commonly changes capital / labor ratios, causing enhanced productivity, reduction in labor use and increased demand for new skills in the work force (Holmes 1983). Production strategies change in order to adapt to the new technology, and management strategies as well are required to adjust to new production strategies (Goddard 1980). Thus, the introduction of innovations alters the overall mechanism of a firm's production system through a domino effect.

The Lean production system is a dominant innovation in the contemporary phase of industrial restructuring (Womack, Jones and Roos 1990; Debbage and Rees 1991), adopted by the firms in order to gain competitiveness (Sayer 1986; Schoenberger 1987; Mair, Florida and Kenney 1988; Oliver and Wilkenson 1988; Womack, Jones and Roos 1990; Law 1991; Wells and Rawlinson 1992). However, the LPS was not primarily a technological change (Linge 1991; Wells and Rawlinson 1992); it was a new management concept which increases the efficiency of a firm through greater flexibility in the use of labor and permits machine inputs and greater differentiation of output to respond to changing consumer preferences. The LPS initially increased flexibility *inside* the firm (Scott 1992) through the introduction of modifications in the existing MPS technology, which did not imply large investments in technology[1]. Flexibility increased as smaller,

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[1] Although at the beginning the LPS did not have heavy technology investments, its posterior development has been accompanied by large investments in new technology

multifunctional machines replaced the use of dedicated machines common to the MPS. For example, in the Toyota factory in Japan, where the LPS started in the stamping section, rollers and simple mechanisms were used to move dies in and out of position in order to make several parts of the car (Womack, Jones and Roos 1990). This enabled the production of different parts as needed without having to build up a large inventory of parts. These initial modifications sparked off a new production system, which implied:

- the employment of higher-skilled and higher-educated labor,
- different way of developing labor tasks,
- different relations with suppliers,
- changes in management roles,
- increasing investigation and adoption of flexible technology.

While the main goals of the LPS are to reduce production cost and increase global productivity (Monden 1984, 1); the LPS centers its internal strategy by keeping the automobile parts inventory to a minimum, using a "kanban" (meaning signal) method in order to start the production of any part of the car in the assembly plant in response to production needs at any given moment (NUMMI 1988, 3; Im 1989; Imai 1989; Osleeb and Ratick 1990, 50). In the LPS each step of the manufacturing process is done correctly the first time -even if the assembly line moves slower as a result; by quality control at each level of production; by constant introduction of improvements in the output; and by discharging waste and procuring regularity during the production process. In addition, the industry continually reduces the amount of human labor that goes into each car; there is a

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development; like the implementation of FMS (Flexible Manufacturing Systems) discussed below.

constant increase in worker's skills; and the labor is organized to work in teams (Womack, Jones, and Roos 1990; Linge 1991). The results of the application of this system are, basically, a flexible system of production with the use of flexible machinery by a flexible and responsible labor force (Schoenberger 1987, 207; Monden 1984, 3).

By the end of the 1970s, LPS had become the world's best standard for the automobile and other industries (Mair, Florida, and Kenney 1988; Altshuler 1985). The benefits of this system include a dramatic reduction in the amount of time required to produce an automobile. Globally, this system of production is capable of selling diverse and high-quality products at lower cost, thereby meeting the highly fragmented demand of the market (Dertouzos, Lester, and Solow 1989, 178-180). The outcomes of this new system in industrial processes are different from the results obtained by the Mass production system. The LPS allows factories to be smaller and more compact, and to build closer ties between suppliers and assembler (Child Hill 1987). With the introduction of these improvements, the LPS developed as a new model in the industrial production system and created a competitive advantage[2] over the MPS (Porter 1990).

Hence, the LPS, while it started in the automobile industry in Japan, is continuing to replace the earlier Mass production system in various manufacturing industries around the world (Abegglen and Stalk 1986; Sayer 1986; Schoenberger 1987; Mair et al 1988; Oliver and Wilkenson 1988; Womack 1990; Law 1991). In this section the contrasting attributes of the LPS and the MPS as discussed in the literature are high lighted.

2 "Firms create competitive advantage by perceiving or discovering new and better ways to compete in an industry and bringing them to market, which is ultimately an act of innovation. Innovation here is defined broadly, to include both improvements in technology and better methods or ways of doing things. It can be manifested in product changes, process changes, new approaches to marketing, new forms of distribution, and new conceptions of scope." Porter (1990, 45).

Changes in the production system brought on a different conception of labor tasks -discussed in Section 2.1.3-, and the enhancement of innovation in flexible technology. The speed of technological change in the 1980s has became so rapid (Ironmonger 1983) that the increasing use of the FMS[3] began to drive the manufacturing system towards more efficient ways of input combination, although it required greater labor skills and upgraded management competence (Jaikumar 1986). Hence, the flexible technology redefined both production factors and product markets in such a way that it increased substitutability from both the demand and the supply sides; i. e., using various inputs to produce diverse outputs in different amounts. Diversification of tastes induced the development of technology capable of producing small quantities of large number of different outputs (Jaikumar 1986; Bianchi 1990).

In the MPS, in contrast, technology was designed for producing large quantities of a standard output, which remained in the market for reasonably long periods of time. Thus, machines were suited to the production of a commodity not requiring major changes; for instance, in automobile production, dies were immobilized in the stamping machines for years without replacement (Bianchi 1990; Womack, Jones and Roos 1990). Consequently, it was very difficult to make modifications: even in a cyclical industry, like that of the automobile, any change would take months to obtain some positive results. Consequently, the industry lacked flexibility to adjust to the fluctuation of the market place.

3 "A flexible manufacturing system (FMS) is a computer-controlled grouping of semi-independent work stations linked by automated material handling systems. The purpose of an FMS is to manufacture efficiently several kinds of parts at low to medium volumes. All activities in the system (...) are under precise computer control." (Jaikumar 1986; Womack, Jones, and Roos 1990).

The massive introduction of new technology during the 1980s occurred, in some countries, in new small firms (Rotwell 1983). But cooperation between small and larger firms seemed very important for new investment in technology in small firms. In the majority of cases small firms needed to be linked to industry networks, that is be "part of a specific milieu[4]" (Tödtling 1992, 1568). Alternatively, they have a weak investment base for innovation (Schoenberger 1987; Sayer 1989; Gibbs and Jenkins 1991).

The LPS also activated mechanisms that increased flexibility *outside* the firm's walls through the adoption of JIT inventory system which, by reducing inventory in the assembly plant,created a different organizational structure of suppliers and assembler (Hay 1988). The automobile industry has two major sectors: the assembly sector, and the parts and component sector. The behavior of both varies at all levels of the industry and the firm. While these sectors are discussed in depth in Chapter 4, the assembly sector is formed by the assembly firms, which produce the car by using major components such as engine, transmission, gears, and so forth produced by component firms. The component sector is formed by the producers of discrete parts and major components, as well as the basic tools of the car.

One of the main restructuration caused by the JIT in suppliers network, was the organization of component firms into different tiers (Sola 1990; Womack, Jones and Roos 1990; Linge 1991). Through the introduction of different layers of suppliers: first-tier and second-tier suppliers (Wells and Rawlinson 1992), assemblers reduced the number of suppliers in order to decrease the cost of monitoring quality; firms shifted from double-sourcing to single-sourcing (Cohen 1983; Nissan Motor Ibérica 1991, Structured interview). Monitoring of quality by the assembly firm would also be extended into the

4 Milieu "is a complex system made up of economic and technological interdependencies." Maillat (1991, 113-114) in Tödtling (1992).

production processes of the component plant, even before the component arrived to the assembly plant. In general, this procedure of checking component quality standards by the assembly firm was done by sending assembly plant technicians to its suppliers (Linge 1991).

The first-tier suppliers were responsible for working as an integral part of the product development team. Design of component systems was primarily done by the first-tier suppliers (Burt 1989; Womack, Jones and Roos 147, 1990; Linge 1991). This was possible as the suppliers had longer term contracts (Linge 1991), and the assemblers provided occasional help in accessing credit and in engineering the design of new components. Each of these suppliers produced different components, so they did not compete against each other, and could maintain a two-way flow of information with the assembly firm on how to introduce improvements into the manufacturing process. On the contrary, in the MPS, assemblers worked on the product development and provided drawings to several suppliers, seeking bids for a given level of quality, specifying the number of allowable defects per 1,000 pieces (Womack, Jones and Roos 1990). There were two negative effects. Firstly, the suppliers did not make improvements in the manufacturing process due to the short term contracts; and the competition between suppliers for the winning bid blocked the flow of information that could have improved manufacturing techniques. Secondly, the level of quality did not improve because assemblers knew very little about their suppliers' manufacturing techniques.

In the LPS, suppliers considered to be in the second-tier were assigned to manufacturing individual parts. Since they did not specialize in any particular component, they could also share information with the assembly plants and improve the whole production chain. The production chain of value-added is defined as the way in which raw materials and other inputs are transformed into the final output -products or services- through a series of operations (Christensen et al 1990). In a production system all these operations might be regarded as a value-adding chain in which transactions take place between each operation. The way of organizing these operations, and the transaction costs attached differs in each production system; this concept leads to the idea of networks which is discussed below in Section 2.1.2.

In the LPS, coordination of the flow of parts within the supply system on a day-to-day basis was carried out by the assembler -the Just-in-Time system-. Frequent and timely delivery, as the JIT proposed to manufacturing firms, can be an example of how a company creates competitive advantage by better optimizing or coordinating its links to the outside. The idea was simply "to convert a vast group of suppliers and parts plants into one large machine, by dictating that parts would only be produced at each previous step to supply the immediate demand of the next step" (Womack, Jones, and Roos 1990, 62). This sequentiality was also attained in the components produced inside the assembly plant (NUMMI 1988). Thus, these mechanisms eliminated practically all inventory (Sugimori, Kusunoki and Uchikawa 1977) and it meant that if only a small part failed, the whole production system came to a halt. "This is precisely the power of the LPS, it removed all safety nets and focussed every member of the vast production process on anticipating problems before they became serious enough to stop everything" (Womack, Jones and Roos 1990, 62). This coordination among firms implies a flexible specialization, which is discussed in the following section.

2.1.2 Flexible Specialization, Vertical Disintegration and Strengthening of the Network Economy

The flexible specialization process is the division of the production process into different segments which are contracted to separate firms. These firms employ highly skilled labor, use flexible manufacturing, and information technology in order to achieve

greater flexibility in output and thereby increase efficiency (Sabel 1987; Wells and Rawlinson 1992). Flexible specialization became important with the decrease in demand for standard outputs and the need to meet changing consumer demands (Bianchi 1990). Firms able to satisfy consumer preferences with differentiated products were able to reduce production cost by not having to maintain the heavy machinery and large inventory required for mass production. However, flexible specialization increased a firm's dependence on the collaboration of workers and subcontractors in meeting the market's final demand (Storper and Walker 1989; Scott 1992). This led to the idea of industrial agglomeration and creation of inter-industry production networks (OhUallacháin 1991). Cooperation among firms emerged as one of the most important factors in industrial location.

Flexible production needs guided industrial restructuring (Thomas, Uribe, and Romijn 1991). Due to rapid changes in tastes, and therefore demand for commodities, firms were unable to predict their production levels with accuracy. During economic downturns, larger firms reacted to the economic crisis by closing down whole sections of their own factories (New York Times, 17 November 1986), and by subcontracting these activities to small specialized firms (Ottati 1988). Processes which were more costly in-house -either because their own plants could not be used to full capacity, or because new technical equipment could not be easily adapted to the raw materials utilized- were the activities most affected during a crisis. Consequently, the larger firms used several subcontractors for the tasks that were no longer performed in-house. Large corporations underwent transformations and began to resemble autonomous, small- or medium-sized firms in industrial districts (Sabel 1989; OhUallacháin 1991). Additional new features of flexible specialization were the cooperation between designers and production experts, broader skill requirements of the labor force and training of workers and subcontractors (Sabel 1987).

Managers were encouraged to spin off and create autonomous firms when there was a lack of specialized small firms within the network structure (Ottati 1988). Even workers who had been retrenched from larger firms due to rationalization bought machinery from their former employers and accepted the idea of setting up their own firm. The large corporations and medium-to-large firms maintained a close relationship with these smaller, autonomous firms, who then became their subcontractors. Through these adjustments, large corporations reduced their costs of production and increased flexibility of output. This had a spatial expression in the form of industrial districts (Sabel 1987; Cooke and Imrie 1989; Scott 1990; Cooke and Morgan 1991; OhUallacháin 1992) which consisted of larger firms and numerous interlinked specialized subcontracting firms (Sabel 1987; Amin and Robins 1990). Thus, the current pattern of the industrial world is represented as a patchwork of dense production agglomerations linked together by an extensive system of interregional transactions (Scott 1992).

In the contemporary phase of industrial development, innovations in information technology are critical. They change urban and regional systems through their impacts on production and distribution processes. Empirical studies done on computer networks (Hepworth 1986) and in diffusion of robot technology (Camagni 1989), document that innovations in computer networks and, in general, improvements in high technology cause changes in the movement of people as well as material production inputs. In particular, job opportunity in a particular region was affected by the distance-shrinking effects of computer networking (Hepworth 1986, 407-408).

All of these processes taking place led to a 'vertical disintegration' of the corporation. Production costs were reduced as firms "unloaded" their costs on to their supplier firms. Vertical disintegration also permitted product variability as well as greater flexibility in the quantity of output (Ottati 1988). Economies of scope began to be important, with standardization in each phase and subphase of the production process.

External economies -used by Perroux (1950) (also in Scitowsky 1954) in his growth pole theory- also become important in explaining interdependencies between firms in an industrial district. Perroux used the growth pole concept to explain and identify various growth -introducing mechanisms associated with a propulsive unit. This concept clarified how economic units were connected to each other and how the development of one firm was directly dependent on what happened to other firms. The expansion of one firm was directly connected to investment, or expanding production in other units of the economy through multipliers; the expansion or contraction worked its way through the whole system of spatially interlinked firms. It is possible to interpret the spatial aspects of flexible specialization in the development of industrial districts through this concept.

The strengthening of industrial networks, resulting from flexible specialization and subcontracting, provides an useful explanation of recent industrial restructuring. Industrial networks are composed of nodes and links in which the output of a production unit is part of the production chain of a final output produced by other firms (Christensen et al 1990). Both the MPS and the LPS use intermediate products and thus industrial networks are important in both. Interrelations between independent firms change when the production moves from MPS to LPS. One of the differences between the MPS and the LPS networks is that the MPS has a weaker network with supplier firms, with short term contract (Wells and Rawlinson 1992), and clear *domination* of larger firms over others. LPS shows a pattern of more permanent links between firms, with a common final production goal, and which requires *cooperation* between firms in different aspects, like R&D and labor training. While both the MPS and the LPS use transportation networks to move intermediate products to the firm and to send final products to the market, the LPS system is more dependent on interfirm transportation and communication networks, relative to the MPS, because of flexible specialization and vertical disintegration.

These different forms of relationship between nodes in the network -domination, cooperation- have been connected with the theoretical literature on "linkage networks" (Taylor and Thrift 1982) in industrial environments since the 1950s, and the concept of "power networks" between firms in the linkage approach opened up the perspective of dominant and dominated firms in linkage networks. The costs associated with establishing network relationships has been examined by Johanson (1991; Williamson 1981; Christensen et al 1990). Johanson discusses the sunk cost and the large investments required to develop network links. Tödtling (1992) notes that recruitment of members and type of linkages within a network have to be carefully delimited in order to make firms profitable and efficient.

The importance of networking increases qualitatively and quantitatively in the LPS through enhanced cooperation between firms, technology exchange agreements between producers and suppliers, and subcontracting. Von Hippel (1988) notes that the firm's role in the network is not fixed; it changes depending on the particular functional role of the firm within the chain. There are strong relationships between specialization tendencies within the production system, strategic positioning of the firm within the network and the use of network relations in order to include different kinds of assets from other firms and organizations to increase the competitive advantage of the firm, which is a function of how well a company can manage this entire system.

In the automobile industry, firms are becoming more and more dependent on the resources of other firms, so an increasing share of the resources has to be provided by joint efforts which require specific investments and presuppose long-term commitments by the parties involved. The basic features of network-related developments could be studied from the value-added chain, in which the interpretation of production is a vertical market system supplied with support activities from horizontally integrated actors. A *value chain* of a particular industry includes a large stream of activities in which suppliers are an

important part of the company (Porter 1990, 43). The final output is based on the efficiency of the joint structure of the chain (Christensen et al 1990). The strength of a network is determined by the combination of skills and resources that none of the participants would be able to achieve independently.

Thus, a complex network of linkages in the automobile industry creates mutual interdependence between independent firms (Christensen et al 1990); consequently, locational research makes more sense if networks of interdependent firms are studied together. Firms are integrated into long production chains where coordination between firms within the chain is a necessary requirement for effective performance; the development of JIT deliveries further refined coordination and emphasized the interdependencies between firms.

The competitive advantage of a firm is a function of how well a company can manage this entire system. Frequent and timely delivery, as the JIT system proposes to the manufacturing firm, can be an example of how a company creates competitive advantage by better optimizing or coordinating its links to the outside.

Enhanced networking is feasible due to advances in information technology. The most important impact of information technology on spatial economy is through enlarging the information space. There are basically two vital functions of information technology in telecommunications: 1) it enables organizations to share centralized computer resources (software) among dispersed users; and, 2) it enables labor productivity generated by the application of computer technology at one place to be transmitted and used at any other (Heptworth 1986, 408). These two processes, separately or combined, are the ones which affect the spatial organization of labor and capital at a regional level. Information leads to re-evaluation of job opportunities on a larger spatial scale, and increases its potential as catalyst for regional development.

The most important characteristic of innovation in information technology is its potential for overcoming time and distance constraints on production and distribution processes (Hepworth 1986; Camagni 1989). It allows for controlling of "dispersed operations, and converting material intermediate inputs into electronic form such that they are transmittable over telecommunications lines" (Hepworth 1986, 407). There is no doubt that these technologies changed the relative location and relative distance of a manufacturing place or a tertiary activity very quickly, deriving a time, cost and space convergence (Abler 1975) and cost savings, in the same way the development of the phone or the rail system did in earlier production systems.

The network approach also changes the way in which innovations occur. In the MPS innovations were primarily made by the manufacturers of the product; sources of innovation vary greatly in the LPS (von Hippel 1988). Tödtling (1992, 1567) notes that innovations "take place in an articulated division of labor -not only within firms but also between them" . Network approach has replaced the traditional assumption that large assemblers were the only source of innovation. In the LPS, the innovation process is predictable, and is distributed across assemblers and suppliers (von Hippel 1988). In the CPS, in addition, consumers, dealers and other users are a source of innovation, as is discussed in Chapter 4.

2.1.3 Labor Impacts, Job Rescaling, and Management Roles

Massey and Meegan (1982) proposed a three part taxonomy for explaining production restructuring. Using the relationship between labor, technology, and productivity, they differentiated between intensification, technical change, and rationalization. They stated that *intensification* in productivity was achieved when only minor changes in labor practices or machines were introduced at the production points.

Intensification involved cost reduction with no major capital investment (also in Teubal 1983). According to Massey and Meegan *technical change* involves a major reorganization of the production process with high levels of capital investment in existing plant facilities. Production *rationalization* was a form of industrial reorganization which implied disinvestment, that included not only reduction in the maintenance of current facilities, but also closures of whole plants. They claimed that these three forms of industrial restructuring involved job loss. OhUallacháin (1991) and MacLachlan (1992, 129) noted that "none of the (these) forms of restructuring is a necessary and sufficient condition for employment decline within an industry". Other factors such as stagnation or declining market conditions could also cause loss of employment.

In the reorganization of production, which has taken place on a national as well as international scale, manufacturing has intensified capital investments. In the pressure to increase productivity and cut costs, capital/labor substitution occurred, resulting in the displacement of manufacturing workers and downward rescaling of jobs (Holmes 1983; Scott 1986). This is debated between scholars such as Massey and Meegan (1982), who claim that the reorganization and retooling of manufacturing forced layoffs of workers, and those who argue that industrial restructuring caused upward rescaling of jobs (Holmes 1983, 253) and changed the demand for employment categories (Johanson and Karlson 1986). Empirical studies suggest that there was little displacement of labor as a result of the introduction of information technology (Mandeville and Macdonald 1983, 171), but they showed that there was more job diversification or rescaling. For instance, manufacturing employees would not continue to perform traditional tasks in manufacturing, but they could be transferred to new activities. And in service industries such as banking, small businesses and local government, the overall staff numbers had been maintained, although they might be performing different jobs. Firms using computers increased their employment during the 1974-1979 period, and employment in firms that failed to use computers declined. Although the fact of labor uncertainty was used by unions in attacking new technology processes because it directly affected employment change inside the factory, in the aggregate introduction of new technology, it did not cause employment decline.

Regional competition and labor market characteristics are two related factors, and they changed together over time. On one hand, Johanson and Karlson (1986) observed that the configuration of the labor market depended upon the following components: R&D facilities, cultural opportunities and regional infrastructure. On the other hand, regional attributes depended upon the characteristics of the labor market and the level in which regional manufacturing was related to the spatial product cycle model. Hence, rescaling employment would provoke a region's new competitive profile, so it would vary the competitive advantage of an area.

The LPS called for changes in labor organization as well, and labor was organized into groups in which all members of the group were required to know how to operate all the machines for which the group was responsible. This made for a more flexible and skilled worker who was capable of doing different tasks in the production chain. Moreover, workers in the group were encouraged to make suggestions for improvements. Thus, technological change demanded more flexibility from both employees and the educational system. It required a readjustment of workers' career expectations. It sometimes brought disappointment to certain employees and opportunities to others, but above all else, it brought uncertainty to labor (Mandeville and Macdonald 1983, 172).

The functional nature of managerial skills also changed with the introduction of LPS. Chandler (1977, 1990) noted that in the modern industrial enterprise, which started at beginning of the century, management had been one of the most important factors for the development of the firm. The function of the manager was to run the firm while, most often, the owner(s) had little or no knowledge of what the work was about. Basically, the

enterprise defined by Chandler was run by a "visible hand", in which the senior executives of the firm coordinated the purchase of raw materials and intermediate products needed for production from outside production divisions, or subsidiaries. Otherwise, in the definition of Adam Smith, the firm was run by an "invisible hand", in which there were no financial or other relationships between buyers and sellers; i.e., a firm bought necessary parts and services from independent firms having only trade relationships among them, with the intermediate goods orders far from planned and coordinated in advance (Womack, Jones and Roos 1990).

With the Lean production system, coordination was not limited inside the walls of the factory; the executives coordinated how to get the intermediate products in small amounts from numerous suppliers and supervised their quality in the supplier firm in addition to their own firms as these products and services were supplied from external, independent units of production. Occasionally, the buyer had financial or some other type of relationship with the seller's firm. This managerial innovation in how to run a network of the firm could be termed as the "shaded hand".

Hence, within the firm the role of management basically changed with the LPS (Chandler 1990). Since the mid 1970s, a dramatic increase of company investments in "information intensive processing technologies" could be observed within, giving it larger flexible automation, and the role of managers in this innovation is fundamental. Comparison of Japanese and U.S. firms can illustrate the importance of managers. Although industries in both countries invested in information-intensive technologies, the system was more efficient in Japan than in the USA. Jaikumar (1986, 70) claimed that the lack of good performance in the US was due to bad performance on the part of the managerial class in US firms: "The U.S. companies used FMSs (flexible manufacturing systems) the wrong way ". The US managers were accustomed to producing mass products, even while using FMSs, and even though their usefulness was for diversifying the product in order to meet diversified demand. For example, a comparison made between U.S. and Japanese firms with similar levels of FMSs showed that while in the US the job-run per part was 1727, in Japan it was 258; so, US job-runs were almost seven times Japanese job-runs.

Thus, the role of managers is indispensable to the successful use of FMS ("US automakers reshape for world competition" 1982). The manager's role in these FMSs-CNC machines is to speed product development and encourage organizational learning, which improve the capabilities of the system.

2.1.4 Decentralization of production

From the last quarter of the 19th century to the first quarter of the 20th century, the MPS was developed, in which the main structural trend was toward transformation of a single-plant enterprise to a multi-plant firm or corporation. Chandler (1977, 1990) called this new form of organization in manufacturing production "modern industrial enterprise". The path of expansion of corporations through branches was determined by the strategy that each firm followed, which depended on a firm's intrinsic characteristics -like amounts and rates of profit, size of firm or level of investments (Erickson 1980; Healey 1982). The strategy of a firm centered on decisions regarding the diversification of its production facilities, selection of the degree of its product diversity and the determination of required or potential interdependence among the several integrated plants.

The expansion in size of industrial firms brought about a structural division of the firms' production sections and these sections spread out-spatially, first into other regions within the same country , and then around the world. They became multinational firms in which the headquarters were located in the home country, with different branches in foreign countries (Drucker 1986). Important decisions were centralized; for instance,

research and development (R&D) was done exclusively at the company headquarters in the home country. Affiliates, however, had full autonomy on systematic decisions in manufacturing, marketing, finances, and personnel administration. Affiliates were primarily managed by local professionals; only top management was recruited from the home country.

This was a general form expression of multinational or multiplant firms in the MPS (Birch 1979). Standardization of product and labor tasks allowed MPS managers to locate production facilities for different parts where factor endowments of a given area were more favorable for minimizing costs. Even though the dispersion of plants around the world started in the 1920s, it was not until the 1950s, that the MPS found its full spatial expression, that is, until manufacturing was fully dominated by corporate enterprises. Between 1960 and 1980 branch plants became the predominant form of global expansion.

It was generally recognized that this form of MPS was advantageous for the production of systematic, standard commodities, but there were disadvantages for the branch plant regions. For example, new employment generated in these region reflected a deformed or incomplete structure of the labor market. Technical and managerial jobs were concentrated at the headquarters while lower skilled jobs were the only ones offered at production sites (Hayter 1982; Chapman and Walker 1986). The expansion of a corporation through branches was closely related to the growth of a region, in the sense that branch plants generated a multiplier effect through increasing employment and improving labor force skills, affecting other firms of the area through external economies and subcontracting (Keeble 1972; Erickson and Leinback 1979; Erickson 1980; Healey 1982). While the primary concern for setting up branch plants in regions around the world was the availability of a cheap labor market, other factors also influenced location decisions, for example, a low cost industrial area, good infrastructure of transportation and communications, and favorable market conditions (Sayer 1989; Florida and Kenney 1990; OhUallacháin 1991).

With the LPS, decentralization is obtained in another way. The LPS allows for customized products, therefore requiring the flexibility for production and vertical disintegration discussed above. Thus, decentralization in the LPS can be viewed as a network of firms performing different functions, in which diverse linkages, -such as technology, R&D and subcontracting- are the predominant ones. A change in technology was fundamental to altering the international location of production (Stout 1983, 123-124), and flexible technology shaped the new industrial landscape at the regional level (Rotwell 1983; Tödtling 1992).

In summary, decentralization in the MPS system expressed itself through branch plants; decentralization in the LPS is expressing itself through a network relationship between firms and their subcontractors.

2.1.5 De-Industrialization of Old Industrial Areas

The shift from the MPS to the LPS has caused earlier manufacturing regions to decline as new areas adopted the LPS. For instance, Storper and Scott (35, 1989) stated that the successful development of "flexible production complexes" has occurred in "places without a prior history of Fordist industrialization, where the relations of production and work could be reconstructed anew". Here the term Fordist industrialization refers to the MPS. Also, Jones and North (1991) stated that in the UK, Japanese investments have chosen "non-traditional sites" of industrial labor.

In general, differences between locations have been explained by the difference among diverse locational and comparative advantages (Johanson and Karlson 1986; Debbage and Rees 1991), which are: natural resources, infrastructures, labor force, and

production knowledge among others (Porter 1990). Changes in the production systems also suggest changes in the requirements of the locational and comparative advantages of a region. Thus, the difficulty in adapting to these new requirements for a region might cause de-industrialization. The concept of de-industrialization is related to the characterization of locational advantages of a region, and it might be used in different ways: 1) it may define the counterpart of a service activity process in the presence of stable or growing total employment; 2) otherwise, it may indicate a process of industrial job losses without the counterbalancing gain of tertiary jobs; 3) it may also be used to indicate a process of decline in international competitiveness, such as the British experience. The indicators that may be used for recognizing de-industrialization are the following: a reduction in the share of industrial employment, a reduction of industrial and total jobs, and a permanent disequilibrium in trade balance (Camagni 1991).

Some of the primary causes of de-industrialization of old industrial places are the increasing trend toward a service-based economy from a manufacturing-based economy, technological change and product innovation (Twaties 1978; Goddard and Twaties 1980; Malecki 1980; Healey 1981; Thomas 1981) and the incapacity of some older industrial areas to respond to the requirements of the new industrial production system discussed above.

The capacity to adopt new technology is one of the most important factors in the revitalization of industrial regions, where revitalization can be viewed as a process that implies a clean break with the old industrial structures in a region and a positive response to the challenge of a highly unbalanced situation (Camagni 1989; 1991, 79) produced by the transition towards a new type of production system. He notes that the conditions for success in revitalizing old industrial regions seemed to be the existence of a rich urban environment capable of making changes in the milieu of "collective (economic) agents".

While de-industrialization is a common phenomena in many older industrial areas, the relationship between LPS and de-industrialization is not definitive. Whereas in Great Britain, de-industrialization has accompanied the decline of international competitiveness, in industries such as automobiles in Spain, there is no example of de-industrialization in older industrialized areas such as Barcelona and Madrid. While specific firms such as Seat may have declined in competitiveness, the region has not undergone de-industrialization due to the location of new firms, including automobiles, in that region.

2.2 SPATIAL IMPLICATIONS OF INDUSTRIAL RESTRUCTURING

Classical industrial location theory attempted to explain the location of economic activity and predict the spatial pattern of the location of economic agents. Most of the theory was concerned with location decisions of goods-producing firms.

Alfred Weber (1909) attempted to find the optimum location point of a manufacturing firm based on the minimization of transportation cost. He located the firm between the points of raw material extraction (supply), and the points of demand for the output of the firm (market). As in classical economic theory, producers were assumed to be 'price takers', firms were profit maximizers, and production costs were assumed to be the same everywhere. Under these assumptions, whether the firm located closer to the market or to the source of raw material depended, mainly, on how the firm was minimizing its total costs of transportation.

Weber considered factors such as availability of low labor cost and agglomeration as friction agents, jointly with transportation cost. These factors actively contributed to the location process of a plant. To solve this problem, Weber introduced the concept of 'isodapane' or lines joining points of equal transportation cost, which he contoured on maps to find the optimal minimum cost location.

Subsequent studies followed the Weberian principle. Walter Isard (1951) studied the location of a single firm in which, as in Weber, the production occupied at one point -a point he tried to locate optimally. He made two assumptions: 1) labor and other services were ubiquitous; and, 2) none of the quantities of inputs, used in transformation to get a given level of output, changed as the potential production point was moved from one place to another. Only the distances in obtaining raw materials or the distance in transporting the final product to the market changed as the point of production moved. Defining the amount of raw materials required per ton of product as invariable with any shift in location, and simplifying the problem by using as weight units the amount of raw materials required per ton of product, then the distance inputs, which were variables, became the actual distances. Transportation rates were the prices of these distance inputs. In order to minimize the cost of producing a given level of output, a firm would choose the point at which the quantities of input required for each final product and transportation rate were minimized and coincided.

Later studies became more complex. Energy costs, scale and agglomeration economies, demand and revenue potentials, competition and decision-making procedures were added to transportation and labor costs (Karaska and Bramhall 1975). Moses (1958) relaxed the assumption used in the Weber and Isard models of equal prices of input and output at any location. He suggested that the proper combination of inputs and output, together with possible locations, would predict the optimal site of a firm.

In the analysis of a manufacturing firm, August Lösch (1954 translation) introduced variations in the structure of demand using the demand curve. He postulated that there was a point in space where transport costs would reduce demand to zero. He began by assuming that a country consists of a flat plain with evenly spaced population and raw materials and studied monopolistic competitive equilibrium in which the dimension of product differentiation was space. Through, theoretically independent, his approach had certain parallels to Christaller's Central Place Theory.

Hottelling (1929) considered the optimum location of two firms in which the decision of one firm concerning the choice of location for its plant was affected by the locational choices of its competitor. Under assumptions of demand evenly distributed along a finite line, both firms would locate at the center, creating a concentration of firms. This interdependence approach was one facet of the problems dealt with in the theory of oligopoly.

Greenhut (1952, 1987) introduced in his theory variations in cost and demand in a maximum-profit plant location. Production cost varied significantly across the landscape, so there were high-cost and low-cost locations. What emerged from his analysis was that high-cost locations tended to be inhabited by small scale firms and that most industrial structures were characterized by a relatively small number of large firms and a comparably large number of small firms. Furthermore, agglomeration forces emerge whenever the managers in one company could identify the low-cost locations; it followed that the managers in other similar (and non-similar) companies were likely to identify the same locations. On the other hand, location policy was also likely to be characterized by a substantial degree of inertia, i.e.; the spatial allocation of resources in a particular industry was likely to change significantly only in response to a major change in technology or in cost conditions. The contributions reviewed so far represent an important part of the literature that constitutes the body of classical industrial location theory.

The basic factors that were considered the most important elements in traditional location theory are currently considered to be so significant (Massey 1973; Massey 1979; Massey and Meegan 1979; Sayer 1982; Holmes 1983; Christensen et al 1990). The contemporary trend is to study industrial location from a more macroeconomic perspective as microanalytic studies on the determinants of firm behavior overlooked some important

factors. For example, in studies of the reasons why the Massachusetts area has been so successful in attracting high technology firms, three important factors were noted: the intersection of more than sixty five universities in the area, the availability of venture capital in the Massachusetts banking community, and the supportive relationship between state government and businesses (Lampe 1988). None of these were considered in classical location theory.

Alterations in the pattern of firm locations and, consequently, in its analysis were produced by different factors in which the substantial decrease in the degree to which manufacturing firms relied on access to low cost labor and raw materials in total industrial production in recent years played a very important role. Newer firms rely more on advanced technology and capital intensiveness, and are dependent on a larger sophisticated labor pool.

In 1967, Pred (1967, 1969) introduced the behavioral approach to locational analysis of a firm, emphasizing factors, other than purely economic ones, which affect locational decisions. Since then, new concepts in social science emphasizing behavioral aspects of individuals and organizations have contributed new insights. As a consequence, the firm was considered to be a more flexible unit with respect to location (Hewings and OhUalacháin 1983). Optimum location was not just seen as a question of choice of a site based on technology, product, organization, etc; but rather as a matter of an ongoing process of interactive adjustments between changes in the firm and changes in the environmental conditions in the choice of location (Christensen et al 1990, 29).

In the 1960s and 1970s, there was a common understanding in the field that the innovation process of the firm and its spatial manifestation went through a sequence of phases (Hamilton and Linge 1981). That was part of the product-cycle model (Vernon 1966; Hirch 1967; Moran 1979; Tödtling 1992; Rees and Stafford 1986), in which the invention phase, development and design of a product, as well as the diffusion processes, were analyzed as different stages of the product, firm and industry. Then, as these different stages were developed, diverse type of locations were identified. Thus, in the early phases of production invention and innovation, as well as in the early phases of the diffusion process firms were considered to be concentrated in the largest agglomerations; whereas the later phases, consisting of process innovation and late adoption, as well as non innovator firms, were seen to be more in non-metropolitan areas and peripheral regions (Tödtling 1992).

After the 1970s, the "structural approach", with ideas common to the behavioral approach, started gaining ground. Its point of departure was the rejection of any "independent" locational decisions, in the sense that the locational choice of the firm was related to investment decisions from a *strategic* perspective (Erickson 1980, Healey 1982, Chandler 1990). The investment decision was a part of the strategic choices the firm could weigh, and the strategy was not isolated, but rather it was in a setting where regional structures framed the environment where the firm had to locate.

Different approaches (Christensen et al 1990) also note that the firm's optimum location -where to produce- is based on characteristics of the firm such as how much has to be produced, for whom and using what technology. The question of where to produce is not limited to a simple question of location; it is more a question of activity location.

Another approach to the location of firms linked the structural theory of industrial location -in which the "network concept" was interpreted as an underlying structure in contemporary location- to the regional theory. In this line of thought, concepts such as agglomeration, linkages among firms, growth poles and external economies are presented as crucial tools for understanding the location of production activities and firms in modern economies.

The economic space where a firm locates is also shaped by functions such as "economic linkages" between plants, firms and industries (Perroux 1950). With this approach to

locational matters, different features such as regional supply-side conditions, the absence or presence of able suppliers, work force, institutions, etc., are very important in analyzing the conditions under which firms could create networks with other firms in space. For instance, several authors (Massey 1984; Walker 1989; Scott 1990) noted that the existence of highly relationing networks found in the implementation of the LPS in manufacturing led to rapid flexible production agglomerations, expansion of external economies, and deepening division of labor in the US and in Western Europe.

2.3 RESTRUCTURING OF THE MOTOR VEHICLE INDUSTRY: THE EMPIRICAL RECORD

The automobile industry (AI) has been in a constant process of structural change since its beginnings. From its beginning as a craft industry in the late 19th century, it has been through several modifications that permitted economies of scale and scope. The shift from the MPS to the LPS is only the most recent structural change in the industry. For the last twenty years, the causes of restructuring in the automobile industry can be found in the globalization of production, increasing fragmentation of demand, market saturation and the goal of maintaining competitiveness -mainly with the push of new entrants in the global industry, such as the Newly Industrialized Countries (Bustelo Gómez 1990; Vogel 1991).

The main characteristics of assembly plants at the early stages of the industry consisted of a great quantity of plants, all of them very small: "a small machine shop, boatyard, or wagon works, might have become an automobile-assembly plant." (Boas 1961, 219). The change in production technology introduced in 1914 caused big savings in production costs through economies of scale; which made it very difficult for the smaller manufacturers to compete with larger companies, so the outcome was a reduction in the number of plants and an increase in the size of the survivor firms.

While the MPS was established in the 1920s in Ford factories, it dominated the basic developments, not only of the automobile industry, but also of the general manufacturing system until the 1970s. The main feature of the MPS was the invention of the assembly-line method of production and this implied the development of machinery dedicated to single tasks and strict job demarcations with multiple skill classifications for the workforce. There was clear divisions between employees responsible for mental and manual labor (Albernathy 1978; Aglietta 1979; Altshuler 1985; Sayer 1986; Holmes 1987; Mair, Florida and Kenney 1988). This allowed for production of low-cost automobiles in great quantities for a mass market (Mair, Florida and Kenney 1988; Bianchi 1990). To achieve the goal of reducing production cost through economies of scale, Ford concentrated on a uniform product with a single color: the model T. By 1924, all new car manufacturing processes were done by Ford in a profound, vertically integrated structure (Dertouzos, Lester and Solow 1989, 176-177) from carrying and processing the raw materials (iron and ore) to assembly of the car. At the time, a car manufacturing process took 81 hours (Blackburn 1991, 42).

Later on, applying MPS, General Motors went one step further by diversifying the output. Economies of scale were obtained through mass production of the major parts of the car (engines and transmissions); while only cosmetic changes were introduced to other parts of the car. The final output offered relatively superficial product differentiation with small differences in prices (Dertouzos, Lester and Solow 1989, 176; Schoenberger 1987, 202). However, this was an increased response to consumer preferences and tastes in demand relative to the earlier phase of the production of a car with a single color and single design.

While Henry Ford, and Alfred Sloan (at General Motors) invented the assembly line and the diversification of final output to meet differences in consumer tastes, Frederic Taylor improved the MPS with a study of methods of time-and-motion, where jobs were precisely defined and delineated -sometimes the MPS has also been called the Taylorism method. Job subdivision reached all levels of factory functions, and was also introduced into the machinery, with every machine designed for each specific task. Narrowing of worker skills and the designing of specific task oriented machines allowed for increased productivity and decentralization of the corporate organization with increased economies of scale. In the long run, it produced an inflexible system.

As a result of this inflexibility, monitoring of quality occurred at the end of the production line, and problems were corrected after the product had been made, for stoppages in the assembly line were not allowed. Job monitoring and performance evaluation were done by professionals, and not by the workers in the plant. A period of 5 years was required to develop a new product (Dertouzos, Lester and Solow 1987, 178; Linge 1991). From an economic point of view, MPS drove the industry toward standard, long-run production in order to minimize capital and to maximize short term profits. While the MPS achieved steady productivity increases for over 20 years (Mair, Florida and Kenney 1988), since early 1970 its rates of productivity improvement declined as a result of difficult labor relations, technical problems in reorganizing production, increasingly obsolete technology and weak product development (Aronowith 1973; Aglietta 1979; Altshuler 1984).

The term Lean Production System was coined by Womack, Jones and Roos (1990, 8) to distinguish the characteristics of this system, invented in Toyota automobile factories in 1973, from those of the Mass production system. Toyota created this system and developed it in Toyota City, Japan, where 9 of its major assembly plants and most of its major suppliers were located a few miles apart from one another within a vast urban industrial complex. The levels of efficiency that the Toyota system obtained with respect to Ford's were astonishing: Toyota's production per worker was three times that of Ford; and a Toyota engine plant took up only 300,000 square feet compared to 900,000 at a comparable Ford facility (Child Hill 1987, 30).

In a way, Toyota City was based on Ford's Rouge Complex (Hounshell 1978). Ford's ideal was to build a completely integrated system: steel, glass, engines, car bodies and components, all produced at one place. But the difference between these systems was the way of organizing production: standardization of product versus fragmentation and fragmented workers' skills versus group cohesion and workers cooperation (Friedman 1983; Sheard 1983; Monden 1984; Altshuler 1985; Sayer 1986; Holmes 1987; Cusumano 1989). Although global markets had been achieved through improved transportation and communication, the Toyota production system was directed towards concentration of production facilities and intensified integration of networking between suppliers and assemblers in a local region.

The economic agents of the AI operations are the assemblers and the component producers, but the relationship between them is quite complicated because there is a network with links, not only between assemblers and part producers, but also among component suppliers and among assemblers. For instance, Child Hill (1987) notes that

"The chain in the auto parts production can be broken down into four basic elements: major mechanicals, like the engine and drive train, which tend to be produced by major assemblers themselves, or by joint ventures with big supply companies; vehicle systems, like lighting, braking, suspension steering, and instrumentation, which are generally produced by transnational special system suppliers (...); finished parts for which fit and appearance are crucial, like seats, dashboards, and major stamping -these are mostly produced by the majors or in close collaboration with suppliers; and minor parts,

like fasteners, trim, glass and tires, which are usually purchased from outside suppliers" (Child Hill 23).

In the patterns of location of the automobile industry, the location of a plant depends on where other plants of the value chain are located in order to maximize the efficiency of the whole structure of the chain and to achieve greater strength in the network.

2.4 SPATIAL MANIFESTATIONS OF RESTRUCTURING IN THE AUTOMOBILE INDUSTRY

The automobile industry started in Detroit (US) and, until the 1950s, the US had the largest automobile industry in the world. In this period, Europe had already started producing cars but in lower quantity. Japan became a large car producer in the 1970s. Thus, the historical beginning of the AI is in the US; later Europe and Japan also became large producer regions[5] (Gunwald and Flamm 1985). In the 1980s, Japanese and European firms reached the economies of scale required to challenge the monopoly held by US companies in the world market; thus, Japanese and European firms began to spread around the world, so the AI required a global competitive strategy. The automobile industry also faced a "global market", in which the oil crises of 1973 and 1979, and government regulations, caused a big expansion of the market of small, fuel-efficient cars

5 As Ward (1982, 447) pointed out: "The Motor Industry, from its beginnings in Europe and the North America at the end of last century, has grown to become one of the world's largest industries, employing in the region (Europe) two million workers".

in Europe, the US and the rest of the world, and led toward an unprecedented global convergence in product characteristics.

With the MPS, the automobile industry turned toward "global integration". The global convergence in demand afforded car manufacturers the opportunities to pursue a global strategy -one where firms produce different parts and assemble finished vehicles in different countries, depending upon the advantages offered in each, and where they could integrate their operations on a transnational plane (the world car) (Cohen 1983; Child Hill 1987, 26). In the 1980s, other industrializing countries, such as Brazil and South Korea, began to produce for the global market (Bustelo Gomez 1990; Vogel 1991). The shift in location in the AI is significant as new competitor nations with cost advantages broke into the industrial market.

The location of automobile assembly plants has had different trends since its foundation. Most authors seem to agree that the spatial structure of the automobile assembly plants was not static; distinctive patterns depended on different stages of the life cycle of the industry (Rubenstein 1986). For example, although the location of assembly plants in the US was, until the 1950s, near important points of demand (Boas 1961, 229-230; Glasmeier and McCluskey 1987, 146), the points of location changed. Boas distinguished three assembly plant belts in the U.S.A. at the beginning of the century: the 1900-1905 period, in which the plants were located on the East Coast (Boston, Philadelphia, and New York); the 1909-1911 period in which the mid-western industrial centers (Chicago, Cleveland, Saint Louis, and Cincinnati) experienced their peak; and it was not until 1914 that Indianapolis and Detroit became the most important areas for the location of assembly plants. Until the 1950s, in addition to these points, there were also sites scattered over the country. For instance, Boas notes that as many as 46 cities have been of some importance in the history of the industry.

Rubenstein (1986, 288-289) explains these temporal patterns of spatial concentration by noting that site and situation factors influencing location decisions have changed their relevance over time. For instance, since the beginning of the century assembly plants were near important markets because of a higher cost of shipping assembled products. Since 1965, changes in total transportation, due to improvements in the railroad industry -such as the introduction of trivelled rack cars, in 1960- permitted the shipment of finished automobiles to the final market at a relatively low cost and thus changed situation costs (Rubenstein 1986, 291-293). Changes in site factors -such as labor, energy, amenities and taxes- changed economic benefits and encouraged flexibility in the location of the assembly firm.

Thus, since its beginnings the motor vehicle industry has changed its structure and its spatial manifestations (Bloomfield 1981; Hoffman and Kapinsky 1988; Hill 1989; Wells and Rawlinson 1992). The automobile industry started with customized products and very small production[6] in scattered points; its development towards a large scale production in the 1920s resulted in a concentration of plants near big cities where the demand for the final product was located. In the 1940s and 1950s, under the MPS, the automobile industry managed to create the transnational firm, whereby the objective of

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6 The definition of motor industry plant production had also changed over time. Before Ford introduced the moving assembly line in 1914 (Boas 1961, 225), firms producing 3 or more passenger automobiles a year were considered to be production plants; after 1914, only those plants producing 12 or more passenger automobiles per year were considered production plants (Boas 1961, 219). Nowadays, the smaller motor vehicle production firms -such as Porche- has about 40,000 workers while bigger firms, such as General Motors, has 1,000,000 workers and many production plants scattered around the world (Dertouzos, Lester and Solow 1989).

minimizing production cost and meeting distant points of demand drove the industry to locate in different countries around the world.

At the international level, with the MPS, the trend was towards the location of plants where cheap labor and other factor endowments were available. For example, Ford's European strategy in the 1960s and beginnings of 1970s was based on peripheralization of auto production seeking cheap labor in peripheral locations as well as government subsidies or tax breaks. Cohen (1983, 138), for instance, argues that the location of a Ford factory in Valencia, Spain, in the 1970s was the result of 1) the growing internal market, 2) the important cost advantages in producing for the southern European market, and 3) the avoidance of high Spanish import duties. Due to lower labor costs in Spain, the car would cost less to produce in Spain as opposed to Germany (Financial Times July 14 1992). But these factors are not static; on the contrary, they are very sensitive to changes in related structural factors. For instance, this strategy, followed by Ford Europe in the 1970s (Bloomfield 1981; Dicken 1986; Doz 1986), was drastically changed in 1979 (Dicken 1992) when, upon visiting Mazda's plan in Japan, Ford realized that Mazda's levels of efficiency were outstanding.

Other factors of increasing importance, apart from the classical ones of cheap labor and low transportation costs, emerged with the LPS. Non-unionized locations, usually small mid-western towns rather than sites associated with traditional automobile production became attractive to automobile assembly plants (Cohen 1983; "New GM plant . . ." 1985; Rubenstein 1986, 298-300; Mair, Florida and Kenney 1988; Jones and North 1991). This trend explains the concentration of assembly plants in the Mid-west corridor, at a distance from important points of demand. In the US, for example, with the introduction of the LPS features, Ford also followed a regionalization pattern, leaving the old industrial cities and moving to low-wage, less unionized areas. Also the Big Three were recently moving towards places with little history of industrialization,

specifically greenfield centers, small towns and rural areas; that is, places known for their work ethic and that had a concentrated ethnic population (Cohen 1983, 137-141).

The location of assembly plants had always been of great importance in the location of component suppliers[7]. For example, at the beginning of the automobile industry in the US, the fact that assembly plants were located in the states of the Great Lakes was an important factor in attracting component plants to the region. But given the diversification of component output, the location of component plants did not follow a unique pattern. For instance, different factors seemed to influence their location, depending on the type of output and the system of production. Factors such as labor cost differentials, direct contacts with technicians of big assembly plants, scale economies associated with big plants and differentiation of standardized product plants -which could be located closer to low-wage areas-, or design intensive product facilities which had to be closer to the core automobile region become critical (Glasmeier and McCluskey 1987, 146-148; Rubenstein 1986, 296; Debbage and Rees 1991).

Nevertheless, the influence of the changing LPS system of production to component plants, seems to be of great importance in their locational decisions. The JIT delivery system, implemented with the use of the LPS, could have diminished the

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7 There was no simple definition of what a component plant produced. According to Glasmeier and McCluskey (1986, 144) "auto parts are considered as all components incorporated in a finished automobile, with the exception of body panels which are largely produced in facilities owned and operated by the 'big three' auto producers". But even within the big three (Ford, GM, and Chrysler) there were differences in the components produced in the same assembly plant and the ones that were out-sourced. Another distinction can be made based on primary products used in the production of the components, for example tire suppliers and primary material producers (steel, aluminium, glass, rubber, and plastics).

influence of other factors which were significant in MPS. For example, Rubenstein (1986, 296) notes that "Because of the short notice for delivery, proximity and accessibility between supplier and assembly plant are crucial. (...) When a firm has only one customer, as in the case for many past manufacturers, one most efficient plant site may be near that user.". Also, trends towards concentration of assembly plants and parts production plants with LPS might also be encouraged by a new concept of "self-containment", in which the location of the assembly plant constitutes a complex of kindred firms (Fisher 1985; Bingham and Sunmoun 1992). For instance, the GM Saturn project in the US was constructed in a way that "In addition to an assembly plant, the [Saturn plant] complex will have two foundries, a stamping plant, and a components factory for the production of engines, transmissions, and other parts" (Rubenstein 1986, 297). This complex is a network of independent, closely related firms with a common objective ("GM Saturn won't fly so high" 1986). Hence, the implementation of JIT in the automobile manufacturing sector seemed to enforce the role of the assembly plant as the most important factor in the location of supplier plants, which may result in the concentration of component plants near the assembly plant (Mair, Florida and Kenney 1988).

Thus, the manifestation of JIT has an explicit spatial context (Estall 1985; Mair 1991a, 1991b; Wells and Rawlinson 1992). However, Japanese component firms in the US, supplying Japanese transplants in US, show a spatial concentration (Mair et al 1988; Rubenstein 1988; Hill 1989; Wells and Rawlinson 1992; Florida and Kenney 1992). In the UK the aggregate data for the industry also shows some clustering (Morris 1989; Tighe 1991), however, this is not true for several other countries, such as Ford's European plants (Schoenberger 1987). The location of the automobile industries in Spain is discussed in Chapter 7. Thus, Toyota City would be hard to reproduce in many parts of the world (Mair 1991a; Wells and Rawlinson 1992).

The translation of LPS practices overseas has been largely discussed in the theoretical literature (Sinclair 1983; Dohle 1985; Mair, Florida and Kenney 1988; Cusumano 1989) and theoretical tendencies have been analyzed. The results of the empirical analysis in this dissertation contradict the idea that JIT causes spatial clustering, at least with respect to Spain.

CHAPTER 3 DATA, METHODOLOGY AND HYPOTHESES

This chapter describes the data and the methods used in this dissertation. Data has been collected from primary as well as secondary sources. The structure of the AI production in Spain has been analyzed using Cobb-Douglas production function. The spatial analysis of the AI in Spain, during the 1980s, uses descriptive data, and the critical path dispersion model drawn from graph theory.

3.1 SECONDARY SOURCES

Different types of data have been collected from secondary sources for selected chapters. For chapter 5, macroeconomic data aggregated for the whole automobile industry in Spain and Europe was collected from the following sources:

1 Automotive News. 1991 Market Data Book;

2 Banco de España. Boletín Estadístico;

3 Banco de España. Central de Balances;

4 Dun and Bradstreet. Principal International Businesses. Different years;

5 EEC. Panorama of EEC Industry;

6 FARA Gremio de Fabricantes de Equipos, Accesorios y Recambios para Automoción;

7 International Motor Businesses;

8 La Tienda de Recambios y Accesorios. Catálogo Profesional para el sector de Recambios y Accesorios;

9 Motor Industry in Great Britain. World Automotive Statistics;

10 OECD. Industrial Structure Statistics;

11 Sernauto. Autorevista;

12 Standard Industrial Classification Codes for the Motor Industry (Appendix A);

13 United Nations. International Trade Statistics Yearbook. Different years;

14 United Nations. Yearbook of Industrial Statistics;

15 US Department of Labor. Bureau of Labor Statistics;

16 Ward's Automotive Reports. Different years;

17 World Automotive Market;

18 World Motor Vehicle Data. Different years.

Data was collected for several variables, of which the following is a representative group: production units, number of component and assembly plants, year the firm started, location, total sales, number of employees, exports in dollars and in physical units, imports in dollars and in physical units, sales in dollars, car registrations, market shares in Europe.

Data for chapter 6 is drawn from several sources, as follows:

1 Production values, value-added, labor cost, raw materials and intermediate inputs for All Industry, Manufacturing Industry, and Automobile Industry in Spain have been collected from Instituto Nacional de Estadística. Anuario Estadístico de España. Various years.

2 Data on sales, capital depreciation, labor cost, and materials for the five firms studied - Fasa Renault, Ford España, General Motors España, Nissan Motor Ibérica, and Seat Volkswagen- has been collected from the Annual Report of each firm, for various years.

3 Data on production value, value-added, investment, wages and salaries of employees and social security costs for the following countries: France, Germany, Greece, Italy, Portugal, United Kingdom, Japan, and the US, has been collected from the OECD. Industrial Structure Statistics, Paris, various years.

The data used for chapter 7 is from the following sources:

1 Data on forms of components and parts distribution between suppliers and assembler is drawn from the Structured interview (Appendix B).

2 Data on number and location of component and part firms, as well as on number of warehouses has been drawn from La Tienda de Recambios y Accesorios. Catálogo Profesional., 1983 and 1992.

3 The remaining data used in this chapter, such as location of Nissan and Renault location of suppliers, has been collected from the Structured Interview conducted in each firm.

3.2 PRIMARY SOURCES

Primary data is based on several interviews conducted in assembly firms and institutions related to the automobile industry. First, there were a set of basically unstructured interviews with automobile firms in Spain and Japan -Nissan Motor Co., in Japan, Nissan Motor Ibérica, Seat Volkswagen, and General Motors España in Spain. The objective was to asses the scope of the general problem and to understand whether the Lean production system was replacing the Mass production system in these different firms.

A second set of structured interviews (Appendix B) where administered to the managers and several departments of the following automobile firms -Fasa Renault, Ford España, General Motors España, Nissan Motor Ibérica, and Seat Volkswagen-, and the following subjects were covered:

1 Level of flexible technology in the firm.

2 Value in dollars of the goods supplied;

3 Percentage of labor force working in teams;

4 Types of skills of the labor force;

5 Number of suppliers per assembly plant;

6 Location of component plants with respect to location of the assembly plant, in length of time or distance travelled;

Information on these variables was solicited for different points in time in the study period 1975-1990. All firms except Ford España answered the structured questionnaire partially, so, the data is not as satisfactory as initially expected.

A third set of unstructured interviews was conducted with the automobile unions, with the purpose of understanding the labor position during the transition in the automobile industry transition. These interviews were performed at the most representative unions in the industry, which are Comisiones Obreras Federación del Metal, in Barcelona and Madrid, and Unión General de Trabajadores Sector del Metal, in Barcelona.

For a better comprehension of the structure and functions of the suppliers in Spain, a fourth set of interviews was conducted with the most representative institutions representing the part and component firms, Fara Gremio de Fabricantes de Equipos, Accesorios y Recambios para Automoción; and Sernauto Asociación Española de Fabricantes de Equipos y Componentes para Automoción.

3.3 A PRODUCTION FUNCTION MODEL OF THE AUTOMOBILE INDUSTRY IN SPAIN

To study the structure of the automobile industry in Spain, a Cobb-Douglas production function is estimated at diverse levels of the industry. A brief description of this production function follows. Activities performed by firms to transform inputs into outputs depend on which choices of inputs a firm makes to produce the output. Thus, a model can be constructed where there is a relationship between inputs and output, and formalized in a production function of the form:

$$Q = f(K, L, M, \ldots)$$

where Q is the output of a good, in this case a car, during a certain period; K is the equipment, or capital used during that period; L is the cost of labor inputs; M represents the materials costs used; and other variables affecting the production could be included in the production function (Nicholson 1978).

In the Cobb-Douglas production function, the isoquants have a normal convex shape, and the mathematical form is given by

$$Q = AK^a L^b,$$

where A, a, and b are all positive constants.

For $a + b = 1$, the Cobb-Douglas function exhibits constant returns to scale. If $a + b > 1$, then the function exhibits increasing returns to scale; if $a + b < 1$, it shows decreasing returns.

The Cobb-Douglas function is linear in logs:

$$\log Q = \log A + a \log K + b \log L$$

The constant a is the elasticity of output with respect to capital input, and b is the elasticity of output with respect to labor input.

Given the fact that the performance of different automobile firms are estimated and compared, and that the inputs and outputs are similar but not identical, the observations of each variable are chosen to be in value terms.

3.4 GRAPH THEORY AND THE SPATIAL ADJUSTMENTS OF THE AUTOMOBILE INDUSTRY IN SPAIN: THE CRITICAL PATH AND THE CRITICAL PATH DISPERSION PROBLEMS

The objective of the Critical Path Problem (CPP) is to find the largest period of time a project takes to be finished. The CPP is useful when there is a complex project to be completed in order to know in advance, before the project starts, which is the most efficient way to perform it. The CPP is based on *activities* -defined as smaller subprojects of the whole project-, and a *digraph* which links these activities in order to reach the end of the project successfully (Chartrand 1985; Buckley and Harary 1990). Thus, the CPP is based on an activity digraph, the formal definition of which is the following (Chartrand 1977 99): "Given a project composed of activities, we define a digraph D containing a vertex labeled S and a vertex labeled E, and such that the remaining vertices of D correspond to, and are labeled as, the activities. The vertex S is directed to a vertex v if the activity v may start without any other activity first being completed, and vertex w is directed to vertex E if no activity requires that w be completed before that activity begins. Furthermore, vertex x of D is directed to vertex y if and only if no activity need intervene between the completion of x and the beginning of y. Finally, we associate the number t with the vertex w if activity w requires t units of time for completion. The digraph D is called the activity digraph of the project. (...) *A longest path (in units of time) in an activity digraph D is called a critical path of D.* (...) *It is no coincidence that the length of the critical path in (a) digraph equals the minimum time necessary to complete the project*" (Figures 3.1, 3.2).

Use of the critical path problem is desired in this dissertation for two purposes. First, to compare the MPS and the LPS levels of efficiency in finishing a car. Second, to see the level of concentration of the MPS and LPS networks. Due to lack of data, the CPP has only been applied to two symbolic illustrations with no empirical estimation, in Chapter 7, in order to represent how its development could be a measure of dispersion or concentration of suppliers and assemblers. A description of the critical path applied to an example of automobile firm's network is given below.

An industrial network is formed by nodes connected by relations. Let's assume we have a network of a car assembly firm and the producer input firms. Inputs are discrete parts and major components of a car. These inputs arrive at the assembly plant in order to be assembled to produce the final product: the car. The inputs produced by each supplier firm have different level of complexity -requiring from steel plates, to the engine. Level of complexity is defined as the quantity of value-added incorporated in a product; for instance, while a truck loaded with steel arriving at the assembly plant has low value-added, an engine has high value-added. Thus, in an automobile network there are nodes producing parts and components of different complexity, since the higher the level of complexity of the components arriving at the assembly plant, the less it time would take for the assembly plant to produce a car, and vice-versa. Theoretical literature postulates that de-verticalization of a firm's activities or flexible specialization is used in order to gain efficiency in the industry, which is one of the main objectives of the transition from the MPS to the LPS (as discussed in Chapter 2).

Hence, the idea is to find the minimum time required to finish all the car-building activities given two different production networks, the MPS and the LPS network; i e., the objective is to see which network is most efficient in completing the project. So, the following variables are appropriate:

1 production time for each part or component, and

2 assembly time for the car.

The assumptions are the following:

1 only one node in each network is the assembler, while the others produce the parts and components to be delivered to the assembler -supplier nodes;

2 components produced in supplier nodes have different levels of complexity;

3 all the inputs and outputs in both networks are equal.

Thus, the critical path problem is stated as follows (The Open University 1991):

Maximize $\Sigma^{n+1}{}_{i=0}\ \Sigma^{n+1}{}_{j=0}\ c_{ij}\ x_{ij}$

subject to

$\Sigma^{n+1}{}_{i=0}\ x_{ij} = \Sigma^{n+1}{}_{i=0}\ x_{ji}$ for $j = 1, 2, \ldots, n$

$\Sigma^{n+1}{}_{j=0}\ x_{0j} = 1$

$\Sigma^{n+1}{}_{i=0}\ x_{i,\ n+1} = 1$

where

$x_{ij} = (0, 1)$

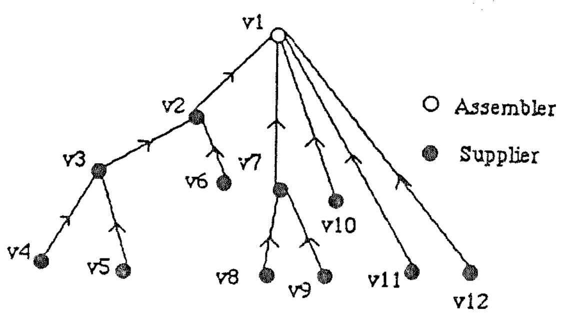
and

c_{ij} = length of the arc incident from vertex i to vertex j.

The objective is to minimize the production time, taking the maximum length required to carry out an activity. The solution to this critical path would tell us how long the car-building activity will take to be finished.

To develop the critical path activity the following is needed for each network: the incidency matrix, the paths, the activity time, and the activity digraph. As an example, the incidency matrix of a network implying MPS relations between suppliers and assembler (Figure 3.1) is shown below.

Figure 3.1 The MPS in the automobile industry



Network of intermediate products

Table 3.1 Incidency matrix of MPS network of Figure 3.1

	v_4v_3	v_3v_2	v_2v_1	v_5v_3	v_6v_2	v_8v_7	v_7v_1	v_9v_7	$v_{10}v_1$	$v_{11}v_1$	$v_{12}v_1$
v_1	0	0	1	0	0	0	1	0	1	1	1
v_2	0	1	1	0	1	0	0	0	0	0	0
v_3	1	1	0	1	0	0	0	0	0	0	0
v_4	1	0	0	0	0	0	0	0	0	0	0
v_5	0	0	0	1	0	0	0	0	0	0	0
v_6	0	0	0	0	1	0	0	0	0	0	0
v_7	0	0	0	0	0	1	1	1	0	0	0
v_8	0	0	0	0	0	1	0	0	0	0	0
v_9	0	0	0	0	0	0	0	1	0	0	0
v_{10}	0	0	0	0	0	0	0	0	1	0	0
v_{11}	0	0	0	0	0	0	0	0	0	1	0
v_{12}	0	0	0	0	0	0	0	0	0	0	1

The incidency matrix shows whether a connection exists between two plants in the MPS network or not. From this matrix, eight paths -defined as a sequence of nodes and arcs where no nodes are repeated (Chartrand 1985)- of the MPS network in Figure 3.1 can be derived; paths in the automobile network show the connection between a subgroup of firms in the network.

Table 3.2 Paths observed in the MPS network of Figure 3.1

1)	v_4, v_3, v_2, v_1	5)	v_9, v_7, v_1
2)	v_5, v_3, v_2, v_1	6)	v_{10}, v_1
3)	v_6, v_2, v_1	7)	v_{11}, v_1
4)	v_8, v_7, v_1	8)	v_{12}, v_1

A component-producing time schedule attached to each plant in the network is assumed: for production of the component in plant v_3, which is a part of the component assembled at v_2, the time of production is t_3. Other times are indicated in Table 3.3.

Table 3.3 Times of production at each plant

1)	$v_4\ v_3 = t_4$	7)	$v_7\ v_1 = t_7$
2)	$v_3\ v_2 = t_3$	8)	$v_9\ v_7 = t_9$
3)	$v_2\ v_1 = t_2$	9)	$v_{10}\ v_1 = t_{10}$
4)	$v_5\ v_3 = t_5$	10)	$v_{11}\ v_1 = t_{11}$
5)	$v_6\ v_2 = t_6$	11)	$v_{12}\ v_1 = t_{12}$
6)	$v_8\ v_7 = t_8$		

Then, the "car-building" activity could be represented by an "activity digraph", which will be formed by a group of activity digraphs, each one being an "activity sub-digraph" of the "car-building" activity (Figure 3.2). Given a pre-start S_1,we can convert these activity sub-digraphs to an "activity digraph of car-building in the MPS".

The longest path by which all activities can be done in the activity digraph of car-building in the MPS is called a critical path of this digraph. And the length of the critical path in a digraph equals the minimum time necessary to complete the project. Thus, assuming

$$\Sigma^4_{i=1}\ t_i > \Sigma^3_{i=1}\ t_i + t_5$$

$$\Sigma^4_{i=1}\ t_i > t_6 + t_2$$

$$\Sigma^4_{i=1}\ t_i > \Sigma^8_{i=7}\ t_i$$

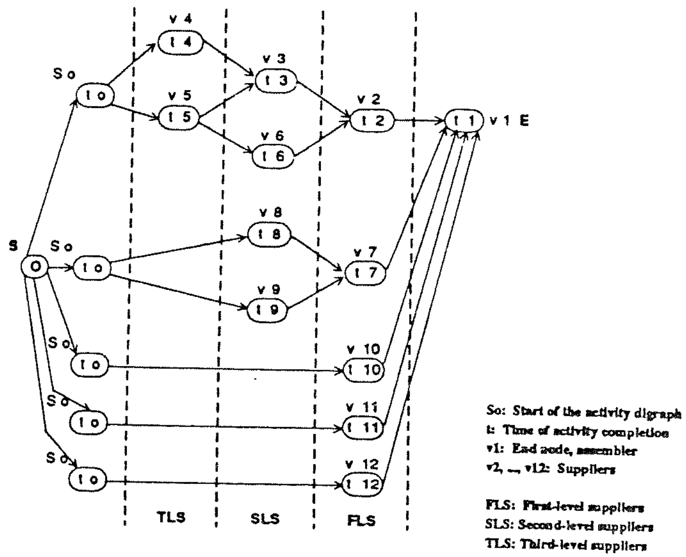
$$\Sigma^4_{i=1}\ t_i > t_9 + t_7$$

$$\Sigma^4_{i=1}\ t_i > t_i\ , \quad i = 10,\ 11,\ 12$$

Then the critical path of activity digraph car-building is : $S\ S_0\ v_4\ v_3\ v_2\ v_1$

As the v_1, the assembler, is reached, which is the end vertex of this activity digraph; i.e.; once all components arrive at v_1, a car could be built. The important question is how much time it will take to build a car in v_1.

Figure 3.2 Activity digraph of car-building in the MPS network of Fig. 3.1



It may take longer as more activities have to be done at v_1, or shorter as less activities are left to be done at v_1. That is, for instance, the more major components[8] arrive at v_1, the less time would be taken at v_1 to construct a car, and vice-versa.

Looking at MPS activity digraph, it may be stated that if there are many more suppliers serving the assembler at the first-level with different levels of component complexity (Figure 3.2), more time will be required at v_1 to build a car; i. e., at the first-level in the MPS network, components of different complexity levels could be found, for instance in the activity digraph of Figure 3.2; v_2 and v_{12} are firms categorized as first-level suppliers because they directly serve the assembler, but v_2 produces a higher level of complexity component than v_{12}; thus, while the v_2 component will go to the assembly line at v_1, the v_{12} component will have to have a value-added process at v_1 before it arrives at the assembly line.

If the number of suppliers decreases as we go from first to third-levels, the time used to build a car at v_1 will increase (see level of incidency below), because that means there are more suppliers of different level of component complexity serving the assembler; hence, more value-added of the product chain[9] has to be done at the assembly plant. This explanation links the level of complexity of the components with the index of incidency of each node in the network. As more components of low index of incidency exist at the first-level suppliers; i. e., a large group of low complexity components arrive at v_1, more value-added of the product chain has to be done at the assembly plant, and vice-versa (Table 3.4).

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[8] Major components here are those which arrive at the assembly plant already assembled, ready to be fitted in the car.

[9] See page 20 in Chapter 2 for definition of the value-added product chain.

Table 3.4 Index of incidency in the MPS network

Index of Incidency $II_{MPS}(v_1) = 5$	$II_{MPS}(v_7) = 3$
$II_{MPS}(v_2) = 3$	$II_{MPS}(v_8) = 1$
$II_{MPS}(v_3) = 3$	$II_{MPS}(v_9) = 1$
$II_{MPS}(v_4) = 1$	$II_{MPS}(v_{10}) = 1$
$II_{MPS}(v_5) = 1$	$II_{MPS}(v_{11}) = 1$
$II_{MPS}(v_6) = 1$	$II_{MPS}(v_{12}) = 1$

It may be observed that v_2 and v_7 have high complexity levels and high indexes of incidency, while v_{10}, v_{11}, and v_{12} are components of low levels complexity and have low indexes of incidency. Similar analysis can be performed for the LPS.

In the LPS, suppliers at the first-level deliver components of higher complexity to the assembler, so the assembly process will be shorter (Figures 3.3, 3.4).

Figure 3.3 The LPS in the automobile industry

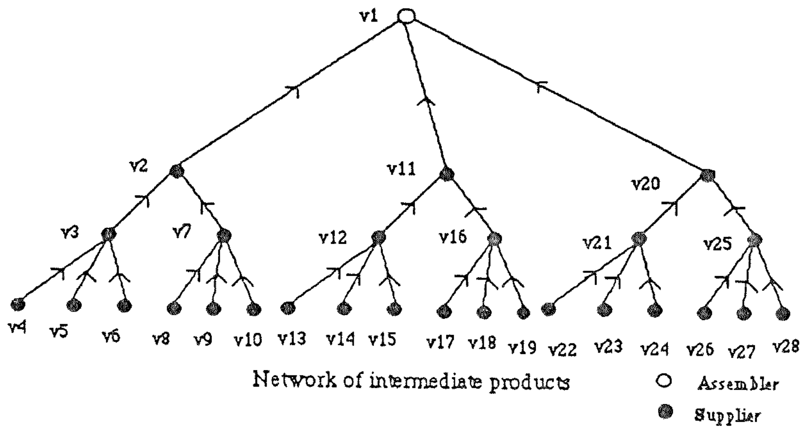
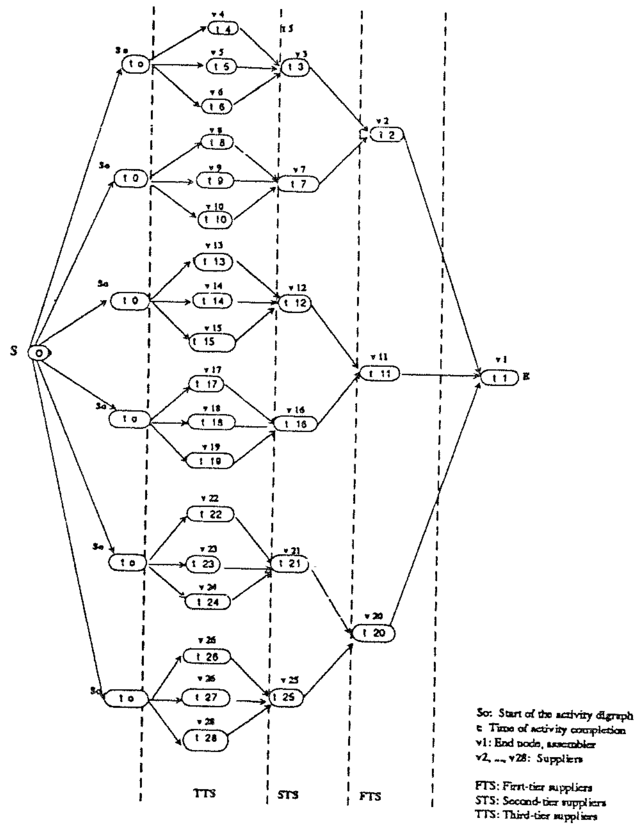


Figure 3.4 Activity digraph of car-building in the LPS network of Fig. 3.3



Similar to the critical path problem is the Critical Path Dispersion (CPD) problem, in which the one the variable we want to maximize is the time distance that an intermediate product takes to arrive at the assembly plant, may be formally expressed as:

Maximize $\Sigma^{n+1}{}_{i=0}\ \Sigma^{n+1}{}_{j=0}\ d_{ij}\ \ x_{ij}$

subject to

$\Sigma^{n+1}{}_{i=0}\ \ x_{ij} = \Sigma^{n+1}{}_{i=0}\ \ x_{ji}$ for $j = 1, 2, \ldots, n$

$\Sigma^{n+1}{}_{j=0}\ \ x_{0j} = 1$

$\Sigma^{n+1}{}_{i=0}\ \ x_{i,\ n+1} = 1$

where

$x_{ij} = (0, 1)$

and

d_{ij} = distance of the arc incident from vertex i to vertex j.

The CPD of a network would give us the overall degree of concentration on the network, because the value will tell us the maximum distance equal to the minimum time necessary for all intermediate products to arrive at the assembly plant. In the MPS and the LPS networks, the $CPD_{MPS} > CPD_{LPS}$ because the initial hypothesis is that activities are more concentrated in the LPS network.

If we maximize both the critical path activity and the critical path dispersion, we will obtain the network in which the car-building activity is optimized:

Maximize $\Sigma^{n+1}{}_{i=0}\ \Sigma^{n+1}{}_{j=0}\ c_{ij}\ \ x_{ij}\ \Sigma^{n+1}{}_{i=0}\ \Sigma^{n+1}{}_{j=0}\ d_{ij}\ \ x_{ij}$

3.5 RESEARCH HYPOTHESES

As noted earlier in Chapter 2, the introduction of the Lean production system in the automobile industry allows for a quick response to changing tastes, permit greater diversification of output, and the production in lower quantities relative to the Mass production system. One of the general hypotheses of this dissertation is that the automobile industry in Spain, following the patterns of the automobile industry in the world, is changing from the MPS to the LPS; with this change, the industry is trying to be more efficient.

Monitoring of product quality in the LSP is done at each stage of the production processes, starting with the production of the car parts. Even when a specific part of the car is produced by an independent firm, the assembly firm monitors the quality of the intermediate product before this enters the assembly plant, by usually sending its own technicians to the component plant. The assembly firm would prefer the component firm to be closer to the assembly plant in order to monitor the quality standards imposed on the independent maker of car components. This can cause spatial adjustment of assembly and component plants. The aspect of monitoring can also affect the number of component firms per assembler. Given the fact that the assembly plant has to send technicians to monitor the quality of its components production, the assembly plant, in order to minimize cost of monitoring, will reduce the number of suppliers. Spatially, the result will be a diminishing number of elements in the network.

The following research hypotheses, derived from the above general hypotheses, are tested using time series data and regression analysis:

1) With the introduction of the LPS, the Spanish automobile industry is increasing productivity,

2) With the LPS more parts of the car will be built outside of the assembly firm,

4) Increasing implementation of the LPS in the plant will be explained by a larger proportion of labor force with higher skills and management practices,

5) Number of workers would decrease as a result of capital intensification,

6) Due to increased monitoring at each stage of the production process, component plants will move closer to assembly plants.

7) Component plants will move closer to their assembly plants due to sequential delivery of components to assembly plant.

8) Due to extension of quality monitoring to all the parts of production process, there will be a diminished number of suppliers per assembly firm.

CHAPTER 4 NEW TRENDS IN THE PRODUCTION STRUCTURE OF THE AUTOMOBILE INDUSTRY: A NETWORK APPROACH

Why do systems of production change?. A related question is where does the basic center for the changes in manufacturing reside?. According to Casti (1986), the introduction of computer capabilities to all manufacturing processes "coupled with an aggressive and innovative management and production attitude in Japan" (Casti 1986, 241), has sparked the recent changes (Bieda 1970; Ohkawa and Rosovsky 1973; Caves and Vekosa 1976; Denison and Chung 1976; Peck and Tamura 1976; Lynn 1982). Although it "was the arrival of unprecedented computer capability, not the Japanese. They were only the first to exploit this capability in a widespread manner." (Casti 1986, 241).

Changes in production systems do not appear suddenly; a new model in manufacturing is a result of multiple changes in existing production methods. Technological improvements may be the basic factor, but other factors also influence the shift from one production system to another, such as cost reduction, production differentiation, changing demand and like. The introduction of the LPS in Japan was the result of multiple changes in the MPS (Hounshell 1978; Business Week 12 June 1982), for example, the development of simple changing techniques allowed the production workers to improve quality, producing small amounts of output rather than large production units, reducing inventory and so on. What seems clear is that changes occur at all levels during the transition from one manufacturing system to another as a result of problems that need to be solved within the currently working model. Casti suggests that "One of the first steps toward the development of any theory of manufacturing is to isolate the level at which the problem is being entered and to identify the system framework and tools most suitable for addressing the characteristic problems of that level." (Casti 1986,

243). A manufacturing system has hierarchical levels, and consists of the following parts: design, production, distribution, and management (Casti 1987). The shift from the MPS to the LPS involved solving problems and introducing modifications in each of the parts.

The automobile manufacturing industry consists of several firms linked in a hierarchical manner. The output of one type of firm is an intermediate input to the next-level hierarchy. The industry can be broadly divided into 3 levels. The assembly firm produces the car using major components such as engine, transmission, gears, and so forth produced by component firms. The component plants produce major parts of the car through assembly process. And the part's plant makes either basic tools or parts of the car (Table 4.1).

Table 4.1 Structural levels of the automobile industry

Type of firm	Activities	Output
assembly firm	assembly components	the car
components plant	assembly parts	components
part's producer	producer parts	parts

Different levels of design and R&D are used for the car. These activities are done by different agents of the network of firms depending on what production system is used. The definitions used in this study are the following. Basic design refers to small variations of the final product, as well as improvements without high capital investment in the major components and discrete parts of the car[10]. Complex design refers to the design of major

10 "The bulk of the (car) process involves engineering and fabricating more than 10,000 discrete parts and assembling these into perhaps 100 major components- engines,

parts of the car. Innovations are defined as development of new technologies involving research.

The automobile industry is a complex system in which the assembly, components and part plants are interconnected. The word "complex" as applied to systems refers basically to a system consisting of two or more parts. "When encountering an unknown complex system one usually has to construct intermediate levels of named parts between the highly aggregate whole, and the disaggregated atoms." (Johnson 1991, 168). Dawkins (in Johnson 1991, 168) says: "If we wish to understand how a machine or living body works, we look to its component parts and ask how they interact with each other."

Different production systems in manufacturing offer a different modeling framework of the manufacturing processes. Casti's idea of modeling a natural phenomenon is found to be a good starting point for modeling these three different manufacturing processes. Having a "natural phenomenon" N, a production system in our case, characterized by a collection of physical observables $f = \{f_1, f_2, . . . , n\}$; for example, raw material inputs, different types of machinery, or computing resources, we have

N = a production system,

$f = \{f_1, f_2, . . . , n\}$; raw material inputs, different types of machinery, or computing resources,

---

transmissions, steering gears, suspensions, and so forth. " (Womack, Jones and Roos 1990, 58).

"As a result of experimental observations and/or other information, certain mathematic relationships Φ_i are found linking the values of the observables.". We can write these relationships in equations of the form

$$\Phi_i = \Phi_j (f_1, f_2, . . . , f_n) = 0 \quad j = 1, 2, . . ., m,$$

where m is the number of such relations. Thus, we have the data for our system N, in which "we would now like to formulate a mathematical model of this situation within some mathematical structure , in order to provide a means for making predictions about the behavior of N." (Casti 1986, 247).

Accordingly, a network approach is used in this chapter to explain industrial relationships. Technically, the idea of network means a graph or digraph with a function which maps the edge set into the set of real numbers (Chartrand 1985, 19), but the concept of network is widely used in different applications, some of them in social sciences, mainly relating to the idea of "establishing relationships" between two or more pairs of nodes. Nodes in industrial networks refer to plants or firms. Relationships in networks are represented by edges transporting different types of flows. Flows in the automobile industry are mainly intermediate products -components or parts of the automobile to be assembled later- and knowledge transmission - design and research and development of the automobile.

As stated before, different systems of production in the automobile industry change the relationship between firms, so that direction and amount of commodity and knowledge flows differ among the nodes of the network. This leads to a new spatial distribution of plants.

The three different systems of production, the MPS, the LPS and CPS described below can be identified as complex systems, which are based on the relationships between the components of the system; i.e., the assembly plants and the supplier of parts and components. Even though they refer to the same industry, these are treated as different systems because the connections and the interactions among components of each system are different in all three models. There are two network models within each of the three systems; one refers to production network, and the other refers to the knowledge network. So, a distinction is made between both networks for each model.

Under the initial MPS -Henry Ford's Rouge complex-, the firm was vertically integrated and performed all four tasks of design, production, distribution and management of all the different parts of a car (Womack, Jones and Roos 1990). Later on, in the 1950s, the MPS firms de-integrated production of several parts of the car by subcontracting the work to subsidiaries or independent firms, while retaining majority of the tasks, such as design, some production, distribution and management.

Under the LPS, however, the firm is not vertically integrated. Therefore, design is done by the assembler and a group of first-tier suppliers (Ib. 1990); production is de-integrated over a large number of firms. "Family firms" in the Japanese system are satellites of the assembly firm that are linked to it by stable relations, loyalty and long term subcontracting. This structure is beginning to show stresses as infrastructure congestion is increasing the cost of delivery of intermediate products to the higher level firms. This gives rise to the Cellular Production System (CPS) discussed below.

The CPS is a new trend in the production of cars in Japan where, due to increasing costs of distribution and congestion in the transportation structures, the assembly firm is moving its production facilities towards points with concentration of demand[11]. The design activity is subdivided into basic design which is done at each production point, by the assembler and first-tier satellite firms, to meet customized demand expressed by the

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[11] Prof. Kiyoshi Kobayashi discussions, Tottori University, Japan, July 1992.

dealers. Complex design and technological improvements related to main car components and systems, for instance engines and sophisticated robots, are done in a main center of the firm serving all of these disseminate production points. The changes can be seen in R&D activities as well. R&D is done by firm's main brain and for few contractors remaining in the firm's family. This knowledge is a proprietary and kept secret, not shared with other firms. However, minor modifications of parts and standardizing of components are done by the suppliers so that parts producers can serve more than one firm. Distribution of intermediate and finished products is easier due to this spatial diffusion of plants. Management has to cope with this new spatial arrangement of production distribution and diversification in the production points.

This chapter explains how these three systems of production -the MPS, the LPS, and the CPS- function in the automobile industry ("car-making" process). The difference between the systems, particularly flows of knowledge of intermediate products, are discussed as a network approach. The configuration of the relationships and the main variables of these networks are highlighted using graphic as well as formal models.

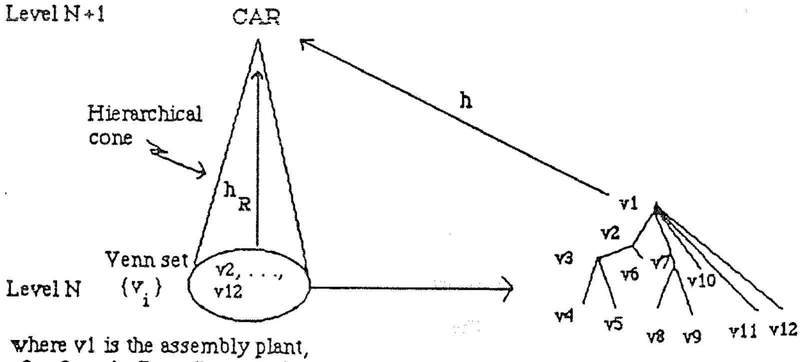
4.1 THE MPS PRODUCTION NETWORK

Considering the MPS as a hierarchical complex system; let v_i be vertices of an automobile industry network in which the components of the system are the different plants involved in the production of an automobile. Let v_1 be the assembler, and v_2 to v_n be the parts suppliers. Then, $\{v_i\}$ could be defined as the set of plants needed to build a car.

Within the production network, let's assume that each plant produces 1 part. It could be said that a car is assembled (and designed) from the parts to satisfy the car relation R. Let $<v_i; R>$ denote the parts assembled (and designed) to form the car. Let the assembly process (design process) be denoted by mapping a: $\{v_i\} \rightarrow <v_i; R>$. Once sets of elements have been assembled (designed) to form structured objects, it is very common to give that object a name. For example h: $<v_i; R> \rightarrow$ car.

Let $h_R = h$ be the hierarchical aggregation mapping which takes the set $\{v_i\}$ to the structured object, the car. Then h_{R-1} (car) = $\{v_i\}$. These definitions are graphically summarized in Figure 4.1 (a similar case for LPS may be seen in Figure 4.3).

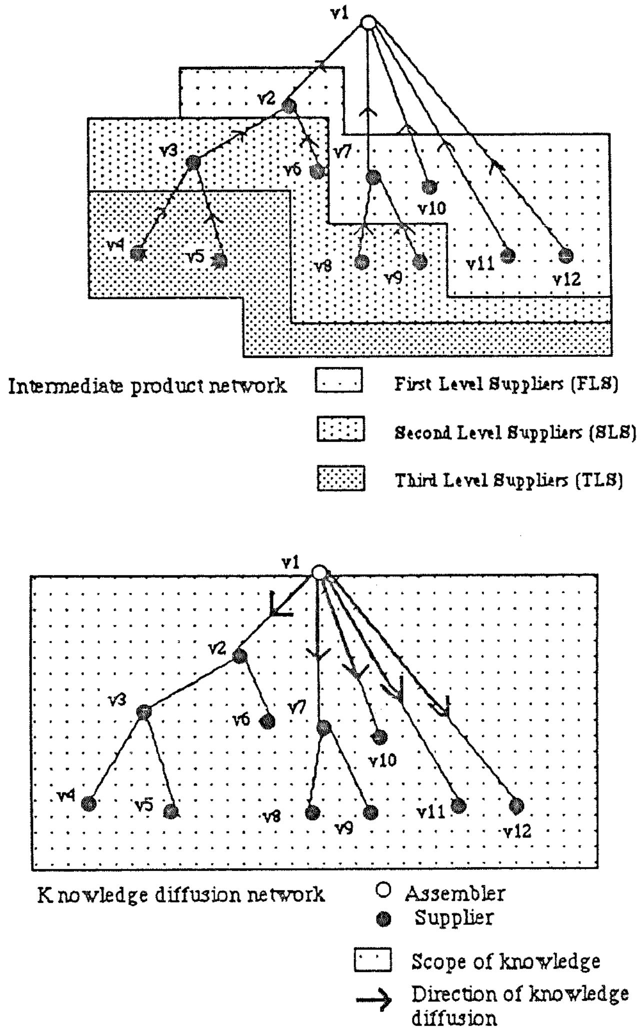
Figure 4.1 Representation of a hierarchical complex production network in the MPS



where v1 is the assembly plant,
v2, v3, and v7 are firms producing components,
v4, v5, v8, v9, v11, v12 are firms producing parts.

In the MPS model several hierarchical levels of suppliers can be observed. This stratification is based on the nature of relationships between the supplier and the assembly firm, wherein the first-level suppliers provide component parts directly to the assembly firm. These range from parts with very low levels of complexity such as sheets of steel, to components with high levels of complexity, such as engines. When levels of low complexity are supplied to the assembler firm, the value is primarily added in the assembly plant. The second-level suppliers provide inputs to component firms and only indirectly to the assembly firms, and so on down through third- and fourth-level suppliers. This network structure is shown in Figure 4.2.

Figure 4.2 The MPS in the automobile industry. Supplier's level, and knowledge diffusion



The relationships between assemblers and suppliers established in the MPS are manifested as flows of intermediate products and knowledge, in which the direction of the network's links changes depending on what type of flow is currently in the arc. Under this system, the intermediate product flow, or commodity flow, goes from the source suppliers, which are the plants producing parts and components, to the sink or assembly plant. Otherwise, when the flow contains knowledge, the direction is the opposite, with the source being the assembly firm and the sink the suppliers, which are the ones that produce the component for the car. The network links are shown in Figure 4.2.

4.1.1 The MPS Assembly Process

From the first- to the last-tier suppliers, the level of complexity in manufacturing the components diminishes. i.e.; components located in the first-tier are more finished than components located in the third-tier, in which discrete parts still have to be assembled on a major component, and this has to be done at the assembly plant (v_1).

In order for a car to be assembled the following is required:

$\{v_2, v_7, v_{10}, v_{11}, v_{12}\}$ should all be at v_1 (1)

$v_2 = v_3 + v_6$ (2)

$v_3 = v_4 + v_5$ (3)

Thus, substituting (3) in (2)

$v_2 = (v_4 + v_5) + v_6; \quad v_2 = \Sigma^6_{i=4}\ v_i$ (4)

$v_7 = v_8 + v_9; \quad v_7 = \Sigma^9_{i=8}\ v_i$ (5)

Thus substituting (4) and (5) in (1)

$CAR_{MPS} = \Sigma^6_{i=4}\ v_i + \Sigma^9_{i=8}\ v_i + v_{10} + v_{11} + v_{12}$ (6)

Adding level of component's complexity

$CAR_{MPS} = \Sigma^6_{i=4}\ v_i + \Sigma^9_{i=8}\ v_i + av_{10} + bv_{11} + cv_{12}$ (7)

Where

a, b, c = time required for the assembly plant to assemble the low complexity components.

4.1.2 The MPS Design Process

Design generated on a node or group of nodes is transferred to the other nodes of the network through links. The amount of knowledge produced by each node has an area covered: the "scope of nodes knowledge". The MPS system design is done at the assembly plant (v_1), and transmitted to the suppliers (Figure 4.2, Knowledge diffusion network). So, the amount of knowledge a car should incorporate is equal to the knowledge produced by one node, and this is transmitted over the car construction network, thus there is one source and various sinks, which is equal to

$$Ds_{MPS} = Ds_{v1}$$

4.1.3 The MPS Distribution Process

Intermediate products in the MPS arrive at the assembly from its first-level suppliers. Thus the distances considered in order to build a car are the length of the links between first-level suppliers and assembler. So,

$\Sigma^n_{i=1} \Sigma^m_{j=1} d_{ij}$

where n = the assembly node, which in the MPS is equal to 1,

m = all first-level suppliers,

where d_{ij} = distance from node i to node j.

4.2 ECONOMIES OF SCOPE AND FLEXIBILITY: THE LEAN PRODUCTION NETWORK

Internal characteristics of the LPS has developed a different complex hierarchical production network (Figure 4.3). There is a stratification of v_i and assembler keeps contacts with some types of suppliers, generally intermediate components and systems producers, leaving small car parts producers out of the direct assembler links. Discrete parts suppliers serve those making intermediate components or systems, they do not directly interact with the assembler. This industrial structure allows closer coordination between suppliers and assemblers to achieve the production goal.

In the LPS, the assemblers establish relationships with a fewer number of suppliers -first-tier suppliers-, which produce the main components of the car, while other smaller parts and components are done by other firms that serve the first-tier suppliers (Figure 4.4). Second- and lesser-tier suppliers have hardly any contact with the assembler. There is a stratification of component suppliers within the network. Flows of knowledge are also diversified under the LPS. Knowledge is created and shared between the assembler and the first-tier supplier, so flow of knowledge is going in both directions at this level, with these nodes being both sinks and sources of knowledge.

Figure 4.3 Representation of a hierarchical complex production network: the LPS

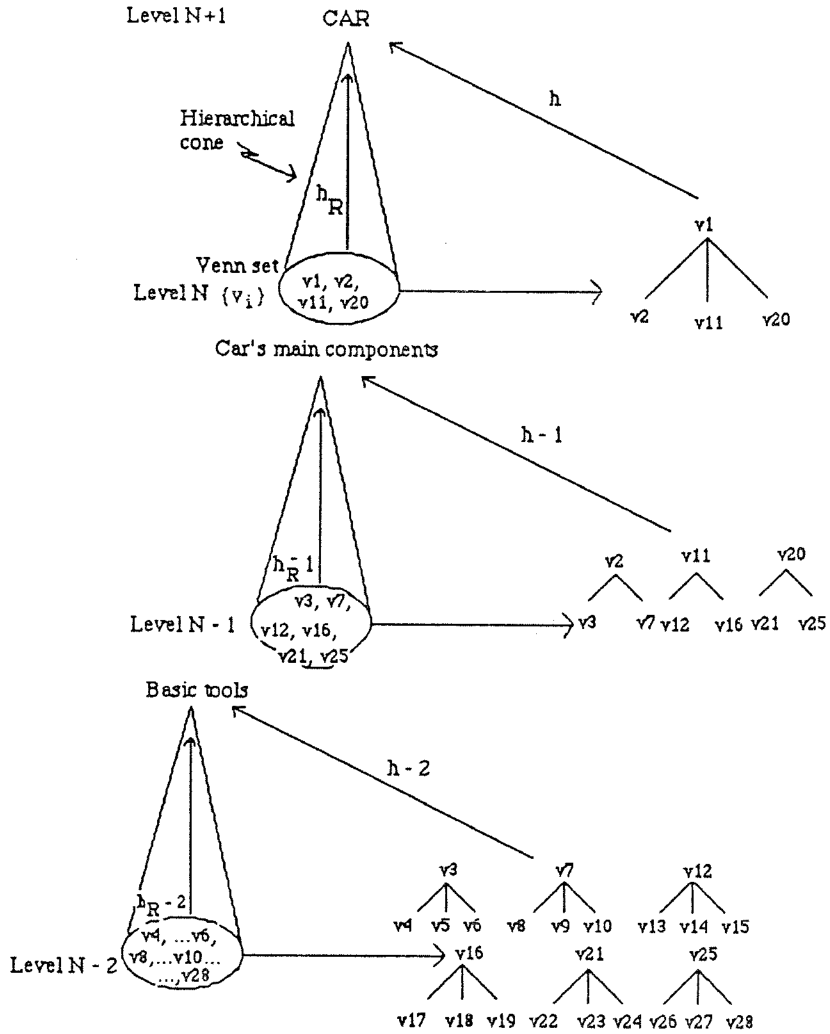
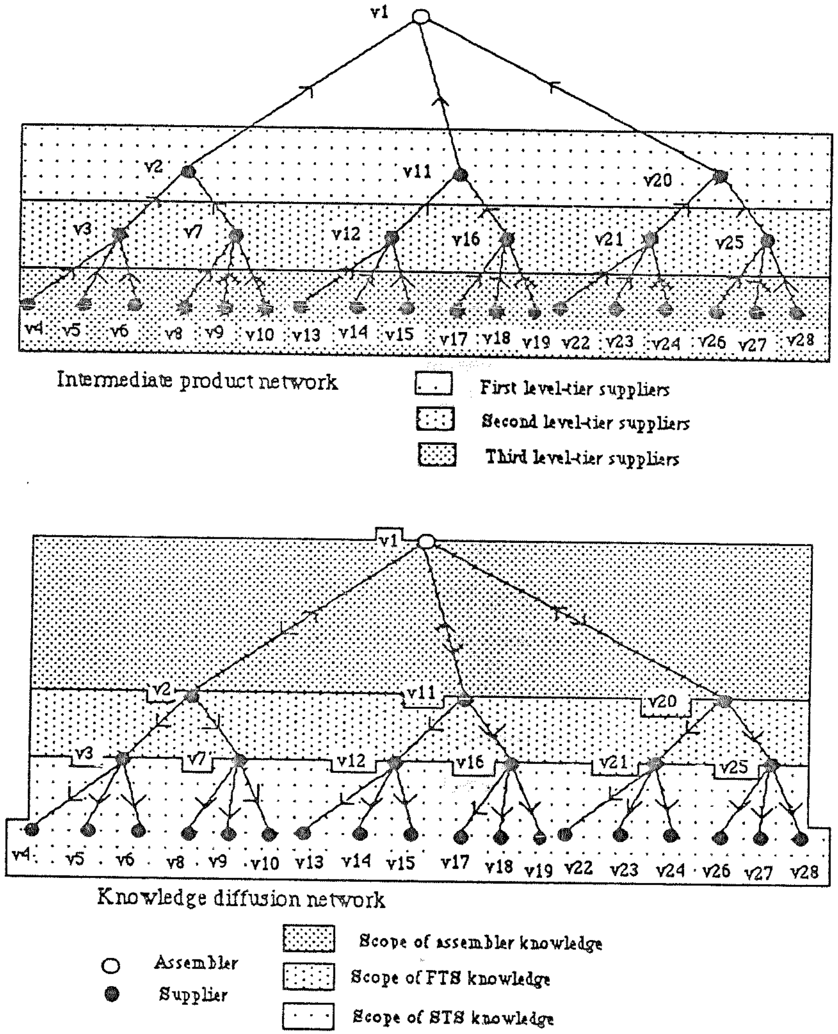


Figure 4.4 The LPS in the automobile industry. Supplier's level-tier, and knowledge network



4.2.1 The LPS Assembly Process

Level of component complexity is stratified among supplier firms, each hierarchical level firm serves its immediate superior level (Figure 4.4), so that components arriving at the assembly plant are higher complexity components. Hence,

$\{v_2 v_{11}, v_{20}\}$ should all be at v_1 (1)

$v_2 = v_3 + v_7$ (2)

$v_3 = v_4 + v_5 + v_6; \quad v_3 = \Sigma^{6}_{i=4} v_i$ (3)

$v_7 = v_8 + v_9 + v_{10}; \quad v_7 = \Sigma^{10}_{i=8} v_i$ (4)

$v_{11} = v_{12} + v_{16}$ (5)

$v_{12} = v_{13} + v_{14} + v_{15}; \quad v_{12} = \Sigma^{16}_{i=13} v_i$ (6)

$v_{16} = v_{17} + v_{18} + v_{19}; \quad v_{16} = \Sigma^{19}_{i=17} v_i$ (7)

$v_{20} = v_{21} + v_{25}$ (8)

$v_{21} = v_{22} + v_{23} + v_{24}; \quad v_{21} = \Sigma^{24}_{i=22} v_i$ (9)

$v_{25} = v_{26} + v_{27} + v_{28}; \quad v_{25} = \Sigma^{28}_{i=26} v_i$ (10)

Thus, substituting (3), (4), (6), (7), (9), and (10) in (1)

$CAR_{LPS} = \Sigma^{6}_{i=4} v_i \ \Sigma^{10}_{i=8} v_i \ \Sigma^{16}_{i=13} v_i \ \Sigma^{19}_{i=17} v_i \ \Sigma^{24}_{i=22} v_i \ \Sigma^{28}_{i=26} v_i$

4.2.2 The LPS Design Process

A car designing process in LPS is different from that in MPS, because design flows have more than one source. Design of the main component is done by the assembler firm and its first-tier suppliers, while design of basic tools is done by lower tier suppliers. So,

$Ds_{LPS} = \Sigma^n{}_{i=1}\ Ds_{vi} \quad n = 1, 2, ... , m$

where m = all nodes doing design

4.2.3 The LPS Distribution Process

In the LPS model, assembler receives components from its first-tier suppliers, so the essential distances for having a car built are,

$\Sigma^n{}_{i=1}\ \Sigma^m{}_{j=1}\ d_{ij}$

where n = the assembly node, which in the LPS is equal to 1,

m = all first-tier suppliers,

where d_{ij} = distance from node i to node j.

4.3 REDUCTION OF TRANSACTION COSTS: TOWARDS A CELLULAR PRODUCTION NETWORK

The structure of LPS is a hierarchy in which the assembly plant is at the top, and contractors at the bottom use Just-in-Time deliveries throughout the entire network. JIT is being implemented in other industries as well. Thus, the increasing use of JIT requires a large and well structured road system, a logistic arrangement where development of transportation networks become very important[12]. Due to the high frequency of good deliveries -resulting from the limited inventory in production plants-, the transaction costs

12 As Linge (1991) notes: "Frequent deliveries add not only to the overheads of subcontractors within the system but also to the costs of the public authorities responsible for maintaining the transport infrastructure." (329).

involved in transfering goods and services from one operating unit to another increase (Linge 1991; Wells and Rawlinson 1992). Due to the increase in transaction cost, aggravate by congestion, firms are moving toward another type of production arrangement involving changes in the spatial distribution of production and flows of commodities and knowledge.

The LPS system is changing and, at the same time, decentralizing physical capital, and concentrating knowledge capital; on the one hand, by diversifying the production plants of the firm, and locating them closer to demand points[13] and, on the other, by developing a different network of knowledge production. Also, final product is more highly customized. Thus, in order to achieve scope economies, the knowledge production and transmission along the network changes. At the lower level of the knowledge network, there is the dealer, whose function is to gather information from the clients and transmit it to its production plant -the idea of more educated demand (Porter 1990). Basic design is done by each production plant and its first-tier suppliers in order to produce the customized product. Major design of the car is done at the firm's "main brain", which creates technological innovations to reach economies of scope in the customized production by increasing technical efficiency -increasing robot multifunctionality. Thus, all production plants from diverse areas of the firm are connected to the main brain in order to request different demands (Figure 4.5). But each production plant and its group of contractors and dealers compete with the other plants in the firm's network. Communication is only with the central brain in petitioning for new technical needs. Hence, the introduction of changes in the production system may produce a new spatial pattern of industrial areas.

13 This trend has been on duty for as long as 5 years (Fisher 1985); but is now increasing due to congestion of the road structure in Japan.

4.3.1 The CPS Assembly Process

Under CPS v_i are stratified differently. Suppliers serving assembler (family contractors) are reduced, and they concentrate in doing R&D for car's systems, either collaborating with the main firm's brain or cooperating with other production points of the same firm to elaborate R&D for intermediate components. Finally, small parts suppliers increase in number and make parts for different companies, they do not belong to the "family", and their knowledge is shared between firms.

4.3.2 The CPS Distribution Process

In the CPS network, and because assembly plants decentralize and concentrate toward the points of demand, there is more than one assembly process for each firm. Mainly, each production plant and its satellites work under LPS system, but all the second- and third-tier suppliers diversify their production, serving more than one firm, and even manufacture products that go to industries other than the automobile firms. This diversification helps to obtain scope economies and to serve other less cyclical industries than the car industry. Thus,

$$\Sigma^{p}_{k=1} [\Sigma^{n}_{i=1} \Sigma^{m}_{j=1} d_{ij}]$$

where

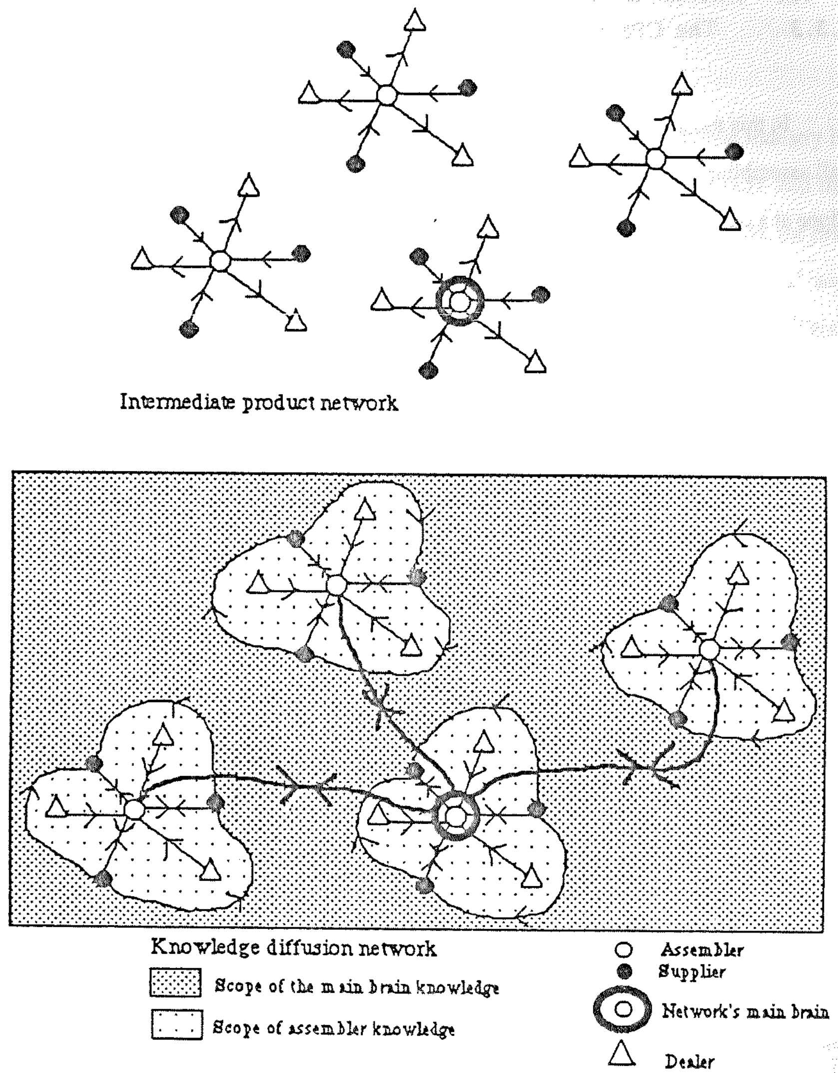
p = number of assembly nodes,

n = the assembly node,

m = all first-tier suppliers,

where d_{ij} = distance from node i to node j.

Figure 4.5 The CPS in the automobile industry. Commodity network and knowledge diffusion



4.3.3 The CPS Design Process

In this model there are 2 levels of design. We call them Ds_1 and Ds_2. Ds_1 is done at all assembling nodes: each assembler does Ds_1 jointly with its first-tier suppliers. Ds_2 is done at a central node, and it is distributed to the rest of assembly nodes. So,

$$Ds_{CPS} = \Sigma^{n}{}_{i=1}\, Ds_{vi}\ \Sigma^{m}{}_{j=1}\, Ds_{vj} \qquad i = 1, 2, . . . , n; \qquad j = 1, 2, . . ., m$$

where n = all nodes doing R&D, type Ds1,

and m = all nodes doing R&D, type Ds2.

CHAPTER 5 THE AUTOMOBILE INDUSTRY IN SPAIN: AN OVERVIEW

Three periods of development may be distinguished in the automobile industry in Spain. The first period, starting with the production of the first car in 1857 and the establishment of the first factories in Spain, ended in the year 1950. In this period, the first automobile firm producing the landmark "Fábrica Hispano Suiza de Automóviles" was founded in Spain. Its factories were located in Barcelona, Switzerland and France. These early factories belonged to the craft production system and employed highly skilled workers to produce customized cars. During this period two other factories were established in Spain: Ford Motor Company, in Cadiz -in 1920 moving to Barcelona in 1923-, and Empresa Nacional de Autocamiones, in 1946.

In the second period, from 1950 to 1960, large scale production began, and heavy investments were made in automobile manufacturing. Main firms established during this period were Seat (1950) -joint venture with the Italian Fiat-, Fasa Renault (1951), Peugeot Talbot (1954), and Citroen Hispania (1957). The number of automobiles per thousand people in the country went from 3.1 to 9.5 (Nissan, 1990). Between 1957 and 1959, reconstruction started in the country's industrial network, which had been completely destroyed during the Civil War (1936 - 1939). In 1963 the economic environment improved and the Spanish Government established its first "Plan de desarrollo" (Development plan), the goal of which was to promote growth in technology and social development.

This was followed by the clear expansion in automobile production in the third period. Starting in the 1960s production increased; for instance, 229,000 cars were produced in 1965, as compared to 1990, when more than 2,000,000 were produced. The rate of growth was 8.68 percent (Figure 5.1, Table 5.1). Export figures indicate that the

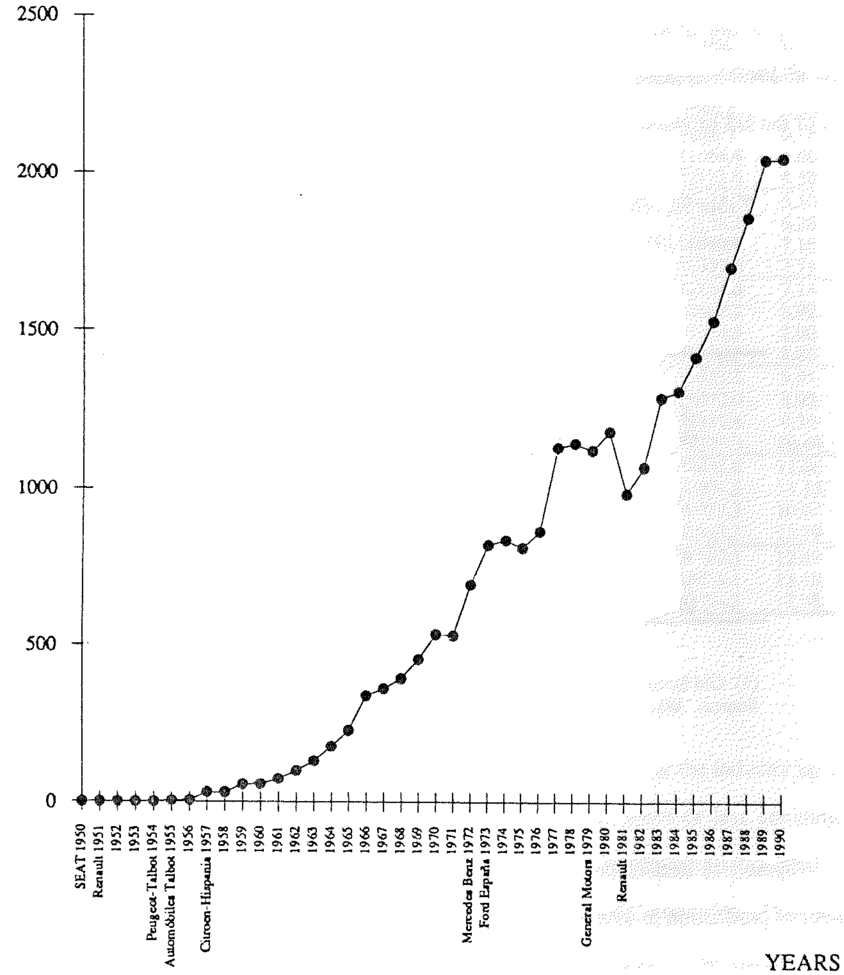
Spanish industry started to become integrated into the World Automotive Industry Market in the 1970's, when 20.8 percent of total production was exported in 1975. Between 1960 and 1990, several large corporations such as Mercedes Benz (1972), Ford España (1973), GM España (1979), and Nissan Motor Ibérica (1980) established themselves in Spain. By 1989, there were 289 cars per thousand people.

Table 5.1 Production of motor vehicles in Spain 1950-1990, thousand units

				Countries of reference	
				USA	Japan
Year	Units	Year	Units	Units	Units
1950	0.3	1971	532.0	1950= 8006.0	1950= 32.0
1951	0.3	1972	695.0		
1952	0.4	1973	822.0		
1953	0.6	1974	837.0		
1954	0.6	1975	814.0		
1955	4.0	1976	866.0		
1956	4.5	1977	1130.0		
1957	30.4	1978	1144.0		
1958	31.1	1979	1123.0		
1959	56.8	1980	1182.0		
1960	58.2	1981	987.0		
1961	75.0	1982	1070.0		
1962	100.0	1983	1289.0		
1963	132.0	1984	1309.0		
1964	178.0	1985	1418.0		
1965	229.0	1986	1532.0		
1966	340.0	1987	1704.0		
1967	362.0	1988	1861.0		
1968	393.0	1989	2046.0		
1969	455.0	1990	2050.0	1990= 9888.0	1990= 13487.0
1970	536.0				

Source: Ward's Automotive Reports, and Automotive News 1991. 1991 Market Data Book.

Figure 5.1 Production of motor vehicles in Spain 1950-1991, thousand units



Source: Ward's Automotive Reports and Automotive News 1991, 1991 Market Data Book.

5.1 THE EXPANSION OF THE AUTOMOBILE INDUSTRY IN SPAIN: 1950 - 1990

The automobile industry expanded during the 1960 - 1990 period. By 1989 Spain had become one of the world's main car producers (Table 5.2). The production of 58,000 units in 1960 increased to 2,050,000 units. Its 1990 production was approximately one fifth of the US production and one sixth of the Japanese production, respectively.

Table 5.2 The top 10 vehicle-producing countries in the world, 1989, thousand units

	Countries	Number of units
1	Japan	13026.0
2	United States	11112.0
3	Germany	4852.0
4	France	3920.0
5	Italy	2221.0
6	Spain	2070.0
7	Canada	1936.0
8	United Kingdom	1626.0
9	Belgium	1248.0
10	USSR (1)	1174.0

(1) Old USSR
Source: Wards Automotive Record, 1991.

Spain also became one of the main European producer countries, sharing the 12.49 percent of production in 1990 (Table 5.3).

Table 5.3 Annual vehicle production and assembly, selected countries in Europe, 1950, 1960, 1970-1990, thousand units

Year	Belgium	France	Italy	Sweden	UK	Germany	Spain	Total	Spain percent
1950	0.2	357.6	127.8	17.6	783.7	306.1	0.3	1593.2	0.02
1960	0.3	1369.2	644.6	128.5	1810.7	2055.1	58.2	6066.7	0.96
1970	272.4	2750.1	1854.3	310.9	2098.5	3842.2	536.0	11664.4	4.60
1971	295.8	3010.3	1817.0	317.3	2198.1	3982.7	532.4	12153.6	4.38
1972	271.5	3328.3	1839.8	351.0	2329.4	3816.0	695.2	12631.2	5.50
1973	299.0	3569.2	1958.0	378.0	2163.9	3949.1	822.0	13139.2	6.26
1974	183.1	3462.8	1772.5	368.4	1936.7	3099.8	837.4	11660.7	7.18
1975	222.2	2861.3	1458.6	366.8	1648.4	3186.2	814.2	10557.6	7.71
1976	327.0	3402.7	1596.7	367.8	1705.5	3868.1	866.2	12134.0	7.14
1977	336.4	3507.9	1583.9	286.1	1714.0	4104.2	1129.7	12662.2	8.92
1978	303.3	3507.9	1656.1	305.5	1607.5	4186.4	1143.8	12710.5	9.00
1979	315.0	3613.5	1632.3	354.8	1478.5	4249.7	1122.9	12766.7	8.80
1980	260.0	3378.4	1611.9	298.4	1312.9	3878.6	1181.7	11921.8	9.91
1981	237.5	3019.4	1433.7	313.7	1184.2	3897.0	987.5	11072.9	8.92
1982	278.0	3148.8	1453.0	349.1	1156.5	4062.7	1069.5	11517.6	9.29
1983	285.5	3335.9	1575.2	414.5	1289.1	4154.4	1288.7	12343.3	10.44
1984	249.5	3062.2	1601.2	431.9	1133.7	4045.5	1308.8	11832.6	11.06
1985	266.7	3016.1	1572.9	461.1	1311.3	4445.9	1417.6	12491.5	11.35
1986	295.3	3194.6	1912.6	487.2	1202.7	4578.3	1306.6	12977.3	10.07
1987	352.4	3493.2	1912.6	501.8	1388.8	4634.1	1704.5	13987.3	12.19
1988	397.7	3678.5	2111.0	485.6	1544.8	4625.3	1866.5	14709.5	12.69
1989	388.8	3919.8	2220.8	465.9	1625.7	4851.6	2045.6	15518.1	13.18
1990	313.4	3294.8	1874.7	335.9	1295.6	4660.7	1679.3	13454.3	12.48

Source: Automotive News, 1991 Market Data Book Issue.

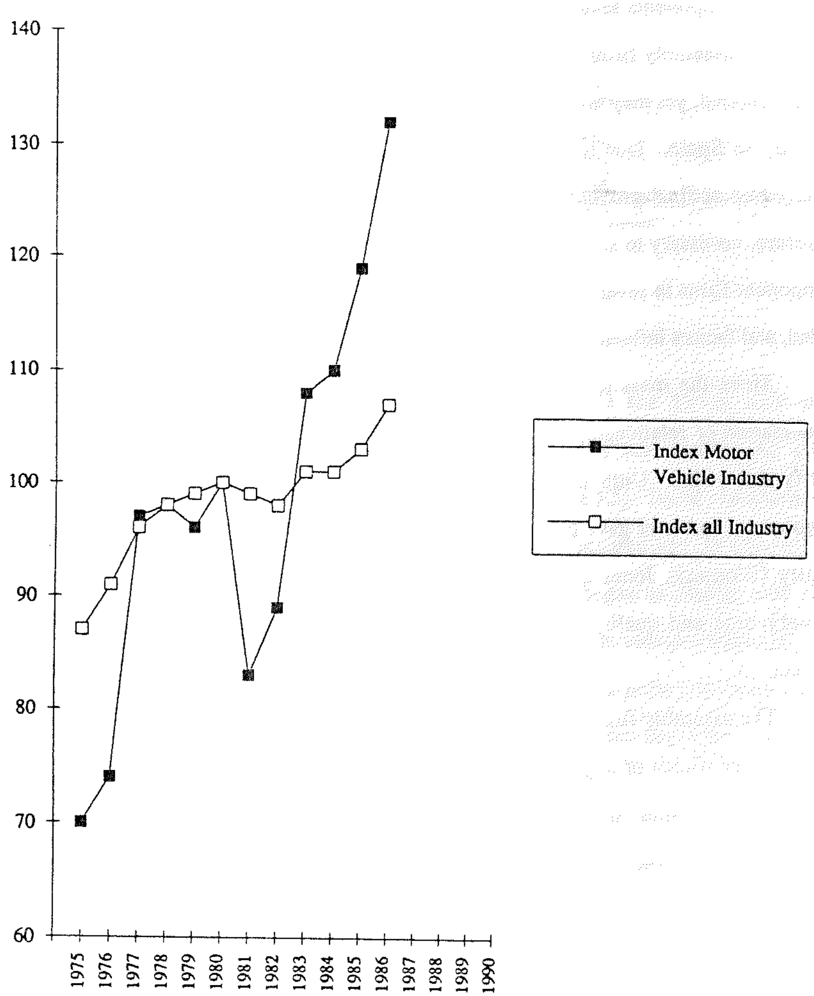
Employment in Spain increased during the years of expansion of the industry up to 1980, with a peak year of 160,000 workers. Then it remained more or less constant, varying between 145,000 and 137,000 workers. Even though employment stagnated in the 1980s, the number of workers did not decrease, as it did in EEC countries. This was probably due to the life cycle stage of the industry in Spain. In contrast to the mature AI in Europe, Spain's relatively young industry was in a growth phase, thus the adverse impact of the global recession was not so severe. Given the contemporary close relationship between the Spanish and the European industries, however, this difference may be short lived.

Although the numbers of employees from 1981 to 1987 (Table 6.4) was stable, wages and salaries increased from 1981. By 1987, they had doubled. Similar increases can be observed in social security costs for the same period. Starting at 45.4 billion pesetas at the beginning, it reached 83.2 billion pesetas when the period ended (Table 6.4).

The expansion stage of the AI in Spain is also seen in figures for gross investment and electricity consumption. Gross investments remained stable, only in 1984 and 1985 was there higher gross investment (Table 6.4). Electricity consumption grew by 10.2 percent between 1980 and 1987. Clearly, the increasing importance of the automobile industry is reflected in the value-added (Table 6.4), in which the figure for 1975 was 51.9 billion pesetas, increasing to 739 billion pesetas in 1987.

Since the 1980s, the expansion of the automobile industry has been higher than that of Spanish industry as a whole. This is reflected in the index of industrial production which, since 1983, is much higher in the AI than the total industry in Spain (Figure 5.2). For instance, the annual growth rate between 1979-1988 was 6.3 percent in the motor vehicle, compared to 1.7 percent for All Industry.

Figure 5.2 Index of industrial production (1980=100), Spain Motor Vehicle Industry, ISIC 3843



5.2 ASSEMBLERS AND SUPPLIERS: THE PRODUCT CHAIN

The automobile industry is composed of two main sectors: the assemblers, and the parts and components sector. The latter supply small, discreet parts, main component or systems to assembly firms, forming the assemblers' supplier group. Both sectors are very closely related, yet they are very different and have different roles in the evolution of the industry in Spain. Due to the large number of components and parts required by the automobile as final product, the industry requires a very large network of firms. It is, therefore, necessary to analyze both sectors. The assembly firms differ from the part and component firms in several respects; such as number of firms, size of labor, sales, value-added, and factors influencing location.

Since the mass production revolution, assemblers have led the industry in the organization of relationships between assemblers and suppliers. A small example will clarify this point. Until the 1980s, two of the Big Three firms in the US designed components and later gave the drawings to different suppliers, seeking bids in price and quality (Womack, Jones and Roos 1990). Usually, the firm offering the best price, delivery time and quality standards -least defects per 1,000 pieces- was awarded the contract.

The assembly firms in Spain are multinational, having established plants in Spain either as greenfields or in joint ventures with Spanish firms. For example, Volkswagen has an important share of Seat; Ford España and General Motors España are greenfield centers in the industrial regions of Almusafes (Valencia) and Figueruelas (Zaragoza). Main assembly firms in Spain, according to production units, are: Seat Volkswagen, General Motors España, Fasa Renault, and Ford España (Table 5.4).

Table 5.4 Principal World Motor Vehicle manufacturers in Spain, according to production units, 1988-1989

Manufacturer	1987	1988
Seat Volkswagen	406391	433482
GM España	297734	361291
Fasa Renault	312558	339588
Ford España	276611	281726

Source: 1989 Ward's Automotive Yearbook.

The parts and component sector began production in the 1950s with the establishment of assembly firms. Initially, the component firms were established with Spanish capital and, even in 1992, they were small in size (Table 5.5). Some were family-owned, a fact which will influence their chooice of location, discussed later in Chapter 7. During the second half of the 1980s, the ownership structure began to change with the penetration of mostly European international firms establishing joint ventures with Spanish firms or purchasing them outright. Thus, the network structure of parts and component firms, which was formed by very small to medium firms, is now moving towards a network of medium to large firms[14].

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14 Although there are no time series data available on number of workers per firm, different interviews with various parts and components associations confirm this statement. There is a tendency towards an increase in size due to professionalization and to mergers and joint ventures with multinationals, which established in Spain in the 1980s.

In 1992, although 40 percent of employees worked in firms of less than 10 workers and approximately 25 percent of the firms employed less than 30 workers (Table 5.5), the entry of large European component firms like the German Bosch, a leader in the field of electronic injection and braking systems; the French Valeo group, which holds 45 percent of the European radiator market; the Italian Magnetti-Marelli firm, a subsidiary of FIAT, which concentrates in electronic ignition; and the British Lucas and GKN leading groups, are likely to change the composition of the component and parts industry (Panorama of the EC Industry 1989 14-8). These five large firms basically dominate the European parts and components market.

Table 5.5 Selected component firms in Spain, by number of workers, small to medium size firms, 1992

Number of workers	Number of firms	Percent
0 to 10	50	39.7
11 to 20	13	10.3
21 to 30	30	23.8
31 to 40	6	4.8
41 to 50	9	7.1
> 50	18	14.3
Total	126	100.0

Source: FARA Gremio de Fabricantes de Equipos, Accesorios y Recambios para Automoción, 1992.

The assembly firms differ from the component firms in terms of number of firms and size of labor force. For the 1984-1990 period, two clear groups can be distinguished, one with a few number of firms -the assemblers- and another with a larger, statistically

significant number of firms -the parts and components producers-. While the number of assemblers in those years ranged from 8 to 12 firms, the suppliers' number of firms ranged from 73 to 105 firms[15] (Tables 5.6, 5.7).

Table 5.6 Spanish automobile industry. Characteristics of the assembly firms. CNAE 361, 1984-1990

Year	Number of firms	Number of workers	Value added Billion Ptas	Value added per worker, 000 Ptas	Sales Billion Ptas	Sales per worker Million Ptas
1984	8	56224	148.3	2638.0	638.9	113.6
1985	9	63037	188.7	2994.0	815.0	129.3
1986	12	91521	343.9	3790.0	1434.6	1567.5
1987	11	90665	431.0	4754.0	1823.3	2011.0
1988	11	93802	497.7	5305.0	2111.8	2251.3
1989	9	63772	345.6	5419.0	1596.6	2503.6
1990	9	61508	302.6	4920.0	1603.9	2607.6

Source: Banco de España. Central de Balances.

15 This is a sampling of suppliers and assemblers intended to be representative of each sector, however those lists are not exhaustive.

Table 5.7 Spanish automobile industry. Characteristics of the component firms. CNAE 362-362, 1984-1990

Year	Number of firms	Number of workers	Value added Billion Ptas	Value-added per worker, 000 Ptas	Sales Billion Ptas	Sales per worker Million Ptas
1984	84	20001	51.0	2550.9	110.8	5.5
1985	99	20216	58.8	2907.2	134.2	6.6
1986	105	21502	69.4	3227.4	159.9	7.4
1987	102	21105	74.8	3544.6	179.4	8.5
1988	96	19976	79.8	3995.2	197.7	9.9
1989	73	16774	69.4	4137.7	181.3	10.8
1990	73	16895	72.5	4291.0	184.1	10.9

Source: Banco de España. Central de Balances.

While assembly firms employ more than 500 workers, component firms show a wide range in size distribution as shown in the data for the 1984 - 1990 period (Table 5.8). For most of the years in this period, 1984-1990, the number of assembly workers was four times the number of employees in component industries.

Table 5.8 Component firms in Spain. Classification of firms according to number of workers, 1984-1990. Number of workers (1)

Year	Number of workers ≤ 9	10 to 19	20 to 49	50 to 99	100 to 199	200 to 499	≥500	TOTAL
1984	6	58	200	1365	2912	6720	8740	20001
1985	17	89	530	1710	2315	6673	8882	20216
1986	10	130	531	1954	2624	6207	10046	21502
1987	6	150	660	1476	2235	5795	10783	21105
1988	0	82	501	2282	1892	5364	9855	19976
1989	0	53	578	1154	1689	5191	8109	16774
1990	0	74	451	1136	1797	5751	7686	16895

(1) Selected firms.
Source: Banco de España. Central de Balances.

Unions are powerful in the assembly sector, while the majority of employees in the component sector are not unionized. Unionized workers constitute 35 to 45 percent of the workers in the assembly sector (Table 5.9), in contrast to the parts and components, with 12 to 15 percent in 1991[16]. Some parts supplier firms employ a minimum of two workers. The atomization of firms in the component sector, and the low profit margin of dependent supplier firms could be cited as explanatory factors. According to Womack, Jones and Roos (1990, 59): "the assembler might ensure that suppliers had low profit margins, but not that they steadily decreased the cost of production through improved organization and process innovations."

16 Source: CC.OO., personal interview.

Table 5.9 Assembly firms in Spain. Level of worker unionization, 1980, 1990

Firm	Number of workers 1980 (1)	1990	Affiliation CC.OO. 1980	1990	UGT 1980	1990	Others 1980	1990
SEAT	31682	21800	8500	6400	6000	7500 (2)	1000	700
Fasa Renault	22027	17040	1700	2100	1800	2600	700	1300
Ford	9714	10855	1500	2600	2000	3500	300	500
GM España	–	9448	–	1400	–	1600	–	300
Peugeot	13757	6378	3700	1600	1000	400	500	300
Citroen	9244	8410	800	400	600	500	500	1000
Santana Motor	3700	3345	300	650	200	100	–	50
TOTAL	90124	77276	16500	15150	11600	8700	3000	4150
Percent			18.3	19.6	12.9	11.3	3.3	5.4

Total Percent	1980		1990	
	1980 Union affiliat.:	34.5	1990 Union affiliat.:	36.2
	1980 Non affiliation:	65.5	1990 Non affiliation:	63.8
	Total	100.0	Total	100.0

(1) Figures for 1980 are estimated.
(2) Confederació General de Treballadors.

Source: Federación del Metal Comisiones Obreras.

Productivity, as value-added per worker, decreases in assembly firms, depending on firm size; bigger firms, with more than 500 workers, have the highest productivity -ranging from 2530 to 5424 pesetas per worker-, and firms with 50 to 99 workers range from 1905 to 4433. Smaller firms with less than 50 workers have the lowest productivity with 792 pesetas. A comparison of the productivity of a firm of 20 to 49 employees shows that it is 6 times lower than for a firm with more than 500 workers, and 4 times less than some firms with 50 to 99 workers (Tables 5.10, 5.11).

Table 5.10 Small assembly firms in Spain, from 48 to 99 workers, value-added

Year	Number of firms	Number of workers	Value added Million Ptas	Value-added per worker, 000 Ptas
1984	1	96	315.0	3281.0
1985	1	63	120.0	1905.0
1986	2	116	300.0	2586.0
1987	1	64	181.0	2828.0
1988	1	67	297.0	4433.0
1989	1	57	250.0	4386.0
1990	1	48	38.0	792.0

Source: Banco de España. Central de Balances.

Table 5.11 Large assembly firms in Spain, ≥ 500 workers, value-added

Year	Number of firms	Number of workers	Value added Billion Ptas	Value added per worker,000 Ptas
1984	7	58490	148.0	2530.0
1985	8	62974	188.6	2995.0
1986	10	91405	343.6	3759.0
1987	10	90591	431.0	4757.0
1988	10	93735	497.7	5309.0
1989	8	63715	345.6	5424.0
1990	8	61460	302.6	4923.0

Source: Banco de España. Central de Balances.

In component firms (Table 5.12) productivity seems to be independent of the size of the firms, at least in more recent years (1989 - 1990), ranging from 3341 to 4350, in 1990. Looking back to other periods, however figures show higher productivity in larger firms, and the smallest firms (< 9 workers) show the lowest productivity. This pattern is similar to the assembly firms.

Table 5.12 Component firms' productivity in Spain. Classification of firms depending on number of workers, 1983-1990. Value-added per worker million pesetas

Year		Number of workers ≤ 9	10 to 19	20 to 49	50 to 99	100 to 199	200 to499	≥500
1984	Value-added	6.0	103.0	420.0	2809.0	6382.0	16430.0	24870
	Number workers	6	58	200	1365	2912	6720	8740
	Productivit. per worker	1.0	1.8	2.1	2.1	2.2	2.4	2.8
1985	Value added	11.0	200.0	1490.0	4075.0	5899.0	19531.0	27565
	Number workers	17	89	530	1710	2315	6673	8882
	Productivit. per worker	0.6	2.2	2.8	2.4	2.5	2.9	3.1
1986	Value added	11.0	221.0	1463.0	5435.0	6717.0	19952.0	35597
	Number workers	10	130	531	1954	2624	6207	10046
	Productivit. per worker	1.1	1.7	2.8	2.8	2.6	3.2	3.5
1987	Value added	16.0	364.0	1965.0	4731.0	6793.0	21516.0	39424
	Number workers	6	150	660	1476	2235	5795	10783
	Productivit. per worker	2.7	2.4	3.0	3.2	3.0	3.7	3.7
1988	Value added	0.0	244.0	1439.0	8201.0	6715.0	22628.0	40592
	Number workers	0	82	501	2282	1982	5364	9855
	Productivit. per worker	0.0	3.0	2.9	3.6	3.4	4.2	4.1
1989	Value added	0.0	163.0	2051.0	4552.0	6230.0	22411.0	33999
	Number workers	0	53	578	1154	1689	5191	8109
	Productivit. per worker	0.0	3.1	3.5	3.9	3.7	4.3	4.2
1990	Value added	0.0	298.0	1507.0	4766.0	7148.0	25342.0	33435
	Number workers	0	74	451	1136	1797	5751	7686
	Productivit. per worker	0.0	4.0	3.3	4.2	4.0	4.4	4.4

Source: Banco de España. Central de Balances.

In summary, the AI shows strong growth in the 1975 to 1990 period and this was reflected in the value-added data. The value-added for 1987 is 14 times that of 1975. Wages and salaries increased as much as 6 times from 1975 to 1987, and the quantity of electricity consumed in 1987 was as much as 3.5 times the amount consumed in 1975.

5.3 DOMESTIC AND FOREIGN MARKETS

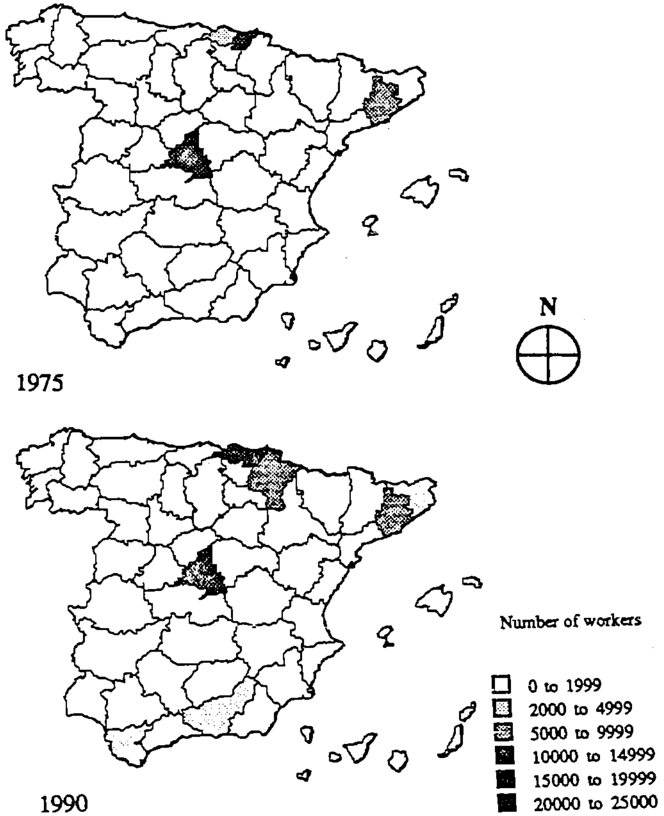
Demand for cars in Spain is composed of domestic and export markets. There has been an increasing domestic demand for cars, in the past 25 years; changes in the economic condition of Spain in the second half of the 1980s (Table 5.12.1), might be one of the causes of higher demand for cars. This trend can be observed in the new vehicle registration data (Table 5.13), in which since 1976, new registration has almost doubled by 1990 . Total registration also showed an increasing trend, the 1990 figure is more than twice as much as the 1975 figure, and more than 11 times the 1965 figure (Table 5.14).

Table 5.12.1 Real GNP growth index, Spain, 1982-1991

Year	GNP growth index
1982	1.2
1983	1.8
1984	1.8
1985	2.3
1986	3.3
1987	5.6
1988	5.2
1989	4.8
1990	3.6
1991	2.4

Source: Banco de España. Boletín Estadístico.

Figure 5.5 Number of workers in selected component firms by region, 1975, 1990



Source: Principal International Businesses. Dunn and Bradstreet Data, 1975, 1990.

5.5 THE AUTOMOBILE INDUSTRY IN SPAIN WITH RESPECT TO EUROPE

5.5.1 The automobile Industry In Europe

The automobile industry in Europe is one of the most important, representing about 90 percent of the EC industrial value-added. It directly employs 1.7 million people (Table 5.16), which represents about 8 percent of manufacturing employment. External trade in the automobile industry in Europe represented 29 percent of total manufactured goods in 1986 (Panorama 1989, 1990, 1991-1992).

Table 5.16 Motor vehicle assembly firms in Europe, main indicators, thousands, 1980-1987

Concepts	1980	1981	1982	1983	1984	1985	1986	1987	1988
Apparent consumption									
Cars	9.1	9.1	9.3	9.6	9.2	9.4	10.5	11.3	11.1
Vans & trucks	1.2	1.1	1.2	1.1	1.1	1.3	1.3	1.4	1.5
Total	10.3	10.2	10.5	10.7	10.3	10.7	11.8	12.7	12.6
Net exports									
Cars	...	...	...	...	0.7	0.9	0.5	0.4	0.5
Vans & trucks	...	...	...	...	0.1	0	0.2	0.1	0
Total	1.4	0.7	0.8	1.3	0.8	0.9	0.7	0.5	0.5
Total Community production									
Cars	...	...	...	...	9.9	10.3	11	11.7	11.6
Vans & trucks	...	...	...	..	1.2	1.3	1.5	1.5	1.5
Total	11.7	10.9	11.3	12	11.1	11.6	12.5	13.2	13.1
Employment (1,000)	1833	1772	1718	1686	1663	1655	...	...	

Source: Panorama of EC Industry, 1989.

By observing the 10 most important European industrial firms, it may be seen that 4 of them pertain to the automobile sector, and that 3 of these hold the top positions (Table 5.17). Given the many external connections with supply firms, the assembly sector is always a focal point of industrial progress. European AI is traditionally oriented towards the European market. This trend has already been seen in data for Spain, in which 97 percent of its car exports are to European countries.

Table 5.17 Ranking of the 10 main European firms

Firm	Rank Posit.	Sales revenues (million ECU) 1983	1984	1985	1986	1987	1988	Annual Index of Growth 1983-1988 %	Industry
Daimler-Benz	1	17619	19438	23541	30776	32562	35429	14.99	Automob.
Wolkswagen	2	17656	20406	23582	24807	26366	28548	10.09	Automob.
Fiat	3	16286	17239	18716	20069	25783	29271	12.44	Automob.
Siemens	4	17384	20472	24532	22095	24820	28622	10.49	Electronics
Bat	5	23576	31178	28954	28543	24357	26568	2.42	Food
Unilever	6	23425	26469	26591	23059	23597	26538	2.53	Food
Philips	7	18202	21323	23913	22924	22571	24019	5.70	Electronics
Renault	8	16287	17111	17975	19844	21312	22943	7.09	Automob.
Basf	9	15464	18051	19933	19017	19418	21147	6.46	Chemistry
CG Electricite	10	8483	9038	10587	11898	18416	18185	16.48	Electronics

Source: Panorama of EC Industry, 1990.

Over the second half of the 1980s, the whole industry received internal and external pressures from multinational firms based in foreign countries, mainly Japan. For instance, Japanese car penetration varies depending upon the country, but while the Japanese percentage share is low in Spain, at 0.6 percent in 1984, the highest in Europe seems to be Greece and Switzerland, with 30.9 and 24.5 percent the same year, respectively (see Table 5.18).

Table 5.18 Japanese passenger car import penetration in Europe and the US. Spain and selected countries, 1975, 1980, 1981-1984

Year	Spain %	France %	W Germany %	Greece %	Italy %	Portugal %	Switzerland %	UK %	USA %
1975	. . .	1.5	1.7	10.8	. . .	20.5	8.4	9.0	9.4
1980	. . .	2.9	10.4	49.2	0.1	7.5	23.2	11.9	21.3
1981	1.3	2.6	10.0	48.2	0.1	11.9	27.2	11.0	21.8
1982	1.4	2.9	9.8	45.8	0.1	8.5	26.7	11.0	22.6
1983	1.2	2.7	10.6	39.9	0.2	8.1	27.4	10.7	20.9
1984	0.6	3.0	12.0	30.9	0.2	8.5	24.5	11.1	18.3

Source: World Motor Vehicle Data, 1986, 1991.

Due to this internal and external pressure, plus an overcapacity resulting from the 1979 oil crisis (Panorama of EC Industry 1989 14-1), the EC Automobile Industry is modifying its strategies. This phenomena of adjustment forces changes at most points in the industry, like implementing changes in the production processes, and in product quality. In summary, these strategies lead towards increasing production and flexibility of the whole industry.

The market stagnation originated by the 1979 oil crisis had different repercussions in each country of the European Community and there have also been different periods of recovery. For instance, countries like France, Italy and the UK suffered the crisis later than Germany; and Spain had a more stable situation due to the building up of the number of automobiles. Panorama claims that smaller countries "benefited from an earlier up-turn because of replacement demand." (14-5).

Direction of trend in the market has changed in the second half of the decade, with demand increasing and reaching a 1987 record of 12.7 million vehicles (18 percent more than 1985). The reasons for recovery vary among countries. While Germany and the UK experienced an increase in disposable income, France reduced its VAT, and Spain is below the EEC in average car density, and is trying to reactivate it -in 1988, 263 vehicles per 1,000 inhabitants compared with an EC average of 359.

European producers face some particular problems which could be listed as follows (Panorama 14-5):

. the inadequate scale, profitability and financial capability of several operators.
. the instability of competition between six nearly equal volume producers.
. the competition with potential Japanese transplants to Europe.
. the falling revenues from exports to the US mainly as a result of currency fluctuations.
. a potential increased flow of exports from the US by both Japanese and American manufacturers.
. the emergence of new producers in the Asia Pacific area who are preparing large-scale production for export.

On the other hand, the parts and components sector in Europe is mainly devoted to the internal market, although some portion is sold to American firms. The European parts and components sector accounts for about 15,000 companies, which employ some 60,000 workers (Panorama 1989), and, like the assembly sector, show an increasing trend of jobs loss, although production is increasing and there is some evidence of increasing investment and technology restructuring.

The importance of the parts and component sector in the European automobile industry is increasing. In 1987 the revenues from these sector companies account for 60 billion ECU's, which represents 30 percent of the overall European motor vehicle industry revenues. Original equipment parts account for 60 percent of these firms revenues, while

the remaining percentage corresponds to replacement parts. Trade surplus of this sector was 7.4 billion ECU's in 1986.

In the last year, the parts and component sector was restructuring itself. This was due to different factors, mainly the internationalization of production, which resulted in enlargement of the firms' sizes, the increasing trend towards technological change and the transition of systems of production throughout the entire motor vehicle industry. The special link between both sectors within the automobile industry -the assembly and the parts and components- makes for a close dependency upon each other.

The main producer country was Germany, which accounted for about 50 percent of the total European production. In numbers, German production accounted for 28 billion ECU's, of which 35 percent was exported to countries inside and outside of the EEC. The remaining 65 percent went to German car production, which accounted for 40 percent of total European production. The strongest group of parts and components in Germany was Bosch -electronic injection and braking systems- which accounted for one-fourth of the German production.

The next producer country is France, which held about 20 percent of the European market share in parts and components. Its main group is Valeo, which bought the Neiman group in 1988. This group "holds 45 percent of the European radiator market, 40 percent of the lighting and clutch market, and 30 percent of the alternator market" (Panorama 14-8).

The following countries: Spain, UK and Italy, accounted for 11, 13, and 9 percent of European production, respectively. The difference with these countries was that while all of them have large transnational groups, which dominate part of the European market, Spain had no large Spanish born firm producing parts and components.

The production of parts that different car makers bought from suppliers varied among firms, depending upon the degree of vertical integration of the company. For instance, while European car makers like FIAT, Renault or Peugeot bought around 55 to

70 percent outside the company; Japanese firms bought around 80 percent; and American firms bought between 30 and 40 percent.

Export figures for EEC producers of this sector was 20 billion ECU's in 1985, with the USA market being the main buyer.

Thus, five large firms dominated the European parts and component sector: the German Bosch, the French group Valeo, the Italian FIAT group Magnetti Marelli, and the British Lucas-Girling and GKN groups. All of these differ in structure and performance levels. For instance, while Bosch pioneered the field of fuel injection with mechanical and electronic systems and brakes, as well as having a bunch of small firms working for them, Italian firms were very closely linked to a big car maker, the FIAT group, and British firms, after restructuring and adjustments, ended up with 2 large groups that have already been mentioned.

5.5.2 The Production of Spain with Respect to Europe

In 1990 Spain occupied the fourth position as a producer country among the European producer countries; only Germany, France and Italy were ahead of Spain. Although in 1950 Spain produced only 0.02 percent of the European production of cars, in 1980 the country reached almost 10 percent, and 12.48 percent in 1990 of European production. Similar trends follow in car exports, which, as mentioned above, go to European countries. In Spain, 1970 car exports represented 8.2 percent of total car production; in 1980 this figure went up to 47.8 percent, and in 1989 it reached 56.4 percent. Spanish car export figures are similar to those of France and Germany, with 56.4 and 63.1 respectively; and higher than those of Italy and the UK, with 35.2 and 21.6, respectively.

5.5.3 The Automobile Industry in Spain and the EEC Single Market

The Spanish automobile industry has old and well established relations with the rest of the European countries. These relationships are of two kinds. First, European AI firms have been located in Spain since the 1950s. For instance, the largest assemblers in Spain - Fasa Renault, and Seat Volkswagen- are joint-ventures of European and Spanish firms. Also, most of the largest component firms in Europe -like Lucas Girling- have plants located in Spain. Second, during the 1980s, the majority of Spanish automobile exports went to other European countries.

In January of 1993, the development of the EEC single market[18] began, and EEC regulations in the automobile industry affect, in general, the homologation of vehicles, the components, and they also pay special attention to the amount of air pollution caused by vehicles. The creation of the unified internal market from 1993 may modify the European industry in the form of restructuring, company mergers, and joint strategic alliances. The major trading areas in the world, North America, Japan, and the EEC, seem to be reinforced by European reunification, and these three markets are of comparable size, each producing about 12 million cars and trucks per year.

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18 Which means the creation within the 12 community countries of a space with no interior frontiers, and with free circulation of goods, services, capital and people. The implication for each country is a process of adaptation to common rules in the productive process, and the break down of physical, technical, and fiscal barriers to allow free circulation of capital, goods, services and people within countries.

The single market might change the competitive advantages of the AI firms. On one hand, it enlarges the market for AI firms which, under free competition, would lower production costs (El País, Dec 31, 1992). On the other hand, the free circulation of labor would, in the intermediate term, equalize labor costs across Europe. While free circulation of people is still not accomplished, there are already laws enforcing free labor force circulation among member countries. And they are especially devoted to guaranteeing equal rights for all workers and their families. Skilled workers are allowed to follow their professional careers in any of the member countries. In general, professional diplomas and careers are recognized and amalgamated in all member countries.

Spain, which was a cheap labor country until the 1970s, had this factor as a competitive advantage in attracting firms (Cohen 1983). In the 1980s, Spanish labor became more expensive, although it was still lower than France, Germany, Italy and the UK (Table 5.19). Thus, assuming the same structural circumstances for the AI, Spain could face the threat that AI firms would choose to locate in other EEC country with cheaper labor cost, like Portugal or Greece. But structural changes in the production of cars, discussed in different sections of this dissertation, suggest that the AI is not primarily influenced in its location by cheap labor; other factors such as skilled labor pools, network of kindred firms and good transportation and communication structures are becoming more important. Also, while the AI is a long term investment, low labor cost could change in a short term; thus, it might become obsolete as a location factor within a common labor market.

Table 5.19 European hourly compensation for motor vehicle production workers. In US dollars, 1975, 1979-1989

Year	Spain value	France value	W Germany value	Italy value	Portugal value	UK value
1975	. . .	5.10	7.89	5.16	. . .	4.01
1979	6.78	8.51	14.05	7.32	. . .	6.50
1980	7.11	9.98	15.56	8.13	2.87	8.25
1981	7.03	9.11	13.34	7.64	2.79	7.87
1982	6.69	8.85	13.03	7.67	2.65	7.62
1983	5.69	8.79	13.16	7.81	2.53	7.11
1984	5.35	8.20	11.92	7.69	2.22	6.66
1985	5.54	8.38	12.09	7.72	2.26	7.05
1986	7.74	11.24	16.83	10.38	3.09	8.70
1987	9.54	13.41	21.44	12.79	. . .	10.63
1988	10.85	14.02	23.00	13.54	. . .	12.28
1989	. . .	13.75	22.29	14.00	. . .	12.30

... Not available

Source: 1991 Ward's Automotive Yearbook.

Accordingly, some authors (Dicken 1992) noted that there is no reason to expect a dramatic and general geographical restructuring of the automobile industry as a direct response to the creation of a single market in the EEC, because firms already behave as if they exist in a single market. This is reflected in the characteristics of the Spanish automobile firms and exports discussed above. The major force generating structural change in the European firms is the increasing competitive threat from the Japanese manufacturers, and not the threat of lower labor costs in other European countries.

In order to protect the European AI from this threat, the quantity of Japanese imports is limited by EEC laws; the amount of Japanese investments is regulated by laws of each member country. In the EEC, Japanese car imports are limited until 1999, after which trade will be free. From 1993-1999 is a transition period, in which Japanese sales within the EEC may reach 16 percent of the European market share by the end of this period[19] -i.e. 1.6 million cars- (CIDEM, "Información Internacional", January 16, 1992). In Spain, the limitation in the number of Japanese car imports in 1992 was to 1200 vehicles, while the number of Japanese indirect car imports -i.e. Japanese cars assembled in the EEC- was 12,860 for the same year (Interbask, S.A. 1992). There is a high demand for Japanese cars in Spain; for instance, in January of 1992, the demand for Japanese cars was for 36,600 vehicles (Interbask, S.A. 1992). Also, Spain is a European countries with one of the lower penetrations of Japanese investment.

In the automobile industry, cars as well as parts and components can be bought throughout all countries of the EEC. The VAT (value-added tax) on a car, as well as the registration tax, has to be paid in the country of destination.

19 There is disagreement with respect to what constitutes a Japanese car, in the sense of whether this market share refers to Japanese direct imports in addition to the production of Japanese transplants in Europe or not (CIDEM, "Information Internacional" January 16, 1992). Another definition ambiguously refers to the "Certificate of origin of goods", which is defined as: "A good will be originally from a country when it is produced entirely in this country or the last justified transformation or substantial elaboration has been done in this country (Diario Oficial de las Comunidades Europeas. Reglamento (CEE) No. 802/68 del Consejo de 27 de junio de 1968).

5.6 THE AUTOMOBILE INDUSTRY IN SPAIN WITH RESPECT TO THE REST OF THE WORLD: JAPAN, USA, AND THE REST OF THE CAR PRODUCER COUNTRIES

The increasing industrialization of Spain since the 1960s and as focused on the automobile industry, is reflected in the production volumes that have experienced an increase over the past 30 years. With respect to the US and Japan (Table 5.20), Spain has been a receptor of investments, with the main factories being branches of international firms of these two countries, mainly in the assembly sector, although some parts and components are imported to Spain from other branches of these transnationals located in other countries of the EEC.

The high production trend in Spain is also reflected in the comparison of this country to the rest of car producing countries, as can be seen in Table 5.21. Some of these countries are newer than Spain in car production, as can be observed in Brazil and South Korea.

Table 5.20 Annual vehicle production and assembly, Spain, US, and Japan, 1950, 1960, 1970-1990
Million units

Year	Countries: USA	Japan	Spain	Total	Spain percent
1950	8.0	0.0	0.0	8.1	0.31
1960	7.9	0.5	0.1	8.4	0.69
1970	8.3	5.3	0.5	14.1	3.80
1971	10.7	5.8	0.5	17.0	3.13
1972	11.3	6.3	0.7	18.3	3.80
1973	12.7	7.1	0.8	20.6	3.99
1974	10.1	6.6	0.8	17.4	4.80
1975	9.0	6.9	0.8	16.7	4.86
1976	11.5	7.8	0.9	20.2	4.29
1977	12.7	8.5	1.1	22.4	5.05
1978	12.8	9.3	1.1	23.2	4.92
1979	11.4	9.6	1.1	22.2	5.07
1980	8.0	11.0	1.2	20.2	5.84
1981	8.0	11.2	1.0	20.1	4.90
1982	6.9	10.7	1.1	18.7	5.73
1983	9.5	11.1	1.3	21.9	5.90
1984	10.9	11.4	1.3	23.6	5.54
1985	11.7	12.3	1.4	25.4	5.59
1986	11.4	12.3	1.3	24.9	5.24
1987	11.0	12.2	1.7	24.9	6.84
1988	11.0	12.7	1.9	25.6	7.30
1989	11.1	13.0	2.0	26.2	7.81
1990	9.9	13.5	1.7	25.1	6.70

Source: Automotive News, 1991 Market Data Book Issue.

Table 5.21 Annual vehicle production and assembly, million units Spain, Brazil, Canada, S. Korea, Mexico, 1950, 1960, 1970-1990

Year	Countries Brazil	Canada	S.Korea	Mexico	Spain	Total	Spain percent
1950	0.0	0.4	0.00	0.02	0.0	0.4	5.82
1960	0.1	0.4	0.00	0.05	0.1	0.6	9.11
1970	0.4	1.2	0.03	0.19	0.5	2.3	22.99
1971	0.5	1.4	0.02	0.21	0.5	2.7	20.05
1972	0.6	1.5	0.02	0.23	0.7	3.0	23.08
1973	0.7	1.6	0.03	0.29	0.8	3.5	23.82
1974	0.9	1.5	0.03	0.35	0.8	3.6	23.53
1975	0.9	1.4	0.04	0.36	0.8	3.6	22.70
1976	1.0	1.6	0.05	0.32	0.9	3.9	22.41
1977	0.9	1.7	0.08	0.28	1.1	4.1	27.48
1978	1.1	1.8	0.16	0.38	1.1	4.6	25.13
1979	1.1	1.6	0.20	0.44	1.1	4.5	24.94
1980	1.2	1.4	0.12	0.49	1.2	4.3	27.27
1981	0.8	1.2	0.13	0.60	1.0	3.7	26.71
1982	0.9	1.3	0.16	0.47	1.1	3.8	27.88
1983	0.9	1.5	0.22	0.29	1.3	4.2	30.57
1984	0.9	1.9	0.27	0.34	1.3	4.7	28.08
1985	1.0	1.9	0.38	0.40	1.4	5.1	27.81
1986	1.1	1.9	0.60	0.34	1.3	5.2	25.29
1987	1.1	1.6	0.98	0.40	1.7	5.7	29.89
1988	1.1	1.8	1.08	0.51	1.9	6.3	29.60
1989	1.0	1.9	1.13	0.63	2.0	6.8	30.29
1990	0.9	1.9	1.32	0.82	1.7	6.6	25.29

Source: Automotive News, 1991 Market Data Book Issue.

Some of the Spain's advantages are good location in relation to Mediterranean countries, good communication infrastructure with the rest of European countries, relatively cheap labor force for the past 40 years, joined with the perspective of the unification of the EEC market, all benefit the country as one of the main receptors of large investments in the AI from transnational firms around the world.

5.7 CONCLUSIONS TO CHAPTER 5

The Automobile Industry in Spain concentrates its activities mainly in the regions of Barcelona and Madrid. Development of large car assembly firms since the 1950s in these regions is an important factor in attracting other assembly firms to locate there, and to create a chain of auxiliary parts and components firms to serve the main large car assemblers. Other factors of attraction, such as good communication infrastructures, might be the reason why General Motors España and Ford España have located in relatively new industrial regions, like Zaragoza and Valencia, respectively. The third factor of attraction of motor vehicle firms, the cheap labor pool, is losing its attraction due to the increasing trend in labor costs in Spain and the decreasing importance of cheap labor as a factor of location, relative to other factors of higher importance, such as higher level of skills and increasing investments in technology.

The search for efficiency in the automobile industry is mostly done by increasing investment in R&D. Improved utilization of existing production facilities is also a path for change, as this does not necessarily require a huge new investment. Techniques leading managerial efforts towards rationalization of plant layout, workers and common platforms[20] for various automobile models are strategies which result most often in increasing productivity, but bring with them a reduction of the labor force. For Spain, France, Italy and the UK, reduction has been the result, only Germany increased employment[21].

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20 A platform is the structural underbody of an automobile (M.I.T. Commission on Industrial Productivity 25).

21 This statement refers to the 1980s before the reunification of the two Germanies.

Management changes also took place in the new relationships that assemblers established with their suppliers. Assemblers now require "more efficient delivery systems and increasing demand for out-sourcing alternatives in an attempt to reduce vertical integration. (...) New standards and quality requirements were also implemented whereby outside suppliers assume full responsibility with regard to quality and warranty. (...), as well as, large training programs for workers to implement total quality systems similar to the Japanese model." (Panorama of EC Industry 1989 14-2).

On the other hand, new investments in technology are taking place, mainly in regard to computer-aided manufacturing (CAM) equipment. The search for flexibility in the production system and the reduction of product life cycle of the output require the help of this sophisticated equipment and improved research infrastructures. Otherwise, the industry faces a period of market stagnation. Thus, both forces play against each other, and most car manufacturers are confronted with large financial requirements that reduce profitability of the sector.

In Europe restructuring of the industry, which started at the beginning of the 1980s, was reflected in the loss of 178,000 direct jobs between 1981 and 1986. This amount represents 10 percent of total direct jobs. The repercussions in all sectors involved in automobile activities is approximately 400,000 jobs lost (Panorama of EC Industry 1989 14-5). In the long run, employment reductions are expected even though investments will remain high. This is a clear substitution of capital for labor in the industry. These two actions in this 5 year period have already had some outcomes. Output per employee went up by 30.5 percent.

CHAPTER 6. STRUCTURAL ADJUSTMENTS IN THE AUTOMOBILE INDUSTRY IN SPAIN

There was a large increase in production between 1975 and 1990; approximately half of the production went to the domestic market. Even in 1990, the average number of cars in Spain was lower than in the Common Market. Even though it was a period of expansion for the industry, employment held steady from 1981, and costs as well as productivity increased.

In this chapter, the structure of the industry is studied in several steps: the study of the industry as a whole is followed by a study of selected firms: Fasa Renault, Ford España, General Motors España, Nissan Motor Ibérica, and Seat Volkswagen. Since more data was available for some firms than for others, the analysis has varying depths depending on the quantity and type of information obtained from the firms.

Specifications of the Cobb-Douglas production function are provided for the entire industry-, for the manufacturing sector, for the automobile industry, and for three firms, during 1975 - 1990. Fasa Renault, Nissan Motor Ibérica, and Seat Volkswagen provided enough data to do this analysis. The Ordinary Least Square method (OLS) is used for estimation. Number of values is 16 for each variable.

6.1 STRUCTURE OF THE SPANISH INDUSTRY

The estimation of the production function for the Spanish industry in this period shows a high output elasticity of .651 with respect to the material input, while capital and labor have output elasticity of .284 and .242, respectively. The output elasticity for labor increased in the 1983 - 1990 period from .130 to .267, while output elasticities for capital

increased from .196 to .310. The whole industry showed increasing returns to scale for all three periods.

Table 6.1 Variables estimated in the Spanish All Industry production function

Category of the variable	Variable name	Definition
Dependent Variable:		
	Q	Gross output, million pesetas
Independent Variables:		
	K	Capital, million pesetas[22]
	L	Wages of employees, mill. pesetas[23]
	M	Cost of materials, million pesetas[24]

Source: Instituto Nacional de Estadística. Anuario Estadístico de España. 1979, 1989, 1990.

22 Capital defined as the value-added minus labor.

23 Refers to wages and social security cost of employees.

24 Refers to intermediate inputs and raw material cost.

The estimated coefficients are the following:

Table 6.2 Estimated coefficients of Cobb-Douglas function: All Industry, 1975-1990

Characteristic	1975 - 1990	1975 - 1982	1983 - 1990
Constant	**-.895**	.057	**-1.065**
	(2.884)	(.256)	(-5.899)
K	**.284**	**.196**	**.310**
	(17.996)	(16.456)	(30.539)
L	**.242**	**.130**	**.267**
	(8.196)	(6.096)	(11.191)
M	**.651**	**.695**	**.630**
	(27.042)	(50.288)	(34.321)
R^2	.989	.999	.998

Bold type indicates significance at the 5% level.

6.2 STRUCTURE OF THE MANUFACTURING INDUSTRY

The manufacturing industry again showed high elasticity of output with respect to the material coefficient throughout the period studied. Manufacturing demonstrated decreasing returns to scale; in 1975 - 1990 the sum of coefficients was .886. Returns to scale increased in the 1983 - 1990 period with a value of 1.051 relating to the 1975; the 1982 period value was .755. The definition of the variables and the source is the same than that for All Industries, discussed above.

Table 6.3 Estimated coefficients of Cobb-Douglas function: Manufacturing industry, 1975 - 1990

Characteristic	1975 - 1990	1975 - 1982	1983 - 1990
Constant	**1.039**	**1.874**	.018
	(2.828)	(2.915)	(.031)
K	**.082**	.050	**.134**
	(4.710)	(1.442)	(2.596)
L	**.063**	.007	.173
	(1.864)	(.140)	(1.679)
M	**.741**	**.698**	**.744**
	(30.81)	(14.42)	(12.101)
R^2	.995	.997	.997

Bold type indicates significance at the 5% level.

6.3 STRUCTURE OF THE SPANISH AUTOMOBILE INDUSTRY

Production in the automobile industry increased rapidly in the 1975 to 1990 period, starting between 1982 and 1983, in which the production index went from 89 to 108. Compared to the production index of all industries, the Spanish automobile industry had steeper growth, with annual growth rates for 1979 - 1988 of 1.7 and 6.3 percent, respectively (Table 6.4).

This growth was probably due to an increase in investment, in more sophisticated technology, and increasing labor force skills. Partial evidence for this was found in the answers given by the firms to the structured interview discussed in Section 6.4. Large investments were made in 1984, with more than a twofold increase between 1983 and 1984 from 18.9 billion to 54.4 billion, and 30.6 billion pesetas in 1985 (Table 6.5). At the same time the number of establishments decreased from 956 to 904. Labor decreased from 160,000 to 142,000 in the period 1980 - 1988. Similar trends of large investments and decreasing labor force in this period are found in the European automobile industry, as previously discussed in Chapter 5.

Table 6.4a Spanish motor vehicle industry, main characteristics, ISIC 3843

Year	Number of establishments	Gross Investment billion ptas[25]	Employment thousands	Wages & salaries employees billion ptas[26]	Social secur. costs billion pesetas[27]
1975	51	. . .	93	40.5	. . .
1976	50	. . .	105	53.81	. . .
1977	49	. . .	112	80.81	. . .
1978	49	. . .	116	102.3	. . .
1979	48[28]	27.5	117	118.5	35.5
1980	1177	25.8	160	138.9	44.6
1981	1084	25.0	145	143.6	45.4
1982	999	25.7	144	154.3	48.5
1983	956	26.9	145	181.7	57.0
1984	925	85.8	143	184.7	60.4
1985	904	52.4	139	208.9	68.9
1986	877	29.3	137	232.6	71.7
1987	908	31.5	143	264.0	83.2
1988	871	38.5	142	282.1	87.3
1989	. . .	. . .	. . .	. . .	. . .
1990	. . .	. . .	. . .	. . .	. . .

Source: United Nations. Yearbook of Industrial Statistics. Volume 1, General Industrial Statistics. UN. OECD. Industrial Structure Statistics.

25 Current prices.

26 Current prices.

27 Current Prices.

28 Although it is not specified in the source, the difference between number of establishments given in 1979 and 1980 suggest that there must have been a change in the standard classification of establishments between these two years.

Table 6.4b Spanish motor vehicle industry, main characteristics, ISIC 3843

Year	Quantity electricity consumed million KWH	Value added billion pesetas	Gross output factor values billion ptas[29]	Index of indust. production 1980 = 100 (1) Motor Vehicle Industry	All industry
1975	673	51.9	189	70	87
1976	813	62.6	233	74	91
1977	911	87.8	361	97	96
1978	916	113.3	432	98	98
1979	924	228.5	515	96	99
1980	926	247.9	590	100	100
1981	1161	240.7	738	83	99
1982	1190	258.1	808	89	98
1983	1479	283.2	1091	108	101
1984	1458	311.1	1253	110	101
1985	1396	350.0	1396	119	103
1986	1674	467.0	1674	132	107
1987	2376	739.0	2376	. . .	. . .
1988	. . .	812.0	2813	. . .	. . .
1989	. . .	. . .	. . .	. . .	. . .
1990	. . .	. . .	. . .	. . .	. . .

(1) Annual growth rate 1979-1988: Motor Vehicle, 6.3; and All Industry 1.7.

Source: United Nations. Yearbook of Industrial Statistics. Volume 1, General Industrial Statistics, UN OECD. Industrial Structure Statistics. Different years.

29 Current prices.

Table 6.5 Spanish motor vehicle industry, main characteristics, ISIC 3843 values deflated

Year	GDP Deflator 1980=100	Gross Investment billion ptas	Wages & salaries employees billion ptas	Social security costs billion pesetas	Value added billion pesetas	Gross output factor values billion ptas
1975	43.8	. . .	92.5	. . .	118.5	431.5
1976	51.1	. . .	105.3	. . .	122.5	456.0
1977	62.7	. . .	128.9	. . .	140.0	575.8
1978	75.4	. . .	135.7	. . .	150.3	572.9
1979	88.0	31.3	134.7	40.3	259.7	585.2
1980	100.0	25.8	138.9	44.6	247.9	590.0
1981	112.0	22.3	128.2	40.5	214.9	658.9
1982	127.4	20.2	121.1	38.1	202.6	634.2
1983	142.2	18.9	127.8	40.1	199.2	767.2
1984	157.8	54.4	117.0	38.3	197.1	794.0
1985	171.3	30.6	121.9	40.2	204.3	814.9
1986	190.0	15.4	122.4	37.7	245.8	881.1
1987	201.2	15.7	131.2	41.4	367.3	1180.9
1988	213.9	18.0	131.9	40.8	379.6	1315.1
1989	229.1	. . .	. . .	. . .	. . .	. . .
1990	245.8	. . .	. . .	. . .	. . .	. . .

The specification of the variables used is given in Table 6.6, and the result of the estimate of the Spanish automobile industry production function is shown in Table 6.7.

Table 6.6 Variables estimated in the Spanish automobile industry production function

Category of the variable	Variable name	Definition
Dependent Variable:		
	Q	Gross output in factor values, bill. pesetas
Independent Variables:		
	K	Gross investment, billion pesetas
	L	Wages and salaries of employees and social security costs, billion pesetas
	M	Cost of materials[30], billion pesetas

Source: United Nations. Yearbook of Industrial Statistics, Volume 1, General Industrial Statistics. Var. years
OECD. Industrial Structure Statistics. Various years.

Table 6.7 Estimated coefficients of Cobb-Douglas function for the Spanish automobile industry, 1975 - 1990

Characteristic	1975 - 1990	1975 - 1982	1983 - 1990
Constant	**.343**	**.467**	.235
	(3.879)	(4.862)	(1.052)
K	**.082**	**.027**	**.083**
	(9.729)	(2.029)	(2.911)
L	**.215**	**.384**	.134
	(5.718)	(8.567)	(.929)
M	**.707**	**.548**	**.807**
	(30.811)	(10.297)	(4.732)
R^2	.996	.996	.997

Bold type indicates significance at the 5% level.

30 Materials are defined as gross output minus value-added.

For the period 1975 - 1990, the Spanish automobile industry experienced constant returns to scale, with value 1.004. The analysis done for 1975 - 1982 showed lower returns to scale of .959. Efficiency increased in the 1983 - 1990, in which there were increasing returns to scale, with a value of 1.024.

Output elasticity to materials was higher in the 1983 - 1990 period, with a coefficient value of .807. In the 1975 - 1982 period (the MPS period) the output elasticity of materials was significantly lower, with a value of .548. Output elasticity for labor declined significantly in the 1983 - 1990 period from .384 to .134. This provides supportive evidence regarding the shift to the LPS, since the material input contains labor inputs from other levels noted earlier. Capital showed a low elasticity with respect to output; coefficients went from .027 to .083.

6.4 THE STRUCTURE OF THREE FIRMS: FASA RENAULT, NISSAN MOTOR IBERICA, AND SEAT VOLKSWAGEN

6.4.1 Fasa Renault

Fasa Renault established its first factory in Spain in 1951, in the Valladolid region. It is a subsidiary of the Renault firm of France. Between 1975 and 1990, Renault's rate of growth in production was 3.04 percent (Table 6.8). Number of workers increased from 17,942 in 1975 to 19, 403 workers in 1990. However, there were fluctuations, with a peak in 1979 of 22.396 workers.

Rate of growth in productivity (counted as production by number of workers) increased by 2.4 percent between 1975 and 1990. In this period, productivity experienced 2 cycles. The first one, starting in 1975, had its peak in 1980 with a 15.5 productivity index, and it had its lower value in 1984 with 11.1. The second one began in 1985 and its peak was in 1989 with a productivity index of 17.2 percent (see Table 6.8).

61 percent of the 1990 output went to the domestic market. The export share increased from 18 percent of total in 1975, to 39 percent in 1990 (Table 6.9). This trend demonstrates an increasing internationalization of production with 91 percent going to European countries. Among these, France obtained 47 percent of the exports in 1990. The export trends were as result of Spain's closer economic ties to Europe.

Table 6.8 Production of vehicles and number of workers Fasa Renault 1975-1990

Year	Production units ,000	Number of workers ,000	Productivity (1)
1975	205.9	17.9	11.5
1976	212.7	19.5	10.9
1977	237.5	20.6	11.6
1978	248.8	21.9	11.4
1979	277.4	22.4	12.4
1980	341.2	22.0	15.5
1981	301.2	21.9	13.7
1982	325.8	21.8	14.9
1983	313.8	21.7	14.5
1984	239.5	21.6	11.1
1985	245.8	20.5	12.0
1986	271.6	19.7	13.8
1987	307.9	19.9	15.5
1988	336.7	21.0	16.1
1989	366.7	21.3	17.2
1990	326.1	19.4	16.8

(1) Number of units divided by number of workers.

Source: Fasa Renault Memoŕia y balance, different years.

Table 6.9 Fasa Renault domestic sales and exports 1975-1990, thousand units

Year	Domestic Units	Expor: Units	Total Units	% Domest.	% Exports	Total %
1975	163.8	38.4	202.3	81.0	19.0	100.0
1976	165.4	42.7	208.1	79.0	21.0	100.0
1977	189.1	50.1	239.2	79.0	21.0	100.0
1978	192.6	57.5	250.1	77.0	23.0	100.0
1979	197.2	76.9	274.1	72.0	28.0	100.0
1980	209.2	123.6	332.9	63.0	37.0	100.0
1981	185.2	105.9	291.0	64.0	36.0	100.0
1982	196.0	136.5	332.4	59.0	41.0	100.0
1983	199.7	112.8	312.5	64.0	36.0	100.0
1984	172.7	67.8	240.5	72.0	28.0	100.0
1985	190.6	75.6	266.2	72.0	28.0	100.0
1986	226.6	69.2	295.8	77.0	23.0	100.0
1987	265.7	49.9	315.6	84.0	16.0	100.0
1988	274.0	67.7	341.7	80.0	20.0	100.0
1989	293.1	96.7	389.8	75.0	25.0	100.0
1990	214.0	126.8	340.9	63.0	37.0	100.0

Source: Fasa Renault Memoria y Balance, various years.

Although France has always been the major receiver country, relative figures changed over this period. Exports to France in 1975 were 72 percent of total exports and this dropped to 47 percent in 1990 (Table 6.10). This decreasing share of exports to France could be interpreted as greater independence of the Spanish factory from the Renault headquarters located in France, and entry into the markets of other European countries.

Table 6.10 Fasa Renault export sales by country, 1975, 1980, 1985, 1987-1988, thousand units and percentages of total exports

Countries	1975 Export units	% export	1980 Export units	% exports	1985 Expt. units	% export	1987 Export units	% export	1988 Expt. units	% export
France	27.6	72.0	91.4	74.0	44.8	59.0	21.2	54.4	39.6	47.0
Portugal	–	–	11.6	9.0	8.1	11.0	–	–	11.9	14.0
Italy	–	–	3.5	3.0	–	–	–	–	7.6	9.0
Rest of Europe	1.4	4.0	1.9	2.0	5.4	7.0	11.1	28.5	17.8	21.0
Colombia	–	–	14.8	12.0	2.8	4.0	–	–	4.7	5.0
Iran	–	–	–	–	10.0	13.0	–	–	–	–
Israel	–	–	–	–	3.2	4.0	–	–	3.3	4.0
Other countries	9.3	24.0	0.5	0.0	1.4	2.0	6.7	17.1	–	–
TOTAL	38.3	100.0	123.6	100.0	75.6	100.0	39.0	100.0	84.8	100.0

Source: Fasa Renault Memoria y balance, various years.

The structure of production in Fasa Renault has undergone some changes since 1975. Labor, as a percentage of total cost, decreased from 26 to 14.9 percent in this period. Materials accounted for the highest percentage in the input cost for the total period - percentage share went from 59.8 to 69.6. Capital depreciation kept to a steady trend of around 4 percent, with some peaks during 1980 - 1981, around 9.4 and 8.0 percent respectively (see Table 6.11).

Table 6.11 Fasa Renault cost trends and percentages for 1975-1990

Year	Labor costs Trend	Material costs trend	External services trend	Capital depreciation cost trend	Total
1975	26.0	69.2	0.0	4.8	100.0
1976	27.8	67.7	0.0	4.5	100.0
1977	28.2	66.3	0.0	5.5	100.0
1978	29.0	66.3	0.0	4.7	100.0
1979	26.0	67.1	0.0	6.9	100.0
1980	22.9	67.6	0.0	9.5	100.0
1981	24.0	59.8	8.2	8.0	100.0
1982	21.4	65.2	8.5	4.9	100.0
1983	21.6	65.0	8.9	4.5	100.0
1984	22.1	64.9	8.6	4.4	100.0
1985	23.5	62.7	9.0	4.8	100.0
1986	20.8	64.2	9.8	5.2	100.0
1987	15.9	69.6	10.0	4.5	100.0
1988	16.2	66.6	13.6	3.6	100.0
1989	15.2	68.0	13.5	3.3	100.0
1990	14.9	67.7	13.1	4.3	100.0

Source: Fasa Renault Memoria Balance, various years.

The estimate of the Fasa Renault production function (Table 6.13) is made using the same method of estimation as for the Spanish automobile industry (OLS), and the variables used are the following (Table 6.12).

Table 6.12 Variables estimated in the Fasa Renault production function

Category of the variable	Variable name	Definition
Dependent Variable:		
	Q	Sales, billion pesetas
Independent Variables:		
	K	Capital depreciation, billion pesetas
	L	Wages of employees and social security costs, billion pesetas
	M	Cost of materials[31], billion pesetas

Source: Fasa Renault Memoria Balance. Various years.

Table 6.13 Estimated coefficients of Cobb-Douglas function for the Fasa Renault automobile firm, 1975 - 1990

Characteristic	1975 - 1990	1975 - 1982	1983 - 1990
Constant	-.089	-.910	-1.774
	(-.169)	(-1.222)	(-.651)
K	**.081**	.026	**.238**
	(9.729)	(.494)	(2.174)
L	**.337**	**.491**	.377
	(3.385)	(2.884)	(1.392)
M	**.645**	**.652**	**.683**
	(21.765)	(5.775)	(9.455)
R^2	.990	.991	.973

Bold type indicates significance at the 5% level.

31 Materials include raw materials, parts and components, external services and other production expenses bought to subsidiary or independent firms.

The elasticity of output with respect to capital experienced a dramatic change in the 1983 - 1990 period. While in the 1975 - 1982 period, output elasticity with respect to capital was very low -.026-, in the second period it rose to .238. The results for material coefficients were similar for all three periods. The highest elasticity of output corresponded to the material input for the three periods. For output elasticity with respect to labor, the coefficient of labor decreased in the second period (1983 - 1990).

Although all three periods show increasing returns to scale, the production function estimation of 1983 - 1990 shows the highest returns to scale, 1.298.

6.4.2 Nissan Motor Ibérica

What is now Nissan Motor Ibérica started in 1920 as a Ford Motor Company factory, which in 1933 changed its name to Ford Motor Ibérica; in 1959 it became Motor Ibérica. In 1980, Nissan Motor Co. bought a share of the firm and the name changed to Nissan Motor Ibérica (Nissan 1990). In this company, not only the name was changed, but the product also changed over these years. Until 1984, production was in industrial vehicles, such as trucks and tractors. In 1984, Nissan started to produce Nissan Patrol and Nissan Vanete, and more recently, in 1992, it started producing Nissan Serena, a station wagon type of vehicle (Nissan Anual Reports). This change in the final product is a big difference from the other firms studied in which, although they changed the model, production was always devoted to family cars.

Production increased a great deal in the period 1984 - 1990; when Nissan Motor Company bought the share, the rate of growth between both years was 22.66 percent (see Table 6.14). The productivity index was about 12 for the years for which we have data, 1988 - 1990, but it can not be compared to the other firms because the product is not the same. Thus, increase in production was not a result of the number of workers, which had a negative rate of growth of 1.57 percent between 1975 and 1990, but to the increasing skills of the labor force, which can be deduced from the much larger number of courses and number of hours taught to the Nissan workers between 1980 and 1991 (Tables 6.15, 6.16).

Table 6.14 Production of vehicles and number of workers Nissan Motor Ibérica 1975-1990

Year	Thousand units	Thousand workers	Productivity (1)
1975	...	8.8	...
1976	...	10.3	...
1977	...	11.3	...
1978	...	11.9	...
1979	...	11.8	...
1980	...	11.4	...
1981	...	10.8	...
1982	...	10.1	...
1983	...	9.0	...
1984	19.5	8.6	2.3
1985	27.7	8.0	3.5
1986	42.7	6.5	6.6
1987	53.5	6.0	8.9
1988	76.1	6.8	11.2
1989	86.4	6.6	13.0
1990	81.3	6.8	12.0

(1) Number of units divided by number of workers.

Source: Nissan Motor Ibérica. Unpublished report.

Table 6.15 Nissan Motor Ibérica worker training levels.

	1980	1990	1991
Number of courses per year	406	778	816
Number of hours per year	. . .	170218	241975
Number of participants	4300	4701	5472

Source: Structured interview.

Table 6.16 Nissan Motor Ibérica: skills of the labor force, academic qualification

Academic qualification	1990 Number workers	1990 % of the labor force	1991 Number workers	1991 % of the labor force
A) Higher education:				
Engineering graduates	136	2.0	150	2.2
Other Graduates (Masters)	-	-	58	0.8
Technical Engineers	225	3.3	223	3.2
Bachelors degrees	155	2.3	126	1.8
B) Secondary education:				
F.P. 1st year	701	10.4	751	10.9
F.P. 2nd year	801	11.8	901	13.1
C) Primary education	4744	70.2	2241	32.5
Other	-	-	2437	35.4
TOTAL	6762	100.0	6887	100.0
Average seniority	12.9		13.9	
Average age	38.6		39.1	

Source: Structured interview.

Around 76 percent of 1990 production went to the domestic market, with the figure being approximately the same throughout the period of 1975 - 1990 (see Table 6.17).

Table 6.17 Nissan Motor Ibérica domestic sales and exports 1975-1990, thousand units

Year	Domestic Units	Export Units	Total Units	Percent Domestic	Percent Exports	Total Percent
1975	34.3	15.0	49.3	69.5	30.5	100.0
1976	33.8	14.3	48.1	70.3	29.7	100.0
1977	41.7	12.9	54.6	76.3	23.7	100.0
1978	43.0	13.9	57.0	75.6	24.4	100.0
1979	37.8	8.7	46.5	81.2	18.8	100.0
1980	34.3	6.2	40.5	84.6	15.4	100.0
1981	23.8	6.9	30.8	77.5	22.5	100.0
1982	25.5	8.6	34.1	74.7	25.3	100.0
1983	23.4	6.4	29.8	78.7	21.3	100.0
1984	20.5	8.1	28.6	71.7	28.3	100.0
1985	26.6	12.0	38.5	69.0	31.0	100.0
1986	31.9	14.8	46.7	68.3	31.7	100.0
1987	40.9	20.1	61.1	67.0	33.0	100.0
1988	53.1	24.7	77.9	68.2	31.8	100.0
1989	64.6	26.0	90.6	71.3	28.7	100.0
1990	60.4	31.3	91.7	65.8	34.2	100.0

Source: Nissan Motor Ibérica. Informe anual. Various years.

Material cost share was very high during the 1975 - 1990 period, reaching the value of 72.9 percent of total cost in 1990. Labor cost had a decreasing trend, from 22.7 percent to 15.9 percent of total costs in 1990 (Table 6.18).

Table 6.18 Nissan Motor Ibérica cost trends and percentages for 1975-1990

Year	Labor costs Trend	Material costs trend	External services trend	Capital depreciation trend	Total
1975	22.7	69.7	4.1	3.5	100.0
1976	23.4	67.9	5.0	3.7	100.0
1977	24.7	67.5	5.0	2.8	100.0
1978	23.4	69.1	5.5	2.0	100.0
1979	26.5	68.3	3.5	1.7	100.0
1980	28.4	62.9	6.5	2.2	100.0
1981	30.2	57.8	9.1	2.9	100.0
1982	27.2	60.4	8.9	3.5	100.0
1983	24.3	59.2	12.3	4.2	100.0
1984	22.3	59.5	13.0	5.2	100.0
1985	19.0	60.5	12.6	7.9	100.0
1986	19.0	64.2	9.0	7.8	100.0
1987	16.9	65.6	8.9	8.6	100.0
1988	14.8	68.8	9.5	6.9	100.0
1989	14.6	69.0	9.3	7.1	100.0
1990	15.9	72.9	10.3	0.9	100.0

Source: Fasa Renault Memoria Balance, various years.

Time series data between 1975 and 1990 on Nissan's R&D showed an increasing participation of the other firms in the car's design as well as the parts and components design (see Table 6.19). This trend corroborates the change from the MPS to the LPS discussed in Chapter 4, in which R&D knowledge under MPS is strictly produced by the assembly firm, while in the LPS it is undertaken in collaboration between assembler and its first-tier suppliers.

Table 6.19 Nissan Motor Ibérica, R&D

	1975 %	1980 %	1985 %	1990 %
Assembly. R&D is done:				
1. By the assembly firm	95.0	90.0	75.0	40.0
2. By other firm	5.0	10.0	25.0	60.0
Parts and components. R&D is done:				
1. By the assembly firm	60.0	60.0	50.0	20.0
2. By the component firm	40.0	40.0	40.0	50.0
3. By other firm	-	-	10.0	30.0
4. Other type of arrangement	-	-	-	-

Source: Structured interview.

The estimate of the Nissan Motor Ibérica production function (Table 6.21) is made using the same method of estimation as for the Spanish automobile industry (OLS), and the variables used are the following (Table 6.20).

Table 6.20 Variables estimated in the Nissan Motor Ibérica production function

Category of the variable	Variable name	Definition
Dependent Variable:		
	Q	Sales, billion pesetas
Independent Variables:		
	K	Capital depreciation, billion pesetas
	L	Wages of employees, and social security costs, billion pesetas
	M	Cost of materials[32], billion pesetas

Source: Nissan Motor Ibérica Informe Anual. Various years.

32 Materials include raw materials, parts and components, external services and other production expenses.

Table 6.21 Estimated coefficients of Cobb-Douglas function for the Nissan Motor Ibérica automobile firm, 1976 - 1990

Characteristic	1975 - 1990	1975 - 1982	1983 - 1990
Constant	3.177	**3.170**	5.323
	(1.994)	(3.495)	(1.301)
K	-.232	-.047	-.176
	(-2.378)	(-.627)	(-1.055)
L	-.426	**-.385**	-1.057
	(-1.382)	(-2.999)	(-1.306)
M	**1.188**	**1.002**	**1.434**
	(5.996)	(10.634)	(4.037)
R^2	.890	.977	.964

Bold type indicates significance at the 5% level.

The elasticity of output with respect to capital was negative. During this period the firm made a massive investment and the negative coefficient can be interpreted in this context. The results suggest that the expected returns to capital were not attained yet. This result is not surprising given the Japanese propensity to look for long term returns and with the goal of increasing their market share before pursuing short term profitability from their investments. The highest elasticity of output corresponds to the material input, as was the case for the other firms. The output elasticity with respect to labor was also negative. A possible explanation of these negative elasticities could be the large restructuration of Nissan Motor Ibérica during the 1980s (NMI Annual Reports, 1985-1990). The goal of this restructuration was to adapt the plant to the requirements of a new product -from commercial and industrial vehicles to station wagons. Moreover, as showed earlier labor cost, consisting of wages and social security benefits per worker has been increasing rapidly.

6.4.3 Seat Volkswagen

Seat was established in 1950, and started producing in 1953. For that year, daily production was 5 cars, and the number of workers 925. In 1957, the number of workers was 5000 and, in 1961, the production was 36,000 cars per year. In 1969, the number of workers increased to more than 20,000, and Seat began to export. In 1980 Fiat, at this point partner of Seat, sold its share to Seat, and in 1982 Seat started the company with a new partner, Volkswagen. In 1989, construction was begun on a new plant in a nearby area, 20 minutes away from the old factory.

The rate of growth in production was 2.95 percent between 1975 and 1990. Labor declined in the period (Table 6.22), so the causes of this increase in production cannot be found in the employment figures. Probably the increased skills of the labor force was due, among other things, to a dramatic increase in the number of courses and course hours that the firm offered between 1980 and 1990 (Table 6.23). The larger number of computer controlled machines provides another explanation for the increased production (Table 6.24). For the 1975 - 1990 period, productivity showed two trends. Until 1981 it had a decreasing trend, with 7.5 cars per worker as the lowest for the entire period. Productivity increased since 1982, with its highest value in 1990 of 23.4 cars per worker.

Table 6.22 Production of vehicles and number of workers, Seat Volkswagen 1975-1990

Year	Production units ,000	Number of workers ,000	Productivity (1)
1975	317.2	30.2	10.5
1976	325.4	31.7	10.3
1977	346.8	32.1	10.8
1978	284.9	32.0	8.9
1979	294.9	31.8	9.3
1980	297.0	31.7	9.4
1981	209.0	27.8	7.5
1982	246.0	25.2	9.7
1983	250.0	25.2	9.9
1984	279.0	23.6	11.8
1985	320.0	21.5	14.9
1986	339.0	22.2	15.3
1987	406.0	23.5	17.2
1988	433.0	23.8	18.2
1989	474.0	23.8	19.9
1990	505.0	21.6	23.4

(1) Units divided by number of workers.

Source: Seat Volkswagen, unpublished material; and Seat Informe del Ejercicio, various years.

Table 6.23 Seat Volkswagen worker training levels. Number of courses

	1980	1990
Number of courses per year	320	1300
Number of hours per year	15800	76800
Number of participants	-	-

Source: Structured interview.

Table 6.24 Seat Volkswagen work organization

	1980	1990
% of the labor force working on teams	-	3.0
% of the engineers working on manufacturing teams	-	0.1
Do you have FMS (1) installed in your factory?	-	Yes
Number of CNC (2) machines	8	220
% of the CNC machines	0.2	8.0
% of the engineers trained on CNC machines	-	0.1
How many days of component stock are there in the assembly plant? (average)	15	3

(1) An FMS is a computer-controlled grouping of semi-independent work stations linked by automated material-handling systems. All activities in the system are under precise computer control.

(2) Computer numerically controlled machines.

Source: Structured interview.

The structure of production cost underwent two important changes. One was the decreasing trend in labor costs during 1976 - 1990, from 27.2 to 17.1 percent of total costs. The second was the increase in the percentage of material costs, that went from 50.0 to 68.2 percent (see Table 6.25). This also provided support for the shift from MPS to LPS with greater subcontracting and finished components arising as material inputs.

Table 6.25 Seat Volkswagen cost trends percentages for 1975 - 1990

Year	Labor cost trend	Material cost trend	Capital depreciation trend	External services trend	Total
1975	...	...	...	...	...
1976	27.2	50.0	2.9	19.9	100.0
1977	27.4	51.5	3.1	18.0	100.0
1978	29.8	45.6	3.2	21.4	100.0
1979	28.2	52.4	1.0	18.4	100.0
1980	28.3	50.5	1.3	19.9	100.0
1981	34.3	47.0	3.1	15.6	100.0
1982	20.8	61.8	4.8	12.6	100.0
1983	22.7	58.9	4.3	14.1	100.0
1984	21.4	60.4	3.6	14.6	100.0
1985	20.0	59.7	5.8	14.5	100.0
1986	18.1	58.9	6.2	16.8	100.0
1987	19.4	60.6	4.9	15.1	100.0
1988	18.6	63.4	4.1	13.9	100.0
1989	18.1	65.9	2.4	13.6	100.0
1990	17.1	68.2	0.4	14.3	100.0

Seat's demand behaved differently. While in 1975 most of its production went to the domestic market (84 percent), in 1990 Seat exported 63 percent of its production (Table 6.26). The export destination was in high percentage to EEC countries, where Germany had increased its share, with 8 percent in 1987, rising to 26.8 percent in 1990 (Table 6.27).

Table 6.26 Seat Volkswagen domestic sales and exports 1975-1990, thousand units

Year	Domestic Units	Export Units	Total Units	Percent Domestic	Percent Exports	Total Percent
1975	261.8	51.1	312.9	84.0	16.0	100.0
1976	288.6	59.6	348.2	83.0	17.0	100.0
1977	238.7	64.7	303.4	79.0	21.0	100.0
1978	213.9	86.7	300.6	71.0	29.0	100.0
1979	174.9	118.3	293.2	60.0	40.0	100.0
1980	139.5	132.0	271.5	51.0	49.0	100.0
1981	108.9	101.1	210.0	52.0	48.0	100.0
1982	133.8	124.6	258.3	52.0	48.0	100.0
1983	137.3	84.5	221.7	62.0	38.0	100.0
1984	127.3	148.7	276.0	46.0	54.0	100.0
1985	248.6	100.2	348.8	71.0	29.0	100.0
1986	148.4	197.3	345.7	43.0	57.0	100.0
1987	187.5	246.0	433.5	43.0	57.0	100.0
1988	219.2	269.4	488.6	45.0	55.0	100.0
1989	239.3	321.9	561.1	43.0	57.0	100.0
1990	215.7	369.0	584.7	37.0	63.0	100.0

Source: Seat Informe del ejercicio. Various years.

Table 6.27 Seat export sales (1) by country, 1987-1990, thousand units and percentages of total exports

Countries	1987 Export units	Percent export	1988 Export units	Percent exports	1989 Export units	Percent exports	1990 Export units	Percent exports
Germany	12.6	8.0	17.9	9.3	24.8	11.1	65.3	26.8
Italy	62.0	39.2	72.2	37.3	86.3	38.7	66.9	27.5
France	29.9	18.9	39.9	20.6	46.1	20.7	53.5	22.0
Portugal	–	–	12.4	6.4	9.1	4.1	10.4	4.3
Netherlands	7.6	4.8	6.6	3.4	9.7	4.3	9.9	4.0
Great Britain	8.4	5.3	11.8	6.1	11.8	5.3	9.6	3.9
Belgium	6.8	4.3	6.3	3.3	6.8	3.0	8.3	3.4
Taiwan	–	–	11.9	6.2	11.4	5.1	–	–
Greece	–	–	–	–	–	–	6.3	2.6
Others	30.8	19.5	14.6	7.4	17.1	7.7	13.3	5.5
TOTAL	158.1	100.0	193.5	100.0	223.2	100.0	243.6	100.0

Seat's production function is estimated in a way similar to that of the Spanish automobile industry. Variables are defined in Table 6.28, and the coefficients are shown in Table 6.29.

Table 6.28 Variables estimated in the Seat Volkswagen production function

Category of the variable	Variable name	Definition
Dependent Variable:		
	Q	Sales, billion pesetas
Independent Variables:		
	K	Capital depreciation, billion pesetas
	L	Wages of employees and soc.secur. costs, bil pts
	M	Cost of materials[33], billion pesetas

Source: Seat Informe Anual. Various years.

Table 6.29 Estimated coefficients of Cobb-Douglas function Seat Volkswagen, 1975-1990

Characteristic	1975 - 1990	1975 - 1982	1983 - 1990
Constant	.999	**1.909**	-1.135
	(1.137)	(2.194)	(-.717)
K	.0003082	.071	.022
	(.017)	(1.378)	(1.295)
L	**.158**	**.338**	.116
	(1.606)	(2.465)	(.323)
M	**.741**	**.396**	**1.027**
	(8.673)	(2.635)	(4.707)
R^2	.912	.930	.971

Bold type indicates significance at the 5% level.

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33 Materials include raw materials, parts and components, external services and other production expenses purchased from subsidiary or independent firms.

For 1975 - 1990, and the sub-period 1975 - 1982, Seat experienced decreasing returns to scale with values of .899 and .847, respectively. Otherwise, the sub-period of 1983 - 1990 showed clearly increasing returns to scale: 1.165.

Elasticity of output with respect to materials experienced a high increase in 1983 - 1990, with a value of 1.027. Output elasticity of labor varied for each period, having the lowest value in the 1983 - 1990 period: .116. Capital was the coefficient with the lowest value, from .0003082 to .071.

6.5 TWO MORE CASES: FORD ESPANA, AND GENERAL MOTORS ESPANA

6.5.1 Ford España

Ford established its first factory in Spain in 1920, with the goal of assembling 2,000 cars. After 3 years, the firm moved to Barcelona and in 1933 the company founded Ford Motor Ibérica (Nissan 1990). In 1953 Ford Motor Ibérica sold its share to the local partners. In September of 1972, Ford decided to install a new factory in Spain. And in 1976 production of cars started in this new plant located in Almusafes, Valencia.

The production of cars in the Almusafes plant increased between 1985 and 1990 at a rate of growth of 3.90 percent. The number of workers increased over these years also, and productivity was 30.7 units per worker in 1990 (Table 6.30). Ford's market structure had changed in this period towards a more domestic market. In 1990 a little more than half of the production went to exports (Table 6.31).

Table 6.30 Ford España production of vehicles and number of labor, 1975 - 1990

Year	Production units ,000	Number of workers ,000	Productivity (1)
1975	-	-	-
1976	-	-	-
1977	-	-	-
1978	-	-	-
1979	-	-	-
1980	-	-	-
1981	...	...	...
1982	...	...	...
1983	...	...	...
1984	...	...	...
1985	265.9	8.6	31.0
1986	268.4	8.4	31.9
1987	276.6	8.4	33.0
1988	281.7	9.5	29.7
1989	310.4	10.4	29.8
1990	334.4	10.9	30.7

(1) Units divided by number of workers.
Source: Ford España. Unpublished material.

Table 6.31 Ford España domestic sales and exports 1975-1990, thousand units

Year	Domestic Units	Export Units	Total Units	Percent Domestic	Percent Exports	Total Percent
1975	-	-	-	-	-	-
1976	-	-	-	-	-	-
1977	-	-	-	-	-	-
1978	-	-	-	-	-	-
1979	-	-	-	-	-	-
1980	-	-	-	-	-	-
1981	...	...	...	...	...	...
1982	...	...	...	...	...	...
1983	...	...	...	...	...	...
1984	...	...	...	...	...	...
1985	71.1	204.5	275.6	26.0	74.0	100.0
1986	104.5	178.9	283.5	37.0	63.0	100.0
1987	154.0	152.2	306.2	50.0	50.0	100.0
1988	152.6	163.0	315.7	48.0	52.0	100.0
1989	168.4	181.7	350.1	48.0	52.0	100.0
1990	153.5	211.5	365.0	42.0	58.0	100.0

Source: Ford España. Unpublished material.

There is no time series cost data for Ford España, except for the years 1989 (in which they started publishing their annual report) to 1990. Observing the share of materials for these 2 years, the percentage is very high, about 73 percent of total cost (Appendix D.a).

6.5.2 General Motors España

The establishment of General Motors in Figueruelas (Zaragoza) was in 1979, with the production of cars starting in 1982. GM also has 2 car component factories in Spain, both of them in Puerto Real (Cádiz). Rate of growth of production between 1983 and 1990

at the Figueruelas' plant was 5.67 percent, the number of workers increased since it began, and it had the highest productivity of all firms studied, 37.4 in 1990 (see Table 6.32). The structure of the GM market changed between 1983 and 1990. There was a remarkable increase in the production, with a slight increase in the percentage share of exports (Table 6.33).

Table 6.32 General Motors España production of vehicles and number of workers 1975 - 1990

Year	Production units ,000	Number of workers ,000	Productivity (1)
1975	-	-	-
1976	-	-	-
1977	-	-	-
1978	-	-	-
1979	-	-	-
1980	-	-	-
1981	-	-	-
1982	22.5	...	...
1983	246.2	...	...
1984	260.0	...	...
1985	276.9	...	...
1986	307.6	8.6	36.0
1987	297.7	8.9	33.3
1988	361.2	9.8	37.0
1989	378.5	10.0	37.8
1990	382.7	10.2	37.4

Source: General Motors España Memoria. Informe, different years.

Table 6.33 General Motors España domestic sales and exports 1975 - 1990, thousand units

Year	Domestic Units	Export Units	Total Units	Percent Domestic	Percent Exports	Total Percent
1975	-	-	-	-	-	-
1976	-	-	-	-	-	-
1977	-	-	-	-	-	-
1978	-	-	-	-	-	-
1979	-	-	-	-	-	-
1980	-	-	-	-	-	-
1981	-	-	-	-	-	-
1982	...	...	...	...	...	...
1983	...	198.3	198.3	...	...	...
1984	...	221.4	221.4	...	...	...
1985	...	231.9	231.9	...	...	...
1986	...	224.1	224.1	...	...	...
1987	...	221.4	221.4	...	...	...
1988	89.2	272.4	361.6	25.0	75.0	100.0
1989	85.0	293.4	378.4	22.0	78.0	100.0
1990	82.3	298.0	380.3	22.0	78.0	100.0

Source: General Motors España Memoria. Informe, various years.

The percentage of expenditures on materials in this period is very high, approximately around 73 percent, and it is similar to the other firms studied (Appendix D.b).

6.6 STRUCTURE OF THE EUROPEAN AUTOMOBILE INDUSTRY

The high elasticity of output respect to materials observed in the Spanish industry seems to be occurring to other countries in Europe, like Greece, .811, and the UK, .844; while in Germany the automobile industry has lower elasticity of output respect to the materials, .474 (Table 6.35). The main difference between these countries, Germany and

the rest, is that while Germany has a strong native automobile industry -Opel, Volkswagen-, in Greece, Spain, and the UK the automobile industry is mainly form by plants of multinational firms, of Japanese and American origin, so this suggest a different structure among the industries in these countries. One possible explanation is that the automobile industry in Greece and the UK are increasing their flexibility incorporating higher value-added components to their output, following the same trend of most Japanese and American firms, which incorporate flexible specialization in their production.

Table 6.34 Variables estimated in the European automobile industry production function for several countries

Category of the variable	Variable name	Definition
Dependent Variable:		
	Q	Gross output in factor values
Independent Variables:		
	K	Gross investment
	L	Wages and salaries of employees, and social security cost
	M	Cost of materials[34], billion pesetas

Source: OECD Industrial Structure Statistics, 1992.

34 Materials are defined as gross output minus value-added.

Table 6.35 Estimated coefficients of Cobb-Douglas function for the European automobile industry, 1981 - 1990

Characteristic	Germany	Greece	UK
Constant	.979	.142	.474
	(.815)	(.954)	(2.161)
K	.112	**.055**	.017
	(.8)	(3.026)	(.288)
L	.315	**.189**	.084
	(.459)	(4.877)	(1.519)
M	**.474**	**.811**	**.844**
	(1.601)	(16.254)	(17.38)
R^2	.977	.993	.991

Bold type indicates significance at the 5% level.

6.6 CONCLUSIONS TO CHAPTER 6

Changes in the automobile production system around the world influenced important variables like materials and labor in the Spanish industry. The already high elasticity of output with respect to the material input in the production function of the overall period increased even more at the end of this period, and that of labor decreased. These two facts indicate greater flexibility of production, which was reflected in the increasing trend of buying materials. Hence, this was a transition period wherein the industry kept moving from the MPS model to the LPS model, where more elaborated components arrived to the assembly firm in a higher proportion.

CHAPTER 7 SPATIAL ADJUSTMENTS OF THE AUTOMOBILE INDUSTRY IN SPAIN

Industrial geographers have noted that structural adjustments in production systems are often accompanied by spatial adjustments (Holmes 1983). As noted in Chapter 2, successive developments of technology and the shift from the craft production to the MPS in the automobile industry resulted in locational changes. In this chapter the spatial adjustments caused by the introduction of the LPS in the automobile industry in Spain are analyzed. In the Spanish automobile industry, the introduction of some features of the LPS were adopted 4 to 5 years ago in Nissan, and only 1 - 2 years ago in Seat and Renault. While the restructuration process is recent, some locational adjustments can be expected, for example, implementation of JIT system of distribution is one of the first organizational adjustments made by the LPS. As a shorter time response to production needs, and component sequentiality are the requirements for good results from JIT, decreasing distances between component suppliers and assembler can be expected to be one of the earliest spatial adjustments.

As noted in Chapter 5, the component sector of the Spanish automobile industry is fragmented with a large number of very small firms (less than ten workers), most of them family firms geographically attached to a specific location, with weak capital bases for new investments. Spatial immobility of suppliers, due to relative spatial immobility of labor[35] and capital, is also found in the spatial network of suppliers of Ford's European plants (Wells and Rawlinson 1992). Consequently, the warehouse is becoming a point of distribution of various components in the LPS, and this can be expected to have locational impacts in Spain. The emergence of warehouses as intermediate points between suppliers

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35 In general, labor in Europe is more spatially immobile than in the US.

and assembler also occurs in other countries; for instance, Toyota's factory in Europe, in 1991, built a warehouse to handle components from disperse suppliers (Wells and Rawlinson 1992; Feast 1991). Warehouses appeared in Spain between 1983 and 1992 as independent firms as well as subsidiaries of assembly firms (Fasa Renault, Nissan Motor Ibérica' Structured interview). Independent warehouses are located in assembly regions; warehouse subsidiaries are located within 5 to 10 minutes distance from assembly plants. Hence, it can be hypothesized that the adoption of JIT in Spain in the period studied has not been powerful enough to induce a spatial concentration of component firms towards assembly plants. Rather, given the spatial inertia of component firms, warehouses are functioning as equivalents.

Under the MPS, component production was directly linked with assembly plants. Under the LPS, JIT distribution forces the appearance of the warehouse as a new node; they function as sinks for various components from different producers, and as a source of components for the assembly plant. These sink-and-source warehouse nodes can be closely located to assembly firms to facilitate shorter and sequential deliveries. Confirmation for these type of spatial readjustment are sought in this chapter.

This chapter is organized as follows. In the first section the spatial arrangement of suppliers and assemblers is studied using data from the census of suppliers for 2 years: 1983 and 1992. In the second part, the critical path dispersion method is applied to two cases in order to measure concentration or dispersion of a network. Data on flows of components -windows, batteries, and tires- from suppliers to two assembly firms, Fasa Renault, and Nissan Motor Ibérica are issued for illustration purposes.

7.1 THE IMPACT OF THE LPS ON THE DELIVERY PATTERN OF COMPONENTS TO ASSEMBLY PLANTS

The LPS was implemented in Spain in various years. The LPS was introduced by Nissan Motor Ibérica around 1986 - 1987. Seat Volkswagen began in 1990, and GM España started in 1991. Thus, the LPS was introduced over the last 5 years.

One of the main attributes of the introduction of the LPS brought to the firms is a new way of distributing components from the supplier to the assembly plant (Structured interview). Three examples of this new distribution are given by Fasa Renault, Nissan Motor Ibérica and Seat Volkswagen, in which the JIT distribution is used for components. With this new distribution, these firms want to achieve two important objectives: to diminish the amount of stock in the assembly plant and to introduce sequentiality in the component delivery in order to introduce them directly to the assembly line with no further work. Different types of component delivery imply diverse distances from supplier to assembler. For instance, suppliers delivering with the synchronized model of Fasa Renault or the synchro type of Nissan Motor Ibérica, described below, mean they must be very close to the assembly plant; while deliveries to the assembly warehouses are farther away from the assembly plant.

The current distribution system of Fasa Renault is as follows:

1. Synchronized model. Suppliers are very close to assembler. They deliver pieces depending on assembler's hourly demand. The assembler has not more than 2 hours of stock at the assembly line.

2. Daily model. Suppliers deliver not to the assembly plant, but to Fasa Renault's warehouses, which are set up as independent firms and are located outside the factory walls. The warehouse delivers components to the assembler once daily.

3. Weekly model. Suppliers are distant from the assembler, and they deliver to the Fasa Renault warehouses as many times as stock is ordered. The warehouses deliver to the assembler more than once a day.

Fasa Renault also has warehouses, which they call "centro de reagrupamiento" (regrouping center), consisting of 3 warehouses that receive parts and components from the different supplier locations and send them mostly by truck to the assembler. Warehouses maintain constant information links with the assembler by computer.

Nissan Motor Ibérica's classification of parts and components by type of distribution is as follows:

1. External warehouse. Components go to the assembly plant from a nearby but external warehouse, which groups all components from firms that are distant from the Nissan plant.
2. Internal warehouse. Components that are received mainly from Japan are located in an internal warehouse.
3. Synchro. These are external component deliveries which go directly to the assembly line in sequential form.
4. Milk-run. This is a pick-up component system with pre-established paths which is delivered daily to the assembly plant.

Seat Volkswagen's component deliveries have a different distribution pattern:

1) Regular components. The component does not need to be pre-assembled. It goes directly to the internal warehouse of the assembly plant. Components are stored in different sections and sequentially, following assembly-line sequence needs.
2) Regular components sequenced from outside. They do not need to be pre-assembled. They go from the truck to the assembly line. For example, car seats.
3) Pre-assembled components. They need to be pre-assembled, following the different models of the final product. Pre-assembled components are ordered by computer system

from the assembly plant to the supplier plant. They arrive sequentially and in full containers at the assembly plant from the supplier plant. For example, dashboards.

Seat's types of suppliers depend on location[36]:

1) Regular suppliers. They are located at a maximum of 10 Km from the assembly plant.
2) SIP (Suppliers Industrial Park). They are located close to the assembly plant. These suppliers are, in general, not regular component plants but they do pre-assembly on the car parts that require it. They work on a regular JIT basis with their suppliers. Also located in the SIP are the regular suppliers whose plants are far away from the assembly plant; they do not perform pre-assembly, only storage.

7.2 THE IMPACT OF THE LPS IN THE SPANISH REGIONS

The largest automobile firms in Spain are located in several regions -Barcelona, Valencia, Valladolid, Zaragoza, and La Coruña. Those considered in this dissertation are the following: Barcelona -where Nissan Motor Ibérica and Seat Volkswagen are located-, Valencia -Ford España-, Valladolid -Fasa Renault-, and Zaragoza -GM España- (Figure 7.1). Spanish regions have experienced several changes in the location of component firms between 1983 and 1992. The study of the supplier's spatial distribution before and after the introduction of these new types of deliveries has been done using the 1983 and 1992 census of suppliers.

The observation of the 1983 network of suppliers' production points clearly shows 2 largest regions with a 42.5 and 22.2 percent of total number of suppliers in Spain:

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36 The following distribution pattern in Seat corresponds to the new factory, opened in 1992. This factory was conceived to work under LPS system (Structured and Unstructured interview as well as unpublished material given by Seat).

Barcelona and Madrid, respectively. Only 3 more regions hold a concentration of suppliers not higher than 4 to 8 percent: Vizcaya, Guipuzcoa, and Zaragoza; and 4 more regions with a low concentration of suppliers, from 1 to 3 percent: Alava, Navarra, Girona, and Valencia. Remaining regions have less than 1 percent of suppliers (Table 7.1 and Figures 7.2, 7.4).

Figure 7.1 Location of the assembly plants studied

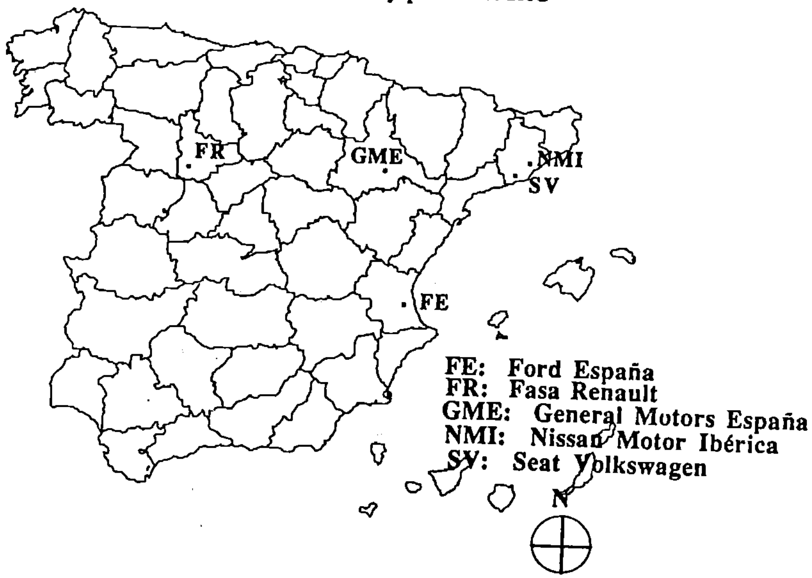


Table 7.1 Production points of parts and components, geographical distribution, 1983

Region in Spain	Number of firms	%	Other Countries	Number of firms	%	%
Alava	25	1.9	Austria	1	0.8	
Albacete	2	0.2	Belgium	3	2.3	
Alicante	6	0.5	Brazil	2	1.5	
Asturias	7	0.5	Denmark	2	1.5	
Barcelona	546	42.5	France	26	19.5	
Burgos	5	0.4	Germany	22	16.5	
Cantabria	7	0.5	Greece	1	0.8	
Cádiz	1	0.1	Hungary	1	0.8	
Canarias	2	0.2	Italy	33	24.8	
Castellón	5	0.4	Japan	5	3.8	
Ciudad Real	3	0.2	The Netherlands	3	2.3	
Córdoba	2	0.2	Switzerland	1	0.8	
La Coruña	2	0.2	UK	15	11.3	
Cuenca	1	0.1	USA	18	13.5	
Girona	17	1.3				
Granada	3	0.2	Total	133	100.0	9.4
Guadalajara	1	0.1				
Guipuzcoa	62	4.8				
Huelva	1	0.1				
Huesca	1	0.1				
Jaen	2	0.2				
León	5	0.4				
Lleida	6	0.5				
Logroño	9	0.7				
Lugo	1	0.1				
Madrid	285	22.2				
Málaga	1	0.1				
Mallorca	2	0.2				
Murcia	7	0.5				
Navarra	40	3.1				
Orense	2	0.2				
Pontevedra	11	0.9				
Salamanca	1	0.1				
Segovia	3	0.2				
Sevilla	5	0.4				
Soria	2	0.2				
Tarragona	8	0.6				
Teruel	1	0.1				
Valencia	34	2.6				
Valladolid	5	0.4				
Vizcaya	99	7.7				
Zaragoza	56	4.4				
Total	1284	100.0		1284		90.6
TOTAL				1417		100.0

Source: La Tienda de Recambios y Accesorios. Catálogo Profesional para el Sector de Recambios y Accesorios, 1983.

Figure 7.2 Hierarchy of regions in number of suppliers, 1983

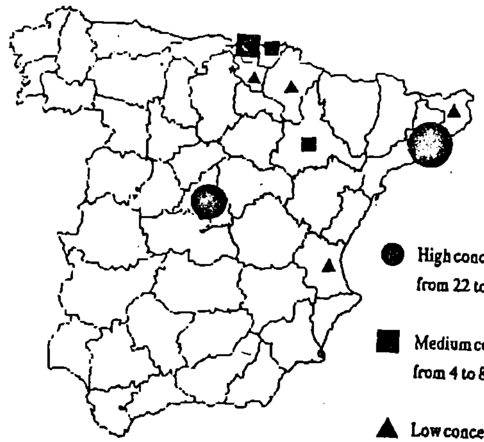
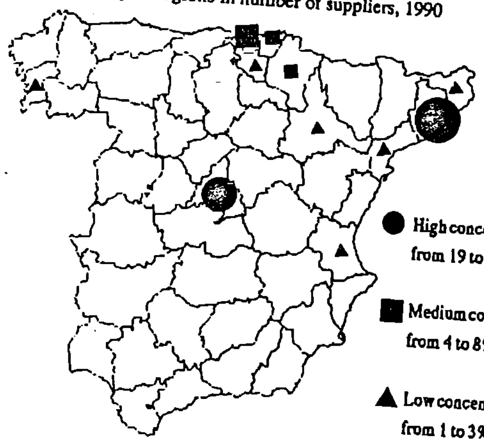
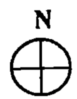


Figure 7.3 Hierarchy of regions in number of suppliers, 1990





Similar analysis done in the 1992 suppliers' network shows only small differences between percentages in the regions. For instance, the larger regions in concentration of suppliers in 1983, now also have a large concentration, between 19 and 40 percent. Although, several new regions with component firms have appeared, but with a percentage equal to or slightly bigger than 1, such as Tarragona and Pontevedra (Table 7.3, Figures 7.3 - 7.5). Tarragona is a region 150 Km from Barcelona, very well connected by highway and train. Pontevedra is where the Citroen assembly plant -not studied in this dissertation- is located.

The proportion of suppliers in Barcelona, where Nissan and Seat are located, has decreased in absolute number -from 546 to 425. Data about suppliers distribution provided for Nissan Motor Ibérica shows that the majority of their suppliers are located in Barcelona and Madrid -42.9 and 19.3 percent, respectively-, this distribution suggest a similar picture with the general spatial distribution of suppliers shown in Figure 7.4.

Valladolid, where Fasa Renault is located, maintained the same proportion of suppliers in both years -.4 percent-, although there was a decrease of 1 supplier. Valencia, where Ford is located, increased the proportion -from 2.6 to 3.2 percent- but kept the same number of suppliers, 34.

Zaragoza showed a decrease in suppliers in both years - from 56 to 44-; although the percentage is approximately the same -4.4 and 4.1, respectively. This decrease could be a result of general decreasing trend in number of plants of the ancillary industry occurring in all the Spanish territory -structural concentration of the component sector. Data provided by GM España, which is located in the region of Zaragoza, shows no large changes in its spatial purchasing behavior between 1983 and 1990 (Table 7.2).

Table 7.2 Volume of intermediate products bought for GM España, as geographically distributed. Billion pesetas

	1983		1990	
	pesetas	%	pesetas	%
Aragón	6.0	6.8	10.5	6.6
Rest of Spain and foreign countries	82.0	93.2	147.5	93.4
TOTAL	88.0	100.0	158.0	100.0

Source: GM España, unpublished material.

On the other hand, however, the number of warehouses located in assembly regions increased between 1983 and 1992 (Table 7.4). For instance, in Barcelona the number of warehouses went from 51 to 103 between both years; Zaragoza, GM's region, went from 3 to 6 warehouses; and Valencia, Ford's region, increased from 2 to 6 the number of warehouses. In Madrid's region, where other smaller car assembly firms, not studied in this dissertation are located, the number of warehouses in both years went from 56 to 102.

Hence, from such changing pattern one can suggest that in Spain the LPS has introduced no spatial changes in component firms. Relative capital and labor spatial immobility are probably more powerful factors in the locational distribution of the ancillary industry in Spain in comparison to the JIT component distribution factor. Given the spatial immobility of capital and labor, warehouse location is a substitute for component plant relocations.

Table 7.3 Production points of parts and components, geographic distribution, 1992

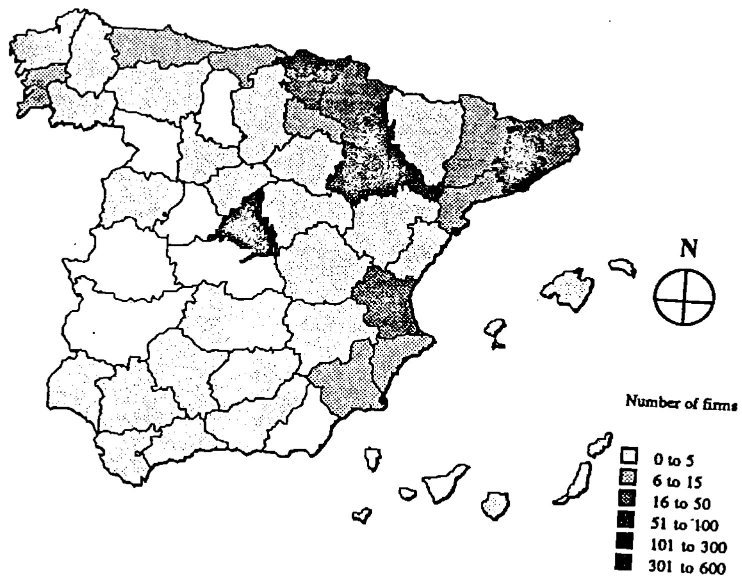
Region in Spain	No. of firms	%
Alava	24	2.2
Albacete	1	0.1
Alicante	6	0.6
Almeria	1	0.1
Asturias	2	0.2
Barcelona	425	39.8
Burgos	4	0.4
Cantabria	9	0.8
Cádiz	3	0.3
Canarias	2	0.2
Castellon	5	0.5
Ciudad Real	0	0.0
Córdoba	4	0.4
La Coruña	3	0.3
Cuenca	2	0.2
Girona	18	1.7
Granada	1	0.1
Guadalajara	4	0.4
Guipuzcoa	62	5.8
Huelva	1	0.1
Huesca	0	0.0
Jaen	2	0.2
León	3	0.3
Lleida	6	0.6
Logroño	10	0.9
Lugo	2	0.2
Madrid	206	19.3
Málaga	0	0.0
Mallorca	0	0.0
Murcia	8	0.7
Navarra	47	4.4
Orense	2	0.2
Palencia	2	0.2
Pontevedra	14	1.3
Salamanca	2	0.2
Segovia	2	0.2
Sevilla	1	0.1
Soria	1	0.1
Tarragona	11	1.0
Teruel	1	0.1
Toledo	2	0.2
Valencia	34	3.2
Valladolid	4	0.4
Vizcaya	85	8.0
Zamora	1	0.1
Zaragoza	44	4.1
Total	1067	100.0

Other Countries	Number of firms	%	%
Belgium	1	3.1	
Brazil	1	3.1	
Denmark	1	3.1	
France	7	21.9	
Germany	6	18.8	
Hungary	1	3.1	
Italy	3	9.4	
Japan	1	3.1	
Korea	1	3.1	
Portugal	1	3.1	
Sweden	1	3.1	
Switzerland	1	3.1	
Taiwan	1	3.1	
UK	3	9.4	
USA	2	6.3	
Yugoeslav.	1	3.1	
Total	32	100.0	2.4

	1064	97.6
TOTAL	1096	100.0

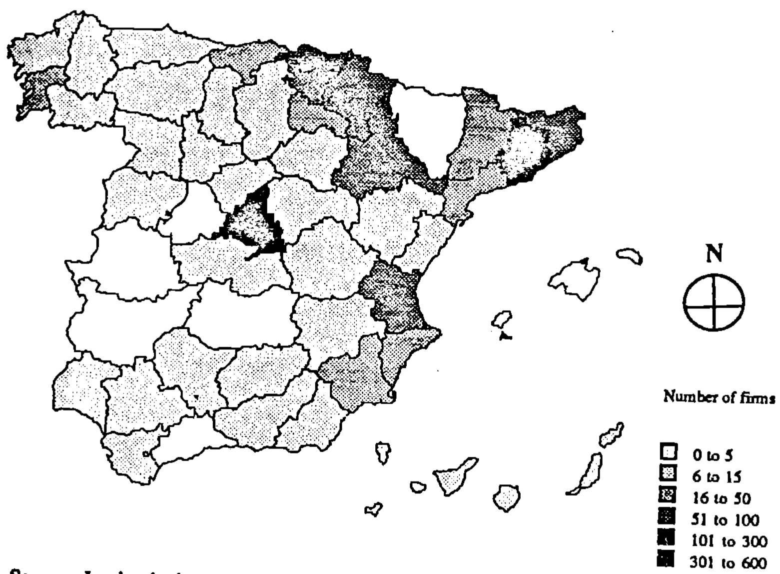
Source: La Tienda de Recambios y Accesorios. Catálogo Profesional para el Sector de Recambios y Accesorios, 1992.

Figure 7.4 Production points of parts and components, 1983



Source: La tienda de recambios y accesorios. Catálogo profesional para el sector de recambios y accesorios, 1983.

Figure 7.5 Production points of parts and components, 1992



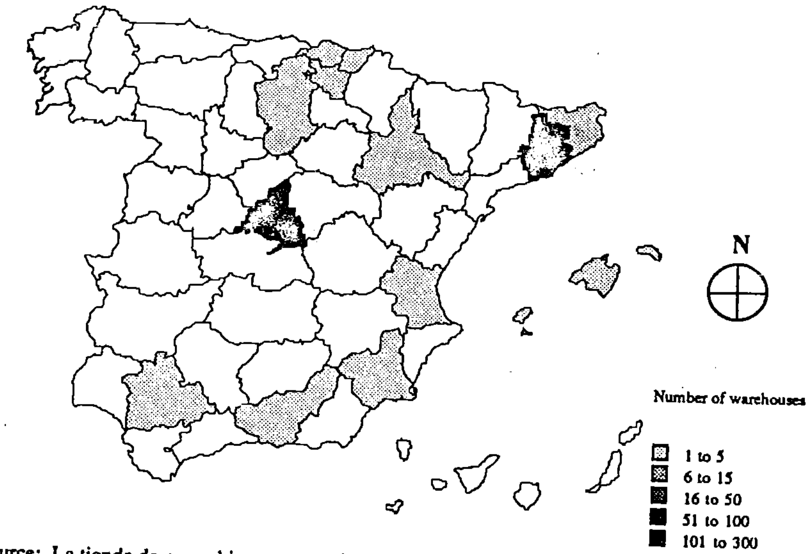
Source: La tienda de recambios y accesorios. Catalogo profesional para el sector de recambios y accesorios, 1992.

Table 7.4 Geographical distribution of parts and components warehouses, 1983 and 1992

Region in Spain	1983 Number of warehouses	Percent	1992 Number of warehouses	Percent
Alicante	-	-	2	0.8
Asturias	-	-	1	0.4
Barcelona	51	39.8	103	39.8
Burgos	1	0.8	0	0.0
Cádiz	-	-	1	0.4
Castellon	-	-	1	0.4
La Coruña	-	-	3	1.2
Girona	2	1.6	2	0.8
Granada	1	0.8	1	0.4
Guipuzcoa	2	1.6	2	0.8
Madrid	56	43.8	102	39.4
Murcia	1	0.8	1	0.4
Navarra	-	-	4	1.5
Palencia	-	-	1	0.4
Pontevedra	-	-	1	0.4
Palma	1	0.8	0	0.0
Salamanca	-	-	1	0.4
Sevilla	2	1.6	3	1.2
Tarragona	-	-	1	0.4
Valencia	2	1.6	6	2.3
Vitoria	1	0.8	3	1.2
Vizcaya	5	3.9	14	5.4
Zaragoza	3	2.3	6	2.3
Total	128	100.0	259	100.0

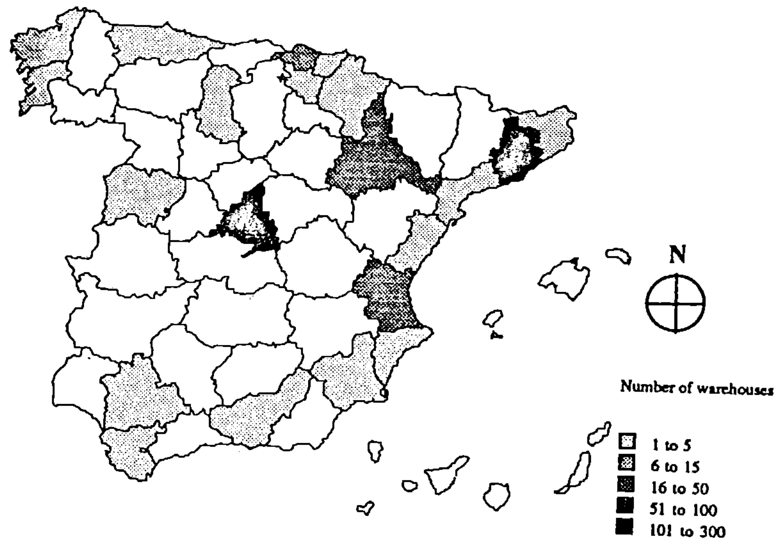
Source: La Tienda de Recambios y Accesorios. Catálogo Profesional para el Sector de Recambios y Accesorios, 1983 and 1992.

Figure 7.6 Geographical distribution of warehouses, 1983



Source: La tienda de recambios y accesorios. Catalogo profesional para el sector de recambios y accesorios, 1983.

Figure 7.7 Geographical distribution of warehouses, 1992



Source: La tienda de recambios y accesorios. Catalogo profesional para el sector de recambios y accesorios, 1992.

7.3 THE CRITICAL PATH METHOD APPLIED TO TWO ILLUSTRATIONS

Automobile construction consists of many activities. These activities are carried out inside the assembly plant as well as outside, by other plants and other firms. Since the beginning of automobile construction, the way in which and where these activities have been done, has varied over time. The implementation of technology to production process and better transportation through railways and highways have been the main triggers of change.

The project manager in a factory must estimate the duration of activities involved in the project, which includes the transportation time for components to arrive at the assembly plant. Even for the same car-building project, this will vary in time. i.e., the duration in 1960 may differ from 1980. For instance, firms will perform differently in the process of assembling a similar car.

The objective of this section is to illustrate how a procedure called the "critical path method" can be used to evaluate what is the minimum amount of time needed to complete all activities in a project such as car-building. When the critical path method is applied to different firms for the same project, different levels of efficiency can be seen between firms. In the case where these firms incorporate different production processes, the critical path method can determine whether one process is more efficient than the other.

An application of the critical path method is issued to evaluate what is the minimum amount of time needed for all components to arrive at the assembly plant in order to complete a project. The critical path in this case is a measure of the level of dispersion or concentration in a network of firms. In this sense, a more concentrated network will be efficient, with less distance between nodes of the network; a less efficient network would be a more dispersed network, with more distance between nodes of the network.

Due to lack of information, the efficiency aspect of component distribution between MPS and LPS could not be analyzed. But two illustrations, using flows of component from suppliers to assemblers, of two firms -Fasa Renault and Nissan Motor Ibérica- provide a partial picture. The estimation procedure makes the following assumptions:

1 The calculation of what is served by each firm is done by assuming that the production served is directly proportional to the number of workers in each suppliers' plant, (the implicit assumption is that output by worker does not vary across the plants).

2 Moreover, there is no consideration of difference in product prices in this estimation. Since the component sector is a very competitive industry, price is assumed to be the same for each firm.

3 There is also the assumption that assembly firms do not consider transport costs in their purchase of components so that the assemblers purchase components proportional to firm size as measured by labor. High value of several components -such as the tires, windows, and batteries- considered in the two examples of this section- makes the proportion of transportation cost to the total costs very low, which may suggest that this cost is assumed by the component firms, so the assembler do not consider distance from the supplier in buying the component. However, *the assembler would consider the time cost of waiting for the component to arrive, the appropriate sequentiality of the components arriving to the assembly plant, and the frequency in which the component should be at the assembly plant due to shortage of assembly plant inventory.*

4 All components used in these cases are assumed to be bought in Spain. This assumption is made considering that major component firms from Europe are located in Spain. Even though several firms may buy components from their own partners in other countries, such as Nissan buys from Japan, GM buys from Opel, in Germany, and Seat buys from Volkswagen, also in Germany.

These assumptions while strong do not appear to be unreasonable, and are necessary since there is no data on prices or actual shipments. Maximum use has been made of available data. However, the objective of this critical path analysis is to show the usefulness of this methodology. The activity digraph, with correct data, would provide an assesment of real flows. The magnitudes obtained in these two illustrations, therefore, are not estimates of critical paths of component flows.

7.3.1 The Critical Path of Fasa Renault

Fasa Renault is a car assembly firm located in the Spanish region of Valladolid. Information about the location of its suppliers is obtained from the structured interview in the following way: for each type of component it is possible to determine the number of locations from which this component is served (Table 7.5). For instance, "Electric components and devices" are supplied from three locations. These locations are mainly in Catalonia, Basque Country, and Central Spain.

From the suppliers' census one can observe that, for example, batteries are produced by different firms located in Barcelona (Catalonia), Madrid (Center), and Burgos (close to Basque Country). Thus, we made the assumption that the suppliers which serve Fasa Renault are in these three points.

In 1990, the reference year, 326,084 cars were produced by Fasa Renault. Thus, the same number of batteries is assumed to have been needed. For instance, Varta Baterias, in Burgos, with 309 workers, would produce about 5.4 percent of what Fasa Renault needed for its 1990 car production (Table 7.6, Figures 7.8 - 7.10). In this way the flow of batteries from the source (suppliers) to the sink (Fasa Renault) is known, and an activity digraph can be drawn (Figure 7.11). Similar reasoning is carried out in doing the critical path dispersion calculations for the other two components: tires and windows.

Table 7.5 Fasa Renault, classification of components by location of production, 1990

	Type of component	Location of production point (note 1)	Value of the product (note 3)	Relation to the supplier (note 2)
1	Suspension, steering, brake and transmission system components	3 locations	A and B	2
2	Plastics, harness and noise insulation	3 locations	A and B	2
3	Forging and stamping components. Foundry	10 locations	C (note 4)	2
4	Electric components and devices	3 locations	B	2
5	Tire ring and rubber tire	3 locations	C	2
6	Laminated components	7 locations	C	2
7	Mechanized and foundry components	Done inside assembly firm		
8	Paints, varnish and resins	4 locations	B and C	2
9	Engine parts and thermal systems	3 locations	A	2
10	Rubber	. . .	. . .	. . .
11	Glass	2 locations	C	2

(1) Location points are in the main industrialized regions: Catalonia, Basque Country, and Center. A few of them (3-4) are located in Asturias and Valencia.

(2) Relation of the assembly firm to the supplier: 1) subsidiary firm; 2) independent firm.

(3) Component firms are classified by : A = supplies < 500 milion pesetas; B = supplies 500mil.-1000 milion pesetas; C = supplies > 1000 milion pesetas. These quantities correspond to volume of sales of the component firm to the assembly firm by year.

(4) Do exist 1 firm A, and 1 firm B. Thus 8 firms C.

Source: Structured interview.

Table 7.6 Suppliers of 3 components to Fasa Renault, 1990

1. TIRES

Served from 3 locations:

	Name of supplier firm		Location of supplier	Number of workers	Percent
a.	Firestone	(TI1)	Vizcaya	5300	27.7
b.	Pirelli	(TI2)	Barcelona	1887	9.9
c.	Michelin	(TI3)	Guipuzcoa	11924	62.4
			TOTAL	19111	100.0

Number of cars produced by Fasa Renault 1990: 326084

Number of tires needed: 1630420 (5 tires per car)

Number of tires served by:

TI1	451,626
TI2	161,412
TI3	1,017,382

2. WINDOWS

Served from 2 locations:

	Name of supplier firm		Location of supplier	Number of workers	Percent
a.	Manufactura Carlos Tarrida	(G1)	Barcelona	160	13.4
b.	Vidrieras del Llodio	(G2)	Alava	1030	86.6
			TOTAL	1190	100.0

Number of windows needed: 1956504 (6 windows per car)

Number of windows served by:

G1	262,172
G2	1,694,332

3. BATTERIES

Served from 3 locations:

	Name of supplier's firm		Location of supplier	Number of workers	Percent
a.	Varta Baterias	(BT1)	Burgos	309	5.4
b.	Three firms[37]	(BT2)	Madrid	3774	65.8
c.	Three firms[38]	(BT3)	Barcelona	1651	28.8
			TOTAL	5734	100.0

Number of batteries needed: 326084 (1 battery per car)

Number of batteries served by:

BT1	17,609
BT2	214,563
BT3	93,912

---

37 FEMSA (Madrid), 1567 workers; Finanzauto (Madrid), 1891 workers; RECON (Madrid), 316 workers.

38 Auto Corona (Barcelona), 66 workers; FEMSA (Barcelona), 1567 workers; Laboratorios Frekendall (Barcelona), 18 workers.

Figure 7.8 Flow of tires from supplier to Fasa Renault, 1990

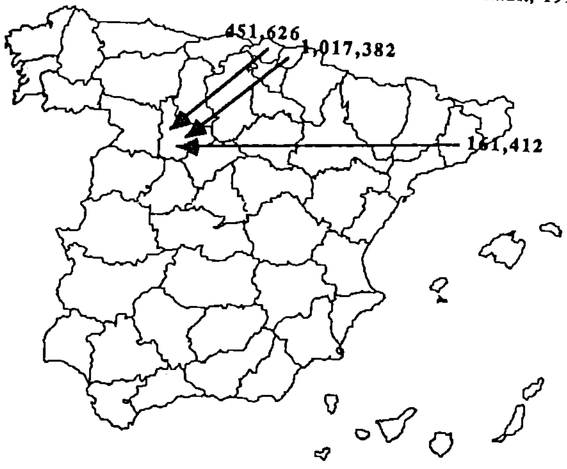
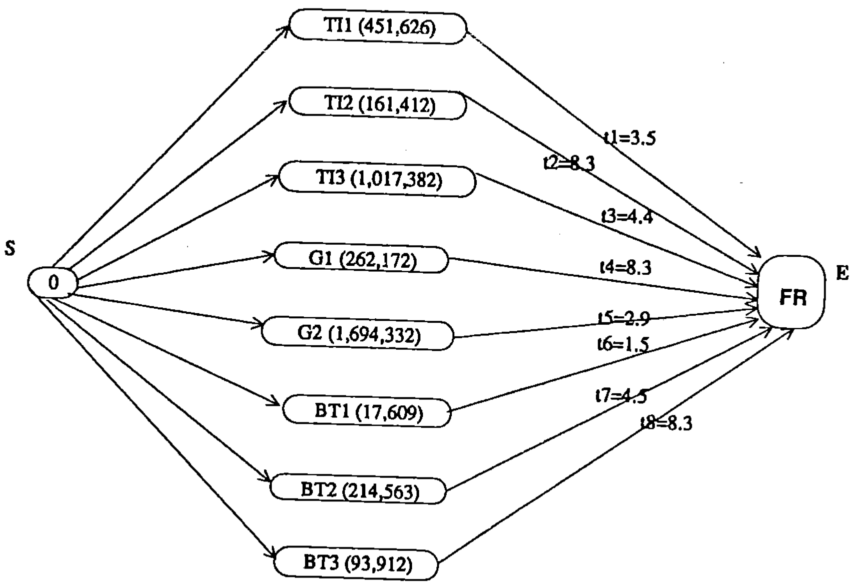


Figure 7.9 Flow of windows from supplier to Fasa Renault, 1990

Figure 7.10 Flow of batteries from supplier to Fasa Renault, 1990

Figure 7.11 Activity digraph of Fasa Renault and first-tier suppliers of three components 1990



Given the suppliers' locations, and given the information from Fasa Renault that almost all components are transported by truck, travel time between suppliers and assembler can be estimated (Table 7.7).

Table 7.7 Travel time by truck from main suppliers' region to Fasa Renault

Fasa Renault, with respect to:

Region	Km	Time by truck
Valladolid	0	0
Barcelona	663	8.3
Madrid	357	4.5
Navarra	325	4.1
Guipuzcoa	354	4.4
Vizcaya	280	3.5
Alava	236	2.9
Burgos	122	1.5

From the activity digraph of Fasa Renault (Figure 7.11) the number of paths, the total path time and the paths' flow are known. From this information, the critical path dispersion of Fasa Renault can be calculated given three components (Buckley and Harary 1990); i. e., the minimum amount of time needed for all components to arrive at Fasa Renault (FR) in order to build a car (Tables 7.9, 7.10).

Although an algorithm could give us this time with this aforementioned data, a kind of weighted-distance time is needed to complete a true value for the critical path dispersion. For example, transporting 3000 units during 3 hours, is not the same as transporting 30000 units during the same amount of time. The dispersion or concentration of a network should be a weighted measurement of distances. Thus indexing by cost could be one of the measurements of critical path dispersion of the network. Then, assuming 1 peseta per hour and unit, an index/cost of flow for each path can be estimated (Table 7.8).

Table 7.8 Fasa Renault' activity digraph path data

Number of paths	Path time (hours)	Path flow	Path cost (Mill. Ptas)
1. TI1 FR	3.5	451626	1.60
2. TI2 FR	8.3	161412	1.30
3. TI3 FR	4.4	1064578	4.70
4. G1 FR	8.3	262172	2.20
5. G2 FR	2.5	1694332	4.20
6. BT1 FR	1.25	17609	.02
7. BT2 FR	4.5	214563	1.00
8. BT3 FR	8.3	93912	.80

Table 7.9 Sequence of trip activity involved in car-building project at Fasa Renault, considering 3 components

Trip activity	Description	Immediate predecessors	Time-cost
Start	-	-	0.00
TI1	Sending tires from Vizcaya	Start	1.60
TI2	Sending tires from Barcelona	Start	1.30
TI3	Sending tires from Guipuzcoa	Start	4.70
G1	Sending windows from BCN	Start	2.20
G2	Sending windows from Alava	Start	4.20
BT1	Sending batteries from Burgos	Start	.02
BT2	Sending batteries from Madrid	Start	1.00
BT3	Sending batteries from Barcelona	Start	.80
End (FR)	Car-building	TY1-TY3, G1-G2, BT1-BT3	

Table 7.10 Component trip time-cost schedule for Fasa Renault car-building project

	Start	TI1	TI2	TI3	G1	G2	BT1	BT2	BT3	End
Duration	0	1.6	1.3	4.7	2.2	4.2	.02	1.0	.8	0
Earliest start time	0	0	0	0	0	0	0	0	0	0
Earliest finish time	0	1.6	1.3	4.7	2.2	4.2	.02	1.0	.8	4.7
Latest start time	0	0	0	0	0	0	0	0	0	0
Latest finish time	0	1.6	1.3	4.7	2.2	4.2	.02	1.0	.8	4.7
Slack time	0	0	0	0	0	0	0	0	0	0

In the longest path dispersion cost in the activity digraph of Fasa Renault, the critical path dispersion has exactly one critical path, TI3 FR; thus, the minimum time needed for car-building activity is 4.7 hours. Lack of data does not allow for an estimate of the Fasa Renault network dispersion in 2 or more points in time, nor for a comparison of levels of efficiency of the firm in these different periods in which two systems of production are taking place.

7.3.2 The Critical Path of Nissan Motor Ibérica

Another illustration is given for Nissan Motor Ibérica, in which slightly different information could lead to different activity digraphs and different critical path dispersions of the network.

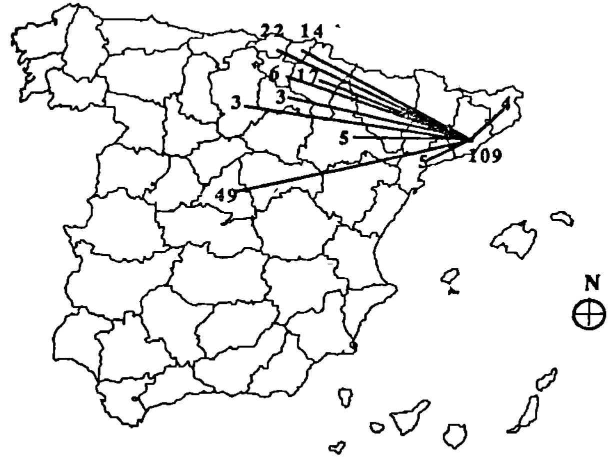
Nissan Motor Ibérica is located in Barcelona. Information about the location of its suppliers is given for 1992 in a list of supplier names and locations. From this list an aggregation of suppliers by location and a map representing the Nissan network of suppliers has been constructed (Table 7.11, Figures 7.12, 7.13). From the 1992 census of suppliers, the suppliers of Nissan serving tires, windows and batteries may be discovered, as well as the number of workers they have. The same type of components as Fasa Renault has been chosen, such as tires, windows and batteries (Table 7.12, Figures 7.14-7.16). Similar procedure than one of Fasa Renault is followed for Nissan Motor Ibérica.

Table 7.11 Nissan Motor Ibérica. Suppliers by location, 1992

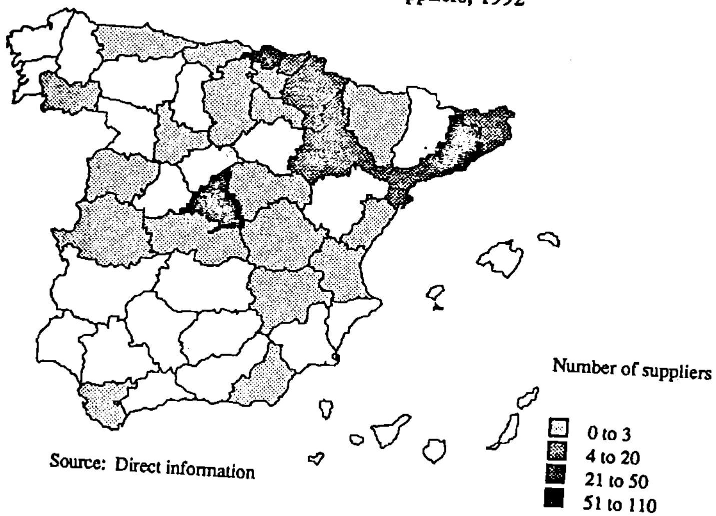
Spain	Number of suppliers	Percent Spain	Percent TOTAL
Alava	6	2.4	1.8
Albacete	1	0.4	0.3
Almería	1	0.4	0.3
Asturias	2	0.8	0.6
Barcelona	109	42.9	33.1
Burgos	3	1.2	0.9
Cáceres	1	0.4	0.3
Cádiz	1	0.4	0.3
Cantabria	1	0.4	0.3
Castellón	2	0.8	0.6
Cuenca	1	0.4	0.3
Girona	4	1.6	1.2
Guadalajara	1	0.4	0.3
Guipuzcoa	14	5.5	4.3
Huesca	1	0.4	0.3
Madrid	49	19.3	14.9
Navarra	17	6.7	5.2
Orense	1	0.4	0.3
La Rioja	3	1.2	0.9
Salamanca	1	0.4	0.3
Tarragona	5	2.0	1.5
Toledo	1	0.4	0.3
Valencia	1	0.4	0.3
Valladolid	1	0.4	0.3
Vizcaya	22	8.7	6.7
Zaragoza	5	2.0	1.5
Total	254	100.0	
Foreign countries			
Belgium	1		0.3
France	11		3.3
Germany	19		5.8
Ireland	1		0.3
Italy	4		1.2
The Netherlands	2		0.6
Switzerland	1		0.3
UK	34		10.3
USA	2		0.6
Total	75		
TOTAL	329		100.0

Source: Nissan Motor Ibérica.

Figure 7.12 Network of suppliers of Nissan Motor Iberica, 1992



7.13 Location of Nissan Motor Ibérica suppliers, 1992



Source: Direct information

Table 7.12 Suppliers of 3 components to Nissan Motor Ibérica, 1992

1. TIRES

Served from 3 locations:

	Name of supplier firm		Location of supplier	Number of workers	Percent
a.	Two firms[39]	(TI1)	Madrid	12224	62.0
b.	Firestone	(TI2)	Vizcaya	5300	26.9
c.	Two firms[40]	(TI3)	Barcelona	2182	11.1
			TOTAL	19706	100.0

Number of cars produced by Nissan Motor Ibérica 1990: 81278

Number of tires needed: 406390 (5 tires per car)

Number of tires served by:

TI1 251,962

TI2 109,319

TI3 45,109

2. WINDOWS

Served from 1 location:

	Name of supplier firm		Location of supplier	Number of workers	Percent
a.	Vidrieras del Llodio	(G1)	Alava	1030	100.0
			TOTAL	1030	100.0

Number of windows needed: 487668 (6 windows per car)

Number of windows served by:

G1 487,668

39 Continental Industria del Caucho (Madrid), 300 workers; Michelin (Madrid), 11924 workers.

40 Norgren Martonair (Barcelona), 295 workers; Pirelli (Barcelona), 1887 workers.

3. BATTERIES

Served from 3 locations:

	Name of supplier firm		Location of supplier	Number of workers	Percent
a.	Delco Products	(BT1)	Cadiz	2000	25.1
b.	Two firms[41]	(BT2)	Madrid	5961	74.9
			TOTAL	7961	100.0

Number of batteries needed: 81,278 (1 battery per car)

Number of batteries served by:

BT1 20,401

BT2 60,877

Given the supplier location, the location of Nissan in Barcelona and the fact that components are transported by truck, travel time between suppliers and assembler can be estimated (Table 7.13).

Table 7.13 Travel time by truck from main supplier's region to Nissan Motor Ibérica

Nissan Motor Ibérica, with respect to:

Region	Km	Time by truck
Barcelona	0	0
Madrid	621	7.8
Navarra	437	5.5
Guipuzcoa	529	6.6
Vizcaya	620	7.8
Alava	530	6.6
Cadiz	1284	16.1

41 Regulacion y Control (Madrid), 316 workers; Robert Bosch (Madrid), 5645 workers.

Figure 7.14 Flows of tires to Nissan Motor Ibérica, 1990

Figure 7.15 Flow of windows from supplier to Nissan Motor Ibérica, 1990

Figure 7.16 Flow of batteries from supplier to Nissan Motor Ibérica, 1990

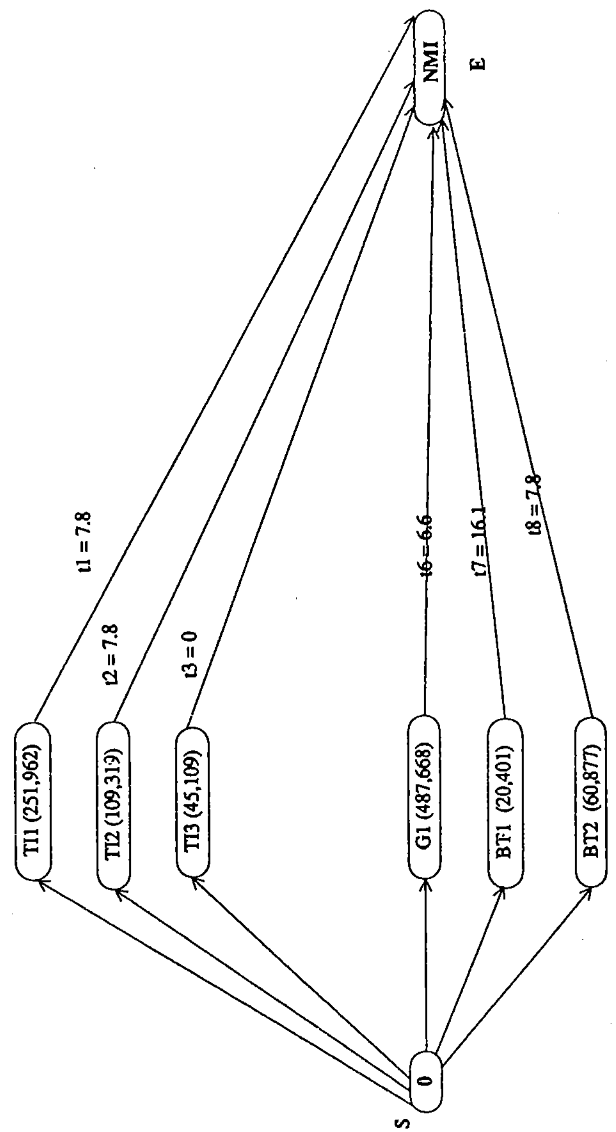


Figure 7.17 Activity digraph of Nissan Motor Ibérica and first-tier suppliers of three components, 1990

The activity digraph of Nissan Motor Ibérica (see Figure 7.17) shows the number of paths, path time, and path flow. From this information, the critical path dispersion of Nissan Motor Ibérica may be calculated given three components; i. e., the minimum amount of time needed for all components to arrive at Nissan Motor Ibérica (NMI) in order to build a car (Table 7.14, using the same assumptions as with Fasa Renault.

Table 7.14 Nissan Motor Ibérica activity digraph path data

Number of paths	Path time (hours)	Path flow	Path cost (Mill. Ptas)
1. TI1 NMI	7.8	251962	2.0
2. TI2 NMI	7.8	109319	.9
3. TI3 NMI	0.0	45109	. . .
4. G1 NMI	6.6	487668	3.2
5. BT1 NMI	16.1	20401	.3
6. BT2 NMI	7.8	60877	.5

Table 7.15 Sequence of trip activity involved in car-building project at Nissan Motor Ibérica, considering 3 components

Trip activity	Description	Immediate predecessors	Time-cost
Start	-	-	0
TY1	Sending tires from Madrid	Start	2.9
TY2	Sending tires from Vizcaya	Start	.9
TY3	Sending tires from Barcelona	Start	. . .
G1	Sending windows from Alava	Start	3.2
BT1	Sending batteries from Cádiz	Start	.3
BT2	Sending batteries from Madrid	Start	.5
End (NMI)	Car-building	TI1-TI3, G1, BT1-BT2	

Table 7.16 Component trip time-cost schedule for Nissan Motor Ibérica car-building project

	Start	TI1	TI2	TI3	G1	BT1	BT2	End
Duration	0	2.0	.9	...	3.2	.3	.5	0
Earliest start time	0	0	0	0	0	0	0	0
Earliest finish time	0	2.0	.9	...	3.2	.3	.5	3.2
Latest start time	0	0	0	0	0	0	0	0
Latest finish time	0	2.0	.9	...	3.2	.3	.5	3.2
Slack time	0	0	0	0	0	0	0	0

In the longest path dispersion cost in the activity digraph of Nissan Motor Ibérica, the critical path dispersion has exactly one critical path, G1 NMI, thus, the minimum time needed for car-building activity is 3.2 hours. Lack of data does not allow for an estimate of Nissan Motor Ibérica network dispersion in 2 or more points in time, nor for a comparison of levels of efficiency of the firm in these different periods, in which two systems of production are taking place.

CHAPTER 8 CONCLUSION

Regional changes are brought about, among other things, by changing technologies of production. The health and survival of regional economies depends on the ability of enterprises to adjust to changing technologies of production and changing consumer preferences. Supply adjustments to the fluctuations of market demand are crucial for the well being of firms and the regions in which they are located.

Changing technologies are accompanied by the need to alter organizational and management systems. Both -the engineering and the management aspects- are inextricably bound together and production efficiencies occur only when there is a synchronization between the engineering / technology and the management / decision systems. The LPS model is only the latest example of manufacturing processes that are self adjusting to internal and external pressure for cost reduction and quality enhancement.

The automobile sector provides a good example of where production efficiencies are occurring in firms where technological changes in production processes are accompanied by changes in spatial structure. Thus, this dissertation analyzed the structural changes and the spatial manifestations of such a transition for the automobile industry in Spain where it is emerging as one of the most important industries in terms of employment, value-added, export share and balance of trade for the country. Moreover, the industry is in a phase of transition as market saturation and declining demand has jointly put pressures on firms to combine higher productivity, increased quality of output at competitive costs. The changing technology of flexible specialization, management and worker roles of the LPS has provided a competitive edge to firms adopting the newer system. Thus this dissertation compared the LPS with the MPS in terms of its general characteristics as well as its empirical manifestations in Spain.

This dissertation accomplished two objectives. First, the framework of the systems of production currently in the automobile industry were analyzed, from a general perspective. Second, it investigated the present situation of the AI in Spain, their structural changes, and the spatial rearrangements resulting from these. This study addressed these main subjects

- the changing structure of production in the automobile industry,
- the introduction of the LPS in the automobile production firms in Spain,
- the spatial restructuring driven by the introduction of the LPS in the assembly firms in Spain,
- the changing potential of the AI in Spain, with the development of the EEC single market.

The major findings are summarized below. At the end of this chapter the directions for future research are discussed.

8.1 TRANSITION IN PRODUCTION SYSTEMS

The LPS, with the numerous advantages it possesses relative to the MPS, provided a competitive edge to automobile firms that adopted this complex innovation. It propelled Japan into a position of dominance in the automobile industry, at the global level. The LPS was instrumental in the loss of market share of older established firms, which were slow to adopt the newer technologies and management strategies -like GM, that continued to operate under the MPS in most of its factories. However, with the positive elements of structural change there occur, in the long run, some negative effects. In this concluding section some of these emerging problems of the LPS are discussed. Since firms in Spain

are beginning to adopt the LPS, it is useful to focus on the areas of probable future costs of implementing LPS, and their implications for public policy.

Japan has the longest record of experience of LPS, and the problems with the LPS are consequently manifest most clearly there. Other countries, such as Spain, have selectively implemented LPS by adopting some of its important features. This selective adoption by Spain reflects its internal economic resources, cultural and political characteristics and thus, the problems might take on a different form than expressed in Japan. With this in mind, the Japanese case is discussed.

Internal characteristics of the Lean production system, related with its JIT distribution system, made the LPS unsuitable for some firms and for some regions; the first country where the LPS shows problems is Japan -where it was invented-, but some other countries or regions might find it unsuitable for their needs, though, important features of the LPS may still be valuable.

The increasing use of JIT is an integral component of LPS. JIT delivery requires a large, well structured, road system. Low inventory in plants implies sending materials from one firm to another, with high frequency, in order to efficiently maintain production. This produced a large amount of traffic on the road called "road warehousing". Where as private sector benefited from the lowered cost of smaller inventories, the public sector had to bear the cost of increased congestion. Problems arose for the production sector when transportation and communication systems did not increase commensurately with the increasing utilization of JIT by manufacturing firms. Hence, the high increase of transaction costs involved in transfering goods and services from one operating unit to another is causing a problem for the firms as the congestion costs are causing the JIT system to become inefficient. Logistics of distribution has emerged as the major constraint. Under these circumstances, automobile firms have searched for a solution to this problem, an another structural arrangement for production of cars seems to be emerging, which involves rearrangements in the spatial distribution of production points, changes in the design process, production of highly customized cars, and enhancement of dealer roles in production decisions.

This new production system, termed the Cellular Production System, has been discussed in this dissertation. This is a spatial reaction and spatial reordering in order to reduce cost of transaction of commodity flows and knowledge. The major features of the CPS are: 1) the relocation of assembly plants closer to points of demand; 2) main components of the car are produced by a reduced number of suppliers; 3) first-order suppliers serve only one firm, and are located close to the assembly plant, in order to diminish transaction (transportation and communication) cost of intermediate products; 4) discrete parts are done by a larger number of small firms who serve more than one firm within the AI, and have their production diversified in order to supply other manufacturing sectors; 5) the role of the dealer is enhanced, in the way that they transfer information from the client to its production plant permitting greater customization of cars.

Information systems have become of critical importance in the Cellular production system. There are three stratified levels of technical information systems operating in the CPS, which are: 1) the dealers transmit client preferences regarding the product to the production plant; 2) the assembler receives the dealer information and produces the customized product in association with its first-tier suppliers; 3) the "main brain" of the firm, which is located in a central point, receives information from the diverse production plants about the technical needs required for producing the customized product. The main brain develops technological innovations (R&D) in order to attain scope economies with the highly diversified production required for all the plants of a firm.

Even though it is at the beginning stage, the CPS allows greater customized product while developing new communication and transportation links which might vary the actual network structure.

8.2 THE INTRODUCTION OF THE LPS IN THE AUTOMOBILE PRODUCTION FIRMS OF SPAIN

The AI in Spain is a relative new industry which is increasing its importance in the economy in terms of production, value-added, employment, export shares, and productivity. In terms of consumption, the number of automobiles per person in Spain is inferior to the average of that in the EEC, this suggest that there is still room for growth in the industry. Quite recent trends in the AI in Spain led to changes towards the introduction of the LPS production system. But, due to the complexity of the AI, changes take a long time to show effectiveness. For similar reason, variations in the car production are introduced step by step. The introduction of the LPS in Spanish automobile firms started in 1986 in Nissan Motor Ibérica, and much later on, in 1990 and 1991, in Seat Volkswagen and General Motors España. One of the first changes introduced in the old production practices of the firms is the JIT inventory system, which implies reduction of inventory, change in ways of delivery of intermediate goods, and the application of Kanban system inside the assembly firm. Other new developments in the system of production have been: increasing labor tasks in groups, increasing labor skills and labor academic qualification, larger investments in flexible manufacturing systems, and increasing strength in quality monitoring and achievement of the intermediate and final product.

However, while important features of the LPS have been introduced in the Spanish AI firms, there are some endowment factors of the Spanish economy, and of the AI network, that make the introduction of the LPS in Spanish firms distinctly different from the Japanese model, and suggest that the "Toyota City" may not be replicated in the AI network of Spain[42]. For instance, the level of unionization in the Spanish labor force is not very high -18 percent of the working population, in 1987- compared to other European countries -Italy, 44 percent; UK and Portugal 53 percent, the same year-, but the quantity of time on strikes is higher than these other countries (Appendix E); which suggests a long process of discussion towards the adaptation of labor to any new job practices. Otherwise, assembly firms located in Spain are subsidiaries of multinational firms -from the US, Japanese, or European origin; and innovations take longer to be inserted in filial firms than in headquarters.

The structure of the production function for the automobile industry in Spain shows a high elasticity of output respect to the material input, .707 for the 1975-1990 period, similar results are given by the estimation of the production function for three of the firms studied: Fasa Renault, .645; Seat Volkswagen, .741; and Nissan Motor Ibérica, 1.188, which is the highest elasticity of output respect materials. However, since the estimation of materials has been made in value terms observations -cost of materials, in pesetas-, these high material shares suggest that firms are buying components with high value-added, so labor and capital cost of component production is embodied in their price. Another possible explanation to this high elasticity is that the increasing use of knowledge intensive materials and advanced technologies -FMS[43] and CNC[44]- make capital and labor more expensive. These results provide supportive evidence regarding the shift to the LPS in the Spanish automobile industry.

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42 Although Seat Volkswagen has opened, in 1991, a factory close to Barcelona's industrial area, where the assembler and its major component suppliers are 10 minutes distant from each other.

43 Flexible manufacturing technologies.

44 Computer numerically controlled machines.

8.3 THE SPATIAL RESTRUCTURING DRIVEN BY INDUSTRIAL CHANGES IN THE SPANISH AUTOMOBILE FIRMS

Space does not react as rapidly as other structural variables. For instance, Fasa Renault, Nissan Motor Ibérica, and Seat Volkswagen which have changed their relationship with suppliers in the sense of receiving the components sequentially and at the time required by the production chain, have not changed their spatial network of suppliers, yet. The study of the spatial changes in the industrial regions of Spain resulting from the LPS restructuration, shows that network of component firms has not changed.

The main hypothesis, derived from the theoretical literature that as a result of the JIT system, the assembly plant and their suppliers would cluster could not be sustained in the Spanish empirical findings. These findings showed that there was no spatial concentration of component firms towards assembly firms, in the period studied (1975-1990). One possible explanation of this result may be the short period of time in which the introduction of JIT practices has been activated in Spanish firms. Another explanation may be the structure of the Spanish component firms, which is formed by small firms attached geographically to one place, with low investment power, and low spatial mobility of capital and labor -high cost of moving and firing labor force-, particular characteristics of the labor in Europe makes it more spatially immobile than in the US. Also, the high price of industrial land close to assembly places, and the attraction of component firms to already industrialized regions support the empirical findings in Spain.

Consequently, those keep component suppliers in their original locations, so that spatial restructuration of component firms in Spain did not happen yet, while organizational factors have already occurred -as discussed in last Section. On the other hand, the emergence of warehouses of parts and components, as intermediate points between suppliers and assemblers, is a deep increasing trend in the Spanish regions, they went from

128 to 259 between 1983 and 1992. The number of warehouses located in assembly regions -defined as regions containing assembly firms- increased with a very large amount in this period. For instance, in Barcelona, where Seat and Nissan are located, the number of warehouses went from 51 to 103 between both years; Zaragoza, GM's region, the number went from 3 to 6 warehouses; and Valencia, Ford's region, it increased from 2 to 6. In Madrid's region, where several smaller car assembly firms are located, the number of warehouses between both years went from 56 to 102. Hence, given the spatial inertia of component firms, warehouses are functioning as equivalents.

Parts and component warehouses could be independent, serving more than one assembler, or dependent of one assembly firm. Dependent warehouses are located 5 to 10 minutes from the assembly plant. They are prepared to facilitate the assembly plant shorter deliveries -on a day-to-day basis, or even on a hourly-basis- with the proper sequentiality required for the LPS production.

8.4 THE AUTOMOBILE INDUSTRY IN SPAIN AND THE EEC SINGLE MARKET

The Spanish AI has old and well established relations with the rest of the European countries. These relations are of two kinds. First, European AI firms have been located in Spain since the 1950s -Seat Volkswagen, Fasa Renault, and more recently, GM-Opel. Also the larger European component firms -like Lucas Girling- have plants located in Spain. Second, the majority of the production of Spanish AI during the 1980s went to European markets. Thu, this suggest that there may not be major changes changes in the characteristics of the product of the AI industry in Spain due to the EEC single market.

Although, the development of the EEC single market -from January 1993- may modify the European industry, as well as the Spanish one, in the form of restructuring,

company mergers, and joint strategic alliances. The competitive advantage of the AI firms may also be changed with the EEC single market. On one hand, it enlarges the market for AI firms which, under free competition, would lower production costs. On the other hand, the free circulation of labor would, in the intermediate term, equalize labor cost across Europe. While free circulation of people is still not accomplished, there are already laws enforcing free labor circulation among member countries. Skilled workers are allowed to follow their professional careers in any of the member countries.

Spain, which was a cheap labor country until the 1970s, had the labor factor as a competitive advantage in attracting firms. In the 1980s, Spanish labor became more expensive, although it was still lower than France, Germany, Italy, and the UK. Thus, assuming the same structural circumstances for the AI, Spain could face a thread that AI firms would choose to locate in other EEC country with cheaper labor cost, like Greece or Portugal. But structural changes in the production of cars, discussed in different sections of this dissertation, suggest that the AI is not primarily influenced in its location by cheap labor; other factors such as skilled labor pools, network of kindred firms and good transportation and communication structures are becoming more important. Also, while the AI is a long term investment, low labor cost could change in a short term; thus it may become obsolete as a location factor within a common labor market.

Although it has not been studied in this dissertation, some theoretical literature argue that there is no reason to expect a dramatic and general geographical restructuring of the AI in Europe as direct response to the creation of the single market, because firms behave already as if they exist in a single market; the major force generating structural change in the European AI firms is the increasing competitive thread from the Japanese manufacturers. EEC institutions as well as member country laws are enforcing European AI protection from the Japanese car penetration.

8.5 DIRECTIONS FOR FUTURE RESEARCH

Geographers have always been interested in distance reduction mechanisms, for instance, increasing improvements of the railroad structure induced to spatial adjustments of the economic activity. This dissertation has made emphasis in how the change between the MPS and the LPS have induced spatial changes in the industrial network, in the sense of reducing distances between supplier firms and assembler, due to the implementation of JIT inventory procedure. This study has been made considering a material network formed by firms and flows of intermediate products. The introduction of flexible specialization in the industrial structure enhance the role of information technology, which transmits information from one to the other node in the network, this is considered to be a nonmaterial network[45]. For instance, the spatial response to the implementation of the LPS in the AI network of Spain, the warehouse, may not be possible without the existence of high information technology linkages. Moreover, the spatial clustering of supplier firms towards the assembler in Spain is not occurring yet, and it may not occur in the future due to implementation of information technology inside the network.

Hence, the results in this dissertation leave future research open in the development of the concept of nonmaterial networks and the spatial restructuration of industrial activities. Mostly concerned with the transmission of information and knowledge among the nodes -firms- of the network, which is increasing in importance with the development of the LPS as well as the CPS production systems.

Moreover, the increasing importance of the dealer's role in the CPS, in the way of transmiting information from the client to the assembler in order to produced a more

45 Nonmaterial networks are defined as "different types of linkages between economic actors, such as knowledge networks, technology networks, financial networks, planning administrative networks, etc." (Lakshmanan 1988).

customized product, leaves the research open to the study of how the implementation of information technology is also introduced in dealer's nodes, suggesting a change in the marketing network of the automobile industry; which is also a nonmaterial network.

Hence, I pursue the idea of how the implementation of information technology in industrial and marketing networks of the AI may induce spatial restructuring.

BIBLIOGRAPHY

Abegglen, James C., and George Stalk, Jr. Kaisha. La corporación japonesa. Barcelona: Plaza y Janés Editores, S.A., 1986 .

Abler, Ronald. "Effects of space adjusting technologies on the human geography of the future". Chapter 3 of Human geography in a shrinking World, R. Abler et al. (Eds). North Scitiate, MASS: Duxbury Press, 1975.

Aglietta, M.A. Theory of capitalist regulation. The US experience. London: Verso, 1979.

Albernathy, W. J. The productivity dilemma: roadblock to innovation in the automobile industry. Baltimore: John Hopkins University Press, 1978.

Altshuler, A. et al. The future of the automobile: the report of MIT's international automobile program. Cambridge (MASS): MIT Press, 1985.

Amin, A. and K. Robins. "The re-emergence of regional economies? the mythical geography of flexible accumulation". Environment and Planning D: Society and Space 8, 1990: 7 - 34.

Aronowitz, S. False promises: the shaping of American working class consciousness. New York: Mc Graw Hill, 1973.

Berry, Brian J. L. "Howard G. Roepke lecture in economic geography. Comparative geography of the global economy: cultures, corporations, and the nation-state." Economic Geography 65 (1989): 1 - 18.

Bianchi, Patricio. "Nivells de política i naturalesa de la competència post-fordista". Barcelona: Revista Econòmica de Catalunya 14, May - August, 1990.

Bieda, K. The structure and operation of the Japanese economy. Sydney: John Wiley and Sons, 1970.

Bingham, R.D. and K.K. Sunmonu. "The restructuring of the automobile industry in the USA". Environment and Planning A, 24 (1992): 833 - 852.

Birch, D. L. The job generation process. Cambridge, MA: MIT Program on Neighborhood and Regional Change, 1979.

Blackburn, J. D. Time based competition. The next battleground in American manufacturing. Homewood, Ill: Business One Irwing, 1991.

Bloomfield, G. T. "The changing spatial organization of multinational corporations in the world automotive industry" in Hamilton, F. E. I. and G. Linge (Eds). Spatial analysis, industry and the industrial environment. Vol. 2: International Industrial Systems. Chichester: John Wiley, 1981.

Bloomfield, G. "The changing spatial organization of multinational corporations in the world automotive industry" in Hamilton, F. E. I. and G. J. R. Linge (Eds). Spatial analysis, industry and the industrial environment. Vol. 2: International industrial systems. Chichester: Wiley, 1981.

Boas, Charles W. "Locational patterns of American automobile assembly plants, 1895-1958." Economic Geography 37 (1961): 218-230.

Buckley, Fred and Frank Harary. Distances in graphs. New York: Addison-Wesley Publishing Company, 1990.

Burt, D. N. "Managing suppliers up to speed". Harvard Business Review 4, 1989: 127 -135.

Bustelo Gómez, Pablo. Economía política de los nuevos países industriales asiáticos. Madrid: Siglo XXI de España Editores SA, 1990.

Camagni, Roberto P. "New technologies as a response to the crisis in the Italian North - West". Spatial aspects of the technological change. Jaime del Castillo, Milagros García Crespo and Stefan A. Musto (Eds). Bilbao: Servicio Editorial Universidad del País Vasco, 1989.

Camagni, Roberto P. "Regional deindustrialization and revitalization processes in Italy". Industrial change and regional economic transformation. The experience of Western Europe. Lloyd Rodwin and Hidehiko Sazamani. London: Harper Collins Academic, 1991.

Casti, John. "Metaphors for manufacturing: what could it be like to be a manufacturing system?". Technological forecasting and social change 29, 1986: 241 - 270.

Casti, John. "Manufacturing as a system-determined science". Technological forecasting and social change 31, 1987: 305 - 321.

Caves, E. and Masu Uekuma. "Industrial organization in Japan" in Patrick, Hugh and Henry Rosovsky (Eds). Asia's new giant. Washington, D. C.: The Brookings Institution, 1976.

Chapman, Keith and David Walker. Industrial location. Principles and policies. Oxford: Basil Blackwell, 1986.

Chartrand, Gary. Introductory graph theory. New York: Dover Publications Inc., 1985.

Chandler, Alfred D. The visible hand. The managerial revolution in American business. Cambridge, MA: Harvard University Press, 1977.

Chandler, Alfred D. Scale and Scope. The dynamics of industrial capitalism. Cambridge, MA: Harvard University Press, 1990.

Child Hill, Richard. "Global factory and company town: the changing divisions of labor in the international Automobile Industry". Global restructuring and territorial development. Jeffrey Henderson and Manuel Castells (Eds). London: Sage Publications, 1987.

Christensen, Poul et al. "Firms in network: concepts, spatial impacts and policy implications" in Illeris, Sven and Leif Jakobsen (Eds). Networks and Regional Development. Copenhagen: University Press Copenhagen, 1990.

Christopherson, S. "Flexibility in the US service economy and the emerging spatial division of labor". Transactions of the Institute of British Geographers 14, 1989: 131 - 143.

Cohen, Robert B. "The new spatial organization of the European and American automotive industries" in Noulart and Wilson Salinas (Eds). Regional analysis and the new international division of labor, 1983.

Cooke, P. and R. Imrie. "Little victories: local economic development in European regions". Entrepreneurship and Regional Development 1, 1989: 313 - 327.

Cooke, P. and K. Morgan. Industry training and technology transfer: the Baden Wurttemburg system in perspective. Regional Industrial Research Report, N. 6, P. O. Box 906, Cardiff. CF 1, 3YN.

Cusumano, M. A. The Japanese automobile industry. Cambridge, MA: Harvard East Asian Monographs 122. The Harvard University Press, 1989.

Debbage, K. and J. Rees. "Company perceptions of comparative advantage by region". Regional Studies 25 (1991): 199 - 206.

Denison, Edward and William K. Chung. "Economic growth and its sources" in Patrick, Hugh and Henry Rosovsky (Eds). Asia's new giant. Washington, D. C.: The Brookings Institution, 1976.

Dertouzos, Michael L.; Richard K. Lester, and Robert M. Solow. Made in America. New York: Harper Perennial, 1989.

Dicken, P. "Europe 1992 and strategic change in the international automobile industry". Environment and Planning A 24, 1992: 11 - 31.

Dicken, P. "Transnational corporations and the UK automobile industry". Working Paper 18, North West Industry Research Unit, School of Geography, University of Manchester, Manchester, 1986.

Doshe, K., U. Jurgens and T. Malsch. "From Fordism to Toyotism? the social organization of the labor process in the Japanese automobile industry". Politics and Society 14.2, 1985: 115 - 146.

Doz, Y. L. Strategic management in Multinational Corporations. Oxford: Pergamon, 1986.

Drucker, Peter. The frontiers of management. Where tomorrow's decisions are being shaped today. New York: Truman Yalley Books, 1986.

Erickson, R.A. "Corporate organization and manufacturing branch plant closures in non-metropolitan areas." Regional Studies 14, 1980: 491-501.

Erickson, R. A. and T.R. Leinback. "Characteristics of branch plants attracted to non metropolitan areas" in Londslale, R. E. and H. L. Seyler (Eds). Nonmetropolitan industrialization. Washington, D.C.: Winston Wiley, 1979.

Estall, R. C. "Stock control in manufacturing: the just in time system and its location implications." Area 16.2, 1985: 129-133.

→Feast 1991 (p. 158).

Financial Times. "World automotive". July 14 192.

Fisher, Anne B. "Behind the hype of GM's Saturn". Fortune. November, 11, 1985: 34-42.

Florida, R. and M. Kenney. The breakthrough illusion: corporate America's failure to move from innovation to mass production. New York: Basic Books, 1990.

Florida, R. and M. Kenney. "Restructuring in place: Japanese investment, production organization, and the geography of steel". Economic Geography 68/2, 1992: 146-173.

Friedman, D. "Beyond the age of Ford: the strategic basis of the Japanese success in automobiles" in Zysman, J. and L. Tyson (Eds) American industry in international competition. Ithaca: Cornell University Press, 1983.

"GM Saturn won't fly so high." Business Week 17 Nov. 1986: 74.

"General Motors to shut 11 plants, 29,000 workers will be affected." New York Times 17 Nov. 1986: 1.

Gertler, M. S. "The limits to flexibility: comments on the post-Fordist vision of production and its geography". Transactions of the Institute of British Geographers 13, 1988: 419 - 432.

Gibbs, D. and T. Jenkins. "A new era of flexibility? Some evidence and problems from the petrochemicals industry". Environment and Planning A, 23, 1991: 1429 - 1445.

Glasmeier, A. and Richard E. McCluskey. "U.S. auto parts production: an analysis of the organization and location of a changing industry." Economic Geography 63, 1987: 142-159.

Goddard, J.B. "Technology forecasting in a spatial context". Futures, April 1980.

Goddard, J. B. and A. T. Thwaties. "Technological change and the inner city". The inner city in context series. Vol 4. London: Social Science Research Council, 1980.

Greenhut, Melvin. "The size and shape of the market area of a firm". 1952. Spatial Economic Theory. New York: The Free Press, 1970.

Greenhut, Melvin. "Integrating the leading theories of plant location". 1952. Spatial Economic Theory. New York: The Free Press, 1970.

Greenhut, Melvin et al. The economics of imperfect competition: a spatial approach. Cambridge, U.K.: Cambridge University Press, 1987.

Grunwald, J. and K. Flamm. The global factory. Washington, DC: Brookings Institution, 1985.

Hamilton, Ian F.E. and G.D.R. Linge. Spatial analysis, industry and the industrial environment. Vol 2. International industrial systems. Chichester: Wiley, 1981.

Harary, Frank. "Graph theory as a structural model in the social sciences" in Harris, Bernard (Ed). Graph theory and its applications. New York, 1970.

Harvey, D. and A. Scott. "The practice of human geography: theory and empirical specificity in the transition from Fordism to flexible accumulation" in MacMillan, W. D. (Ed). Remodeling geography. Oxford: Basil Blackwell, 1988: 217-229.

Hay, J. The just-in-time breakthrough. Implementing the new manufacturing basics. New York: John Wiley and Sons, 1988.

Healey, M.J. "Product changes in multiplant enterprises." Geoforum vol. 12, (1981): 359-370.

Healey, M.J. "Plant closures in multi-plant enterprises. The case of a declining industrial sector". Regional Studies vol. 16, (1982): 37-51.

Hepworth, Mark. "The geography of technological change in the information economy". Regional Studies vol. 20.5 (1986): 407-424.

Hewings, Jeffrey J.D. and Breandan O Huallachain. "Industrial factors in the development of regional systems". Industrial systems, spatial analysis and the industrial environment. Vol. 3. New York: John Wiley and Sons, 1983.

Hill, R. C. "Comparing transnational systems: the automobile industry in the US and Japan". International Journal of Urban and Regional Research 13, 1989: 462-480.

Hirsch, S. Location of industry and international competitiveness. Oxford: Clarendon, 1967.

Hoffman, K. and R. Kapinsky. Driving force: the global restructuring of technology, labor, and investment in the automobile and components industries. Boulder: Westview Press, 1988.

Holmes, J. "Industrial reorganization, capital restructuring and locational change: an analysis of the Canadian Automobile Industry in the 1960's." Economic Geography 59, 3, 1983: 251-271.

Holmes, J. "Technical change and the restructuring of the North American automobile industry" in Chapman, K. and G. Humphrys (Eds). Technical change and industrial policy. Oxford: Basil Blackwell, 1987.

Holmes, J. "The impact of new production technologies on the organization of labor in the North American automobile industry" in Linge, G. and G. A. van der Kamp (Eds). Labor, environment, and industrial change. London: Croom Helm, 1989.

Hotelling, Harold. "Stability in Competition.". 1929. In Spatial Economic Theory. New York: The Free Press, 1970.

Hounshell, David. From the American system to mass production, 1800-1932. Baltimore: John Hopkins University Press, 1978.

Hudson, R. and D. Sadler. The international steel industry: restructuring, state policies and localities. London: Rouletge, 1989.

Im, Jin H. "How does Kanban work in American companies?." Production and Inventory Management 30, 4 (1989): 22-24.

Imai, Masaaki. Kaizen. La clave de la ventaja competitiva japonesa. Mexico, DF: Compañía Editorial Continental S.A., 1989.

Ironmonger, Duncan. "A conceptual framework for modelling the role of technological change". The trouble with technology. Explorations in the process of technological change. Stuart Macdonald, D.McL. Lamberton, and Thomas Mandeville (Eds). New York: St. Martin's Press, 1983.

Isard, Walter. "Distance inputs and space economy: the locational equilibrium of the firm." 1951. In Spatial economic theory. New York: The Free Press, 1970.

Jaikumar, Ramchandran. "Postindustrial manufacturing." Harvard Business Review 6 (1986): 69-76.

Johanson, B. "Economic networks and self organization" in Bergman, E., G. Maier, and F. Tödtling (Eds). Regions reconsidered: economic networks, innovation and local development in industrialized countries. London: Casell, 1991: 17 - 34.

Johanson, Börje and Charlie Karlson. "Process of industrial change: scale, location, and type of job". CERUM, Umea University, Working paper 1986:5.

Johnson, Jeffrey. "The mathematics of complex systems" in Johnson, J. H. and M. J. Loomes (Eds). The mathematical revolution inspired by computing. Oxford: The Institute of Mathematics and its Applications. Oxford University Press, 1991: 165-186.

Jones, Philip N. and John North. "Japanese motor industry transplants: the West European dimension". Economic Geography, 67, 2 (1991): 105 - 123.

Karaska, Gerald L. and David F. Bramhall. Locational analysis for manufacturing. A selection of readings. The regional science studies series, No.6. Cambridge, MA: The M.I.T. Press, 1975.

Keeble, D. E. "Industrial movement and regional development in the United Kingdom". Tn. Plann. Rev. 43, 1972: 3 - 25.

Krugman, Paul. Geography and trade. Cambridge, MA: The MIT Press, 1991.

Lakshmanan, T. R. "Knowledge technologies and networks and economic change". Paper prepared for presentation at the 28th European Science Congress. Stockholm, Sweden, August 1988.

Lampe, David R. (Ed). The Massachusetts miracle. High technology and economic revitalization. Cambridge, MA: The M.I.T. Press, 1988.

Law, C. M. Restructuring the global automobile industry. London: Rouletge, 1991.

Lee, Sang M.; G. L. Moeller and L.A. Digman. Network analysis for management decisions. Boston, 1982.

Linge, G.J.R. "Just-in-Time: more or less flexible". Economic Geography (1991): 316 - 332.

Lösch, August. The economics of location. 1929. Westford: Yale University Press, 1954.

Lynn, Leonard H. How Japan innovates. Boulder, CO: Westview Press, 1982.

Mair, A. "Just-in-Time manufacturing and the spatial structure of the automobile industry". Working Paper 3, Department of Geography, University of Durham, DH 1, 3LE, 1991a.

Mair, A. "The Just-in-Time strategy for local economic development". Working Paper 4, Department of Geography, University of Durham, DH 1, 3LE, 1991b.

Mair, Andrew, R. Florida, and M. Kenney. "The new geography of automobile production: Japanese transplants in North America." Economic Geography 64, 1988: 352-373.

Malecki, Edward J. "Technological change: British and American research themes". Area 12, 1980: 253 - 259.

Mandeville, Thomas and Stuart Macdonald. "Information technology and employment levels". The trouble with technology. Explorations in the process of technological change. Macdonald, Stuart, D.; McL. Lamberton, and Thomas Mandeville. New York: St. Martin's Press, 1983.

Massey, D. "Towards a critique of industrial location theory". Antipode 5, 1973: 33-39.

Massey, D. "A critical evaluation of industrial location theory" in Hamilton, F. E. I. and G. Linge (Eds). Spatial analysis, industry and the industrial environment. London: Wiley, 1979.

Massey, D. Spatial divisions of labor. London: Macmillan, 1984.

Massey, D. and R. Meegan. "The geography of industrial reorganization: the spatial effects of the restructuring of the electrical engineering sector under the industrial reorganization corporation." Progress in Planning 10 (1979).

Massey, D. and R. Meegan. The anatomy of job lost. London: Methuen, 1982.

MacLachlan, Ian. "Plant closures and market dynamics: competitive strategy and rationalization". Economic Geography 68/2, 1992: 128 - 145.

Monden, Yasuhiro. El sistema de producción Toyota. Barcelona: Price Waterhouse - IESE, 1984.

Moran, T. H. "Foreign expansion as an institutional necessity for US corporate capitalism" in Mack, A. and U. Doyle (Eds). Imperialism, Intervention and economic development. London: Croom Helm, 1979.

Morris, J. L. "New technologies, flexible work practices and regional socio-spatial differentiation: some observations from the UK". Environment and Planning D: Society and Space 6, 1988: 301 - 319.

Moses, Leon N. "Location and the theory of production." 1958. In Spatial economic theory. New York: The Free Press, 1970.

"New GM plant site linked to shifts in population." New York Times 31 July 1985: 6.

Nissan Motor Ibérica. Nissan Motor Ibérica. Desde 1920. Pioneros de la automoción. Barcelona: Nissan Motor Ibérica, 1990.

Nicholson, Walter. Microeconomic theory. Hinsdale, ILL: The Dryden Press, 1978.

NUMMI (New United Motor Manufacturing Incorporated). General Motors and Toyota. Text of the video explaining how the system works, 1988.

OhUallacháin, Breandán. "Industrial geography". Progress in human geography. 15/1, 1991: 73 - 80.

OhUallacháin, Breandán. "Industrial geography". Progress in human geography. 16/4, 1992: 545 - 552.

Ohkawa, Kazuski, and Henry Rosovsky. Japanese economic growth. Standford, CA: Standford University Press, 1973.

Oliver, N. and B. Wilkenson. The Japanization of British industry. Oxford: Basil Blackwell, 1988.

Open University Press, The. Graphs, networks and design. Milton Keynes, Great Britain: The Open University Press, Walton Hall, Milton Keynes, 1991.

Osleeb, Jeffrey P. and Samuel J. Ratick. "A dynamic location-allocation model for evaluating the spatial impacts for just-in-time planning." Geographical Analysis 22/1 Jan. (1990).

Ottati, Gabi Dei. "Prato 1944-1963. Reconstruction and transformation of a local system production". Unpublished material. 1988.

Peck, Merton and Shuyi Tamura. "Technology" in Patrick, Hugh and Henry Rosovsky (Eds). Asia's new giant. Washington, D. C.: The Brookings Institution, 1976.

Perroux, F. "Economic space: theory and applications". Quarterly Journal of Economics 64, 1950: 89 - 104.

Piore, Michael. "Perspectives on labor market flexibility". Industrial Relations 25, 1986: 146 - 166.

Piore, Michael J. and Charles Sabel. The second industrial divide. New York: Basics Books Inc, 1984.

Porter, Michael E. The competitive advantage of nations. New York: The Free Press, Macmillan, Inc. 1990.

Pred, A. R. "Behavior and location: foundation of a geographic and dynamic location theory. Part 1." Lund Studies in Geography Series B 27, 1967.

Pred, A. R. "Behavior and location: foundation of a geographic and dynamic location theory. Part 2." Lund Studies in Geography Series B 28, 1969.

Rees, John and Howard Stafford. "Theories of regional growth and industrial location: their relevance for understanding high-technology complexes." In Technology, regions and policy. New Jersey: Rowan and Littelfield, 1986.

Rotwell, Roy. "The role of technology in industrial change: implications for regional policy." Regional Studies 16 No. 5, 1982: 361-369.

Rubenstein, J. M. "Changing distribution of the American Automobile Industry." Geographical Review 76, 1986: 288-300.

Rubenstein, J. M. "Changing distribution of American motor vehicle parts suppliers". Geographical Review 78, 1988: 288 - 298.

Sabel, Charles. "The re-emergence of regional economies". Unpublished material. December 1986.

Sabel, Charles. "Flexible specialization and the re-emergence of regional economics" in Hirst, P. and J. Zeitlin (Eds). Reversing industrial decline. Oxford: Berg, 1989: 17 - 70.

Sayer, A. "Explanation in economic geography". Progress in human geography 6, 1982: 68 - 88.

Sayer, A. "New developments in manufacturing: the Just-in-Time". Capital and class 30, 1986: 43 - 72.

Sayer, A. "Post-Fordism in question". International Journal of Urban and Regional Research 13, 1989: 666 - 693.

Schoenberger, E. "Technological and organizational change in automobile production: spatial implications." Regional Studies Spring (1987).

Schoenberger, E. "Thinking about flexibility: a response to Gertler". Transactions to the Institute of British Geographers 14, 1989: 98 - 108.

Scitowsky, Tibor. "Two concepts of external economies". The Journal of Political Economy, vol. LXII, 2, 62. Chicago, ILL: The University of Chicago Press, April 1954.

Scott, A. J. "Industrial organization and location: division of labor, the firm, and spatial process." Economic Geography 62 (1986): 215-231.

Scott, J. "The technopoles of Southern California". Environment and Planning A 22, 1990: 1575 - 1605.

Scott, J. "The Roekpe lecture in economic geography. The collective order of flexible production agglomerations: lessons for local economic development policy and strategic choice". Economic Geography 68/3, 1992: 219 - 233.

Sheard, P. "Auto-production systems in Japan: organizational and locational features." Australian Geographical Studies 21 (1983).

Sinclair, S. The world car: the future of the automobile industry. London: Economitor, 1983.

Sola Sola, Joaquim. La industria a Catalunya. Industria de l'automoció. Barcelona: Generalitat de Catalunya. Departament d'Industria i Energia, 1990.

Storper, M. and A. J. Scott. "The geographical foundations and social regulation of flexible production complexes" in Wolch, J. and M. Dear (Eds). The power of geography: how territory shapes social life. London: Unwin Hyman, 1989: 21 - 40.

Storper, Michael and Richard Walker. The capitalist imperative. Territory, technology, and industrial growth. New York: Basil Blackwell Inc., 1989.

Stout. D.K. "Technical advance and trade advantage". The trouble with technology. Explorations in the process of technological change. Stuart Macdonald, D. McL. Lamberton, and Thomas Mandeville. New York: St. Martin's Press, 1983.

Sugimori, Y., K. Kusunoki, F. Cho, and S. Uchikawa. "Toyota production system and Kanban system materialization of JIT and respect-for-human system" in International Journal Production Research 15, 1977: 553 - 564.

Teubal, M. "The accumulation of intangibles by high-technology firms". The trouble with technology. Explorations in the process of technological change. Stuart Macdonald, D. McL. Lamberton, and Thomas Mandeville. New York: St. Martin's Press.

Thomas, M. D. "Growth and change and the innovative firm". Geoforum 12, 1981: 1-17.

Thomas, F., F. Uribe-Echevarria and H. Romijn. Small-scale production: strategies for industrial restructuring. London: Intermediate Technology Publications, 1991.

Tighe, C. "Nissan favours north-east suppliers". Financial Times 4 July 1991.

Tödtling, F. "Technological change at the regional level: the role of location, firm structure, and strategy". Environment and Planning A, 24 (1992): 1565 - 1584.

Twaities, A. T. "Technological change, mobile plants, and regional development". Regional Studies 12, 1978: 445 - 462.

"U.S. auto makers reshape for world competition." Business Week 12 June 1982.

Vernon, R. "International investment and international trade in the product cycle". Quarterly Journal of Economics 80, 1966: 190 - 207.

Vogel, Ezra F. The four little dragons. The spread of industrialization in East Asia. Cambridge, MA: Harvard University Press, 1991.

Von Hippel, Eric. The sources of innovation. New York: Oxford University Press, 1988.

Walker, R. "A requiem for corporate geography: new directions in industrial organization, the production of place and uneven development". Geographiska Annaler 71 B, 1989: 43 - 68.

Ward, M.F. "Political economy, industrial location and the European motor car industry in the postwar period." Regional Studies 16, 1982.

Weber, Alfred. Theory of the location of industries. New York: Rusell and Rusell, 1929.

Wells, P. and M. Rawlinson. "New procurement regimes and the spatial distribution of suppliers: the case of Ford in Europe". Area 24/4, 1992: 380 - 390.

Womack, James P., Daniel T. Jones and Daniel Roos. The machine that changed the world. New York: Rawson Associates division of McMillan Inc, 1990.

APPENDIX A Industry groups according to the International Standard Classification Code

Group	Industry title
37	TRANSPORTATION EQUIPMENT
371	Motor Vehicles and equipment
3711	Motor Vehicles
3714	Motor Vehicle parts and accessories
3715	Truck trailers
3713	Truck and bus bodies
3716	Motor homes
3465	Automotive stampings
3592	Carburators, pistons, rings, valves
3647	Vehicular lighting equipment
3691	Storage bateries
3694	Engine electrical equipment

APPENDIX B Structured interview

Firm name:
Date of interview:

1. Classification of components by number of firms

	Number of firms supplying the assembly plant			
	1975	1980	1985	1990
1 Components of the suspension, steering, brakes and transmission syst.				
2 Plastics, harness and noise insulation				
3 Forging and stamping components				
4 Electric components and devices				
5 Tire ring and rubber tire				
6 Spare parts				
7 Laminated components				
8 Mechanized and foundry components				
9 Paints, varnish and resins				
10 Elements of the cabin				
11 Engine parts and thermic systems				
12 Rubber				

2. Classification of components by location of production and distribution points (1) 1975, 1980, 1985, 1990

	Location of productn. point	Location of distributn. point	Mode of transporttn. (see list 1)	Value of the product US$/year	Relation with the supplier (note 2)
1 Components of the suspension, steering, brake and transmission syst.					
2 Plastics, harness and noise insulation					
3 Forging and stamping components					
4 Electric components and devices					
5 Tire ring and rubber tire					
6 Spare parts					
7 Laminated components					
8 Mechanized and foundry components					
9 Paints, varnish and resins					
10 Elements of the cabin					
11 Engine parts and thermic systems					
12 Rubber					

(1) In case of more than one supplier, please, write it down in different forms.

(2) Relation of the assembly firm with the supplier: 1) subsidiary firm; 2) independent firm.

3. Classification of components by type of distribution 1975, 1980, 1985, 1990

	Type of distributn. (see list 2)	Managed by (see list 3)	Frequency of distribution (see list 4)	Length of time of distributn.	Length of time of the contract
1 Components of the suspension, steering, brake and transmission system					
2 Plastics, harness and noise insulation					
3 Forging and stamping components					
4 Electric components and devices					
5 Tire ring and rubber tire					
6 Spare parts					
7 Laminated components					
8 Mechanized and foundry components					
9 Paints, varnish and resins					
10 Elements of the cabin					
11 Engine parts and thermic systems					
12 Rubber					

4. Skills of the labor force, schooling qualification

Schooling qualification	1975 No.	% of the labor force	1980 No.	% of the labor force	1985 No.	% of the labor force	1990 No.	% of the labor force
A) Higher education:								
Graduated Engineers								
Other Graduated (Master)								
Technical Engineers								
Bachelors								
B) Secondary education:								
F.P. 1st grade								
F.P. 2nd grade								
C) Primary education:								
E.G.B.								
Average seniority								
Average age								

5. Skills of the labor force. Trainning, number of courses

	1975	1980	1985	1990
Number of courses				
Number of trainning hours				

6. Work organization

	1975	1980	1985	1990
% of the labor force working on teams				
% of the engineers working on manufacturing teams				
Do you have FMS (1) installed in your factory?				
Number of CNC (2) machines				
% of the CNC machines				
% of the engineers trained on CNC machines				

(1) An FMS is a computer-controlled grouping of semi-independent work stations linked by automated material-handling systems. All activities in the system are under precise computer control.

(2) Computer numerically controlled machines.

7. R&D

	1975 Percent	1980 Percent	1985 Percent	1990 Percent
Assembly. R&D is done: 1. By the assembly firm 2. By other firm				
Parts and components. R&D is done: 1. By the assembly firm 2. By the component firm 3. By other firm 4. Other type of arrangement. Please specify				

LIST 1

Means of transportation:

1. By truck
2. By rail
3. By plain
4. By ship
5. Others. Please specify

LIST 2

Classification of components by type of distribution:

1. Component's external warehouse: outside assembly factory walls[46]
2. Component's internal warehouse: inside assembly factory walls
3. Synchro: direct external deliveries to the assembly line in sequential form
4. Milk-Run: a pick up components system, with pre-established paths
5. Others. Please specify

LIST 3

Managed by:

1. The assembly firm
2. The component firm
3. Other type of arrangements. Please specify

LIST 4

Frequency:

1. Daily deliveries = D
2. Weekly deliveries = W
3. Monthly deliveries = M

46 Factory wall means the complete area in which the factory is located. For example, a component warehouse could be a internal warehouse, but be located outside of the assembly plant.

APPENDIX C

European and Spanish passenger car exports by country of destination, selected countries, 1980-1984, 1986-1989, Thousand units

Year	France	Germany	Greece	Italy	Portug.	Switz.	UK	Total Eur.	Total World	% exports Europe/rest of the world
1980	159.0	52.3	1.1	128.7	15.2	1.3	63.4	443.0	470.2	94.2
1981	140.5	54.9	2.7	70.6	27.0	2.5	61.5	387.0	413.5	93.6
1982	229.1	34.1	0.5	93.1	32.1	0.9	46.3	459.5	490.4	93.7
1983	224.2	96.5	1.2	81.2	19.2	6.3	64.1	573.0	613.1	93.5
1984	252.2	100.5	2.0	108.7	11.5	6.2	99.8	676.2	707.7	95.6
1986	249.9	84.0	9.0	137.1	15.9	12.4	91.4	702.0	723.3	97.1
1987	263.1	97.4	5.9	144.7	27.0	9.9	100.1	732.0	754.5	97.0
1988	251.0	89.6	6.6	133.9	71.3	10.5	130.6	776.1	798.0	97.3
1989	325.3	94.1	11.1	202.0	69.2	14.0	123.2	927.4	950.0	97.6

Source: World Motor Vehicle Data, 1986, 1991.

APPENDIX D.a

Appendix D.a.1 Ford España costs, 1989. Thousand pesetas

Concept	Value	Percent
1 Labor costs	73316000	21.9
2 Materials cost	247096000	73.7
3 Tangible fixed assets depreciation cost	15070000	4.5
4 External services cost	0	0.0
TOTAL	335482000	100.0

Source: Ford España. Informe, 1989.

Appendix D.a.2 Ford España costs, 1990. Thousand pesetas

Concept	Value	Percent
1 Labor costs	36501000	10.4
2 Materials cost	252858000	72.3
3 Tangible fixed assets depreciation cost	20215000	5.8
4 External services cost	40018000	11.4
TOTAL	349592000	100.0

Source: Ford España. Informe, 1990.

APPENDIX D.b

Appendix D.b.1 General Motors España costs, 1988. Thousand pesetas

Concept	Value	Percent
1 Labor costs	25124237	7.6
2 Materials cost	244764221	73.9
3 Tangible fixed assets depreciation cost	26692201	8.1
4 External services cost	34821575	10.5
TOTAL	331402234	100.0

Source: General Motors España. Informe, 1988.

Appendix D.b.2 General Motors España costs, 1989. Thousand pesetas

Concept	Value	Percent
1 Labor costs	30105412	8.7
2 Materials cost	247347247	71.1
3 Tangible fixed assets depreciation cost	31346415	9.0
4 External services cost	38915740	11.2
TOTAL	347714814	100.0

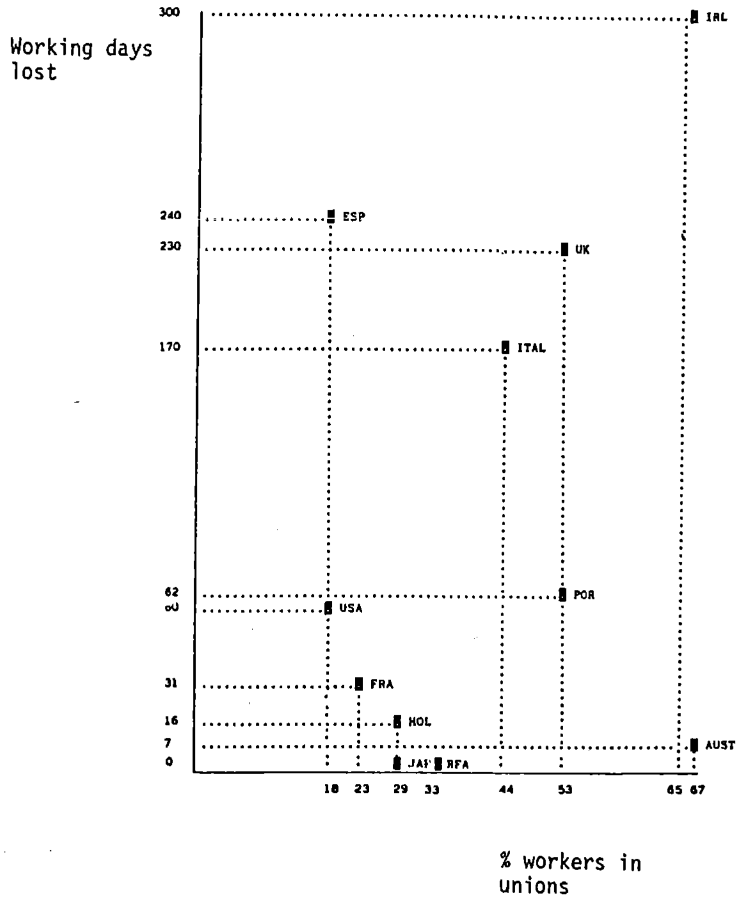
Source: General Motors España. Informe, 1989.

Appendix D.b.3 General Motors España costs, 1990. Thousand pesetas

Concept	Value	Percent
1 Labor costs	32735302	9.6
2 Materials cost	250186281	73.7
3 Tangible fixed assets depreciation cost	17134382	5.0
4 External services cost	39448312	11.6
TOTAL	339504277	100.0

Source: General Motors España. Informe, 1990.

APPENDIX E Working days lost due to labor conflict and number of workers in unions in several countries, 1987[47]



47 Source: Pallares Barbera, Montserrat. Economic factors and institutional incentives in industrial location. A comparative study for ten countries: Austria, France, Ireland, Italy, Netherlands, Portugal, Spain, Switzerland, UK, and West Germany. Barcelona: Barcelona's Development Agency. Consorcio de la Zona Franca, 1988.

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Master of Arts in Geography. Boston University. U.S.A., 1986

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PROFESSIONAL EXPERIENCE

1. Research projects:

Barcelona, megatrends 1990. Urbino Project. Barcelona: Institut d'Estudis Metropolitans, 1991. (With A. Casellas).

A locational study of a warehouse in the Barcelona's Metropolitan Area (Estudi de localització d'un magatzem de distribució a l'Area Metropolitana de Barcelona). Barcelona: Mercuri. Consultoria i Intermediació, S.L., 1991.

Housing and commuting habits of population in the Barcelona's Metropolitan Area (Estudis d'habitatge, mobilitat i imatge del territori a la Regió I. Enquesta Metropolitana 1990. Condicions de vida i hàbits de la població de l'Area Metropolitana de Barcelona). Barcelona: Institut d'Estudis Metropolitans, 1991. (With Pilar Riera).

Secondary housing of the Barcelona's Metropolitan Area population (La residencia secundària de la població de la ciutat de Barcelona i de la seva Area Metropolitana). Barcelona: Institut d'Estudis Metropolitans, 1991. (With Pilar Riera).

Housing and urban development of the Sant Cosme neighborhood, El Prat de Llobregat (Pla Integral d'Actuació del Barri de Sant Cosme, El Prat de Llobregat). Barcelona: INITS, S.A.L. Generalitat de Catalunya. Ajuntament del Prat de Llobregat, 1990.

A socio-economic study of Valldoreix (Sant Cugat) (Estudi socio-econòmic de l'Entitat Local Menor de Valldoreix (Sant Cugat del Vallès). Barcelona: PROMO S. A. Entitat Local Menor de Valldoreix, 1990.

The reform of the spanish primary education system. Effects on the established network of centers in Barcelona city (L'Efecte de la reforma del sistema educatiu sobre la xarxa escolar de la ciutat de Barcelona). Barcelona: Institut d'Estudis Metropolitans de Barcelona. Ajuntament de Barcelona, 1990 (with F. Colomé et al.).

The reform of the spanish primary education system. Effects on the established network of centers in the province of Barcelona (L'Efecte de la reforma del sistema educatiu sobre la xarxa escolar a la província de Barcelona). Barcelona: Institut d'Estudis Metropolitans de Barcelona. Diputació de Barcelona, 1989 (with F. Colomé et al.).

Commercial aspects of the Barcelona's industrial district (Aspectos comerciales del área industrial de Barcelona). Barcelona: Consorcio de la Zona Franca de Barcelona, 1989.

Feasibility of industrial zoning in Ciutadella de Menorca (Estudi de viabilititat de polígon industrial a Ciutadella de Menorca). Menorca: Ajuntament de Ciutadella de Menorca, 1989. (With A. Jové).

Economic factors and institutional incentives in industrial location. A comparative study for ten countries: Austria, France, Ireland, Italy, Netherlands, Portugal, Spain, Switzerland, United Kingdom, West Germany (Determinantes económicos e institucionales de la localización industrial. Un estudio comparativo para diez paises). Barcelona: Consorcio de la Zona Franca de Barcelona, 1988.

A profile of historic centers of Barcelona, Badalona, and Tortosa (Dictàmens sobre els cascs antics de Barcelona, Badalona i Tortosa). Barcelona: Generalitat de Catalunya. Direcció General d'Arquitectura i Habitatge, 1988.

Determination of the tourist area for housing purposes in the coast of Catalonia (La delimitació de Zona Costanera per motius d'habitatge a Catalunya). Barcelona: Generalitat de Catalunya. Direcció General d'Arquitectura i Habitatge, 1988.

Housing behavior of young married couples in Barcelona and Metropolitan Area, 1981-1987 (Joves matrimonis i habitatge a l'ambit de Barcelona i la seva Area Metropolitana. 1981-1987). Barcelona: Generalitat de Catalunya. Direcció General d'Arquitectura i Habitatge, 1988. (With A. Jové and M.A. Caselles).

Factors of industrial attraction of the city of Melilla. Justification for the promotion of an industrial area (Melilla y su atractivo industrial: bases para la promoción de un polígono industrial). Madrid: Sociedad Estatal de Promoción y Equipamiento del Suelo, 1988. (With A. Jové et al.).

Legal associations of urban housing owners in Europe and United States (La representación de la propiedad urbana en Europa y los Estados Unidos). Madrid: Ministerio de Economia y Hacienda. Centro de Gestión Catastral y Cooperación Tributaria, 1987. (With A. Jové et al.).

Organization of the housing system in Catalonia. An economic analysis (Estudis previs al Plà d'Habitatge a Catalunya. Anàlisi de mercat). Barcelona: Generalitat

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The urban planning and zoning of the city of Rubi (Pla General d'Ordenació Urbana de Rubí). Rubí: Ajuntament de Rubí, 1978-1980. Project director: Professor Manuel Torres Capell. Universitat Politècnica de Barcelona.

The urban planning and zoning of the city of Granollers (Pla General d'Ordenació Urbana de Granollers). Granollers: Ajuntament de Granollers, 1978-1980. Project director: Professor Manuel Torres Capell. Universitat Politècnica de Barcelona.

2. Professional positions:

Project Director. Institut d'Estudis Metropolitans de Barcelona. Project: Secondary housing of the Barcelona's Metropolitan Area population, 1991.

Researcher. Centre Internacional d'Estudis Urbans. Project: World network of cities. Preliminary studies, 1990.

Project Researcher. Institut d'Estudis Metropolitans de Barcelona. Projects:

Housing and commuting habits of population in the Barcelona's Metropolitan Area., 1991.

The reform of the Spanish primary education system. Effects on the established network of centers in the city of Barcelona, 1990.

The reform of the Spanish primary education system. Effects on the established network of centers in the province of Barcelona, 1990.

Project Research Coordinator. Institut d'Estudis Metropolitans de Barcelona. Project: Ten years of democratic local governments in Catalonia. 1979-1989 (Deu anys d'ajuntaments democràtics. 1979-1989), 1989.

Project Research Coordinator. Harvard University. Energy and Environmental Policy Center. Project: Study of air-pollution related problems in Spain. Joint project Harvard University-Unidad Eléctrica S.A., June-July, 1985 and 1986.

Research Assistant. Boston University. Department of Geography. Professor: Chi Ho Sham. Project: Assessing the transport of ozone in New England, June-August, 1985.

Urban Planning Technician. Ajuntament de Rubí. Personal advisor of the Mayor on issues concerning the implementation of Rubí's urban planning and zoning, September 1980-September 1982.

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Research Assistant. Boston University. Metropolitan College. Professor: Lata Chatterjee. Course: Urban Research Methods , January-May, 1987.

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PUBLICATIONS

Colomé, Francesc et al. **L'efecte de la reforma del sistema educatiu sobre la xarxa escolar a la província de Barcelona.** Barcelona: Institut d'Estudis Metropolitans de Barcelona. Diputació de Barcelona, 1990.

Jové Armengol, A. et al. **La representación de la propiedad urbana en Europa y los Estados Unidos.** Madrid: Ministerio de Economía y Hacienda. Centro de Gestión Catastral y Cooperación Tributaria, 1988.

Nel.lo Colom, Oriol et al. **Deu anys d'ajuntaments democràtics, 1979-1989. Elements per a un balanç.** Barcelona: Institut d'Estudis Metropolitans de Barcelona. Federació de Municipis de Catalunya. Generalitat de Catalunya. Departament de Governació. Direcció General d'Administració Local., 1989.

Pallarès Barberà, Montserrat. **Determinantes económicos e institucionales de la localización industrial. Un estudio comparativo para diez paises: Austria, Francia, Irlanda, Italia, Holanda, Portugal, España, Suiza, Reino Unido, Alemania.** Barcelona: Consorcio de la Zona Franca de Barcelona, 1988.

MASTER PAPER

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HONORS AND AWARDS

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Graduate Fellowship. Boston University. College of Liberal Arts, June-August 1985.
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