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TRANSACTION COST THEORY AND JUST-IN-TIME MANUFACTURING - A NEW LOOK AT VERTICAL INTEGRATION IN THE U.S. AUTOMOBILE INDUSTRY

By

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ABSTRACT

TRANSACTION COST THEORY AND JUST-IN-TIME MANUFACTURING - A NEW LOOK AT VERTICAL INTEGRATION IN THE U.S. AUTOMOBILE INDUSTRY

By

Thomas Helmut Klier

The introduction of the just-in-time manufacturing system has led to widespread changes in the organization of production in the U.S. manufacturing sector. A central aspect of this production system is the organization of vertical relationships; long-term relationships between fairly autonomous but mutually dependent partners.

This study focuses on one aspect of the change in manufacturing systems; it tests for effects of the introduction of just-in-time manufacturing on the decision to vertically integrate. It is argued that the new manufacturing system is characterized by a high degree of mutual commitment between up- and downstream firms, leading to the formation of market-based vertical relationships. Transaction cost theory provides the framework for the analysis of this question. The automobile industry is the focus of this study since it is there that the new manufacturing system has had its largest impact to date. The empirical analysis utilizes a new data set which was obtained directly from the Big Three U.S. automobile manufacturers by means of a questionnaire.

In testing for the effects of just-in-time manufacturing, a binomial qualitative choice model is estimated which represents the choice between the two governance structures 'make' and 'buy'. In addition, an ordered probit model is estimated which

allows to distinguish an intermediate category, quasi-integration, as a separate form of governance structure.

The results support the hypothesis that the arrival of just-in-time manufacturing influences the decision to vertically integrate. The degree of mutual commitment is consistently found to be a significant determinant of governance structure. The presence of high degrees of mutual commitment, typical for just-in-time manufacturing, strengthens the ability to enforce contractual agreements by making hold-up threats less credible. In doing so, it increases the self-enforcing range of contracts.

Like other work on the issue of industrial relations and plant productivity, this study finds evidence for changes brought about by the introduction of just-in-time manufacturing. It links characteristics of the new manufacturing system to the organization of the firm.

"Non scholae sed vitae discimus."

Gewidmet meinen Eltern

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INTRODUCTION

"Manufacturing is undergoing a revolution. The mass production model is being replaced by a vision of a flexible multiproduct firm that emphasizes quality and speedy response to market conditions while utilizing technologically advanced equipment and new forms of organization"(Milgrom and Roberts 1990). The introduction of this new manufacturing paradigm, which is being referred to as the just-in-time manufacturing system, has led to widespread changes in the organization of production in the U.S. manufacturing sector (see Milgrom and Roberts 1990 for a plethora of examples and references).

This study focuses on the consequences of the introduction of just-in-time manufacturing for the decision to vertically integrate. Based on the framework of transaction cost theory I explore whether and how the introduction of the new manufacturing system affected the determinants of vertical integration. Effects of manufacturing on the structure of the firm are typically not analyzed in the industrial organization literature. That is probably related to the low frequency with which paradigm shifts in manufacturing occur.

The introduction of just-in-time manufacturing techniques raises important questions. How did the introduction of just-in-time manufacturing influence the determinant of vertical integration? Does it affect the comparative assessment of markets and hierarchies, and thereby the choice of governance structure? How well can standard asset specificity arguments, put forward by transaction cost theory, explain the structure of vertical integration after the introduction of just-in-time manufacturing? It is my goal to test for the effects of the introduction of just-in-time manufacturing on the determinants of vertical integration. A better understanding of the underlying relationship between manufacturing technologies and industrial structure will be essential in analyzing and understanding the adjustments and changes currently taking place in the manufacturing sector.

This study focuses on the possible effects of just-in-time manufacturing on the structure of vertical relationships. That inquiry, however, is related to a set of more general questions pertaining to the entire manufacturing sector, domestic and international. A change in the structure of vertical relationships, as a result of the application of new manufacturing techniques, is expected to influence the competitiveness of individual companies as well as that of entire industries. Given real effects of the new manufacturing system, lack of understanding of these can result in competitive disadvantages. Federal, state, and local policies directed at industrial development need to take into account the characteristics of just-in-time manufacturing; in particular effects on the structure of industries and firms, effects on location decisions, the demand for labor, and infrastructure needs.

An empirical analysis of the possible effects of just-in-time manufacturing on the determinants of vertical integration requires data that reflect the impact of the new manufacturing system. Only then can the influence of just-in-time manufacturing be investigated. In order to do that a new data set was obtained directly from three U.S. automobile manufacturers.

In testing for the effects of the introduction of just-in-time manufacturing I will first employ a binomial qualitative choice model; in the context of this study it represents the choice between the two governance structures 'make' and 'buy'. That enables me to compare my results to what earlier studies, done prior to the introduction of the new manufacturing system, have found.

Analyses of the just-in-time manufacturing system suggest that it requires a new kind of relationship between the upstream and downstream firm (see for example Aoki 1988; Milgrom and Roberts 1990, p.515). First, there is a need for frequent exchange of information between the assembler and the supplier both during development and production of a part or component. Second, unless the supplier decides to carry a large amount of inventory for the assembler, introduction of just-in-time manufacturing at the downstream customer requires similar changes in the organization of production at the upstream supplier. In order to meet these requirements, both parties need a long-term mutual commitment to their relationship.

To further investigate the effects of the new manufacturing system on the determinants of vertical integration, I also account for three different types of vertical relationships: 'no integration', quasi-integration, and vertical integration. The category 'no integration' corresponds to pure contractual relations across the market that do not involve ownership of assets used in production. Quasi-integration is defined as an intermediate type of vertical relationship. It refers to the situation where a downstream firm, e.g. Chrysler, owns the specialized tools and dies used by its otherwise independent supplier in the production of a particular part or component. Quasi-integration differs from full vertical integration in that the downstream firm still contracts with a supplier for the actual manufacture of the component, whereas with full vertical integration the production process itself is internalized (see Monteverde and Teece 1982b). It has been known to exist in the U.S. for a long time (see Helper 1987, p.IV-19, and Masten 1989). Distinguishing three categories in the dependent variable, I estimate both an ordered probit model and a sequential binomial probit model of the choice of governance structure. Based on the results one might be able to answer the question if the governance structure chosen in a three-way comparison, or in a two-stage choice that first decides on governance structure and then on the issue of ownership of particular assets.

Since its introduction by Toyota in the 1950s, just-in-time manufacturing has had the biggest impact in the automobile industry. On the basis of this new manufacturing paradigm, the Japanese automobile manufacturers enjoyed a global competitive advantage during the 1980's (Scherrer 1991, 214-216). In reaction to their deteriorating market position, U.S. automobile manufacturers introduced the new manufacturing techniques into North America. As a result, Ford workers at the auto manufacturer's best U.S. plants today match Toyota's average efficiency in the United States (New York Times May 5 1992, A1). It is for the relatively quick introduction of the new manufacturing paradigm that this study focuses on the U.S. auto industry in order to test for effects of just-in-time manufacturing on the structure of vertical integration. Nevertheless, the ramifications of this analysis are not limited to this particular industry. The principles of just-in-time manufacturing apply "everywhere; virtually every U.S. manufacturer is trying some elements of the Toyota system" (New York Times May 5 1992, A1).[1]

During the last 20 years Japanese auto manufacturers have been remarkably successful in non-Japanese markets. In 1970, Japanese imports represented 4.2 percent of the U.S. auto market (Altshuler et al. 1984, 25). In September 1991 their market share (calculated as imports from Japan plus North-American transplant production) had increased to 30.2 percent (Ward's Automotive Yearbook 1992, p.22). That number does not include Japanese cars made for and sold under U.S. nameplates; in 1991 these cars accounted for an additional 5.8 percent. Most remarkable has been the success of the Japanese auto manufacturing operations located in North America, the so-called transplants [see Table 1]. It was not until 1982 that Honda of America began to assemble automobiles in Marysville, Ohio. Less than 10 years later, during the first nine months of 1991, seven Japanese transplants produced 25 percent of all passenger cars built in the United States (Magnusson et al. 1991).[2] By the mid-90s the combined transplant production will be at about 2.5 million cars (Miller and Winter 1991). These transplants were able to replicate quality and efficiency levels of auto plants in Japan (see Womack et al. 1990). Consequently, the transplant share of sales and production in the U.S. market has increased noticeably [see Tables 2 and 3]. In 1990, 39 percent of the Japanese-

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[1]Hollingsworth (1991) specifically refers to the automotive, consumer and durable electronic goods, metal products, aircraft, aerospace, and computer industries.

[2]Four transplants operate in Canada; their combined production capacity reaches 431,000 cars (Herzenberg 1991, Table 19). In addition, about 250 Japanese-owned parts firms operate in the U.S. (Wall Street Journal May 14 1991, A1).

nameplate vehicles sold in the U.S. were built in North America, up from just 9 percent in 1986 (Magnusson et al. 1991).[3]

The tremendous success of the Japanese transplants in North America has shown that the differences in the organization of production between Japanese and U.S. car manufacturing companies are not entirely due to cultural factors and that the just-in-time manufacturing system can be transferred to North America.[4] It also seems to corroborate the argument that just-in-time manufacturing is more efficient than the classic Fordist system; the term Fordism refers to the traditional system of mass production prevalent in North America and Europe (see Chapter I). A plethora of industrial engineering studies has compared the productivity of the American and Japanese manufacturing systems by studying automobile plants in both countries; in general they find the Japanese approach to be more efficient.[5] However, for these studies to be meaningful, differences in product mix, degree of vertical integration, the capital-labor ratio, and capacity utilization across

[3]This trend can of course also be observed at the level of the individual companies. Honda, the first Japanese company to set up a production operation in the U.S. sold 855,000 cars in the U.S. in 1990; 54.3 percent of these cars were produced in the U.S. (Miller and Winter 1991, 28-37).

[4]See for example Williamson (1985, 122), who seems to suggest otherwise.

[5]Aoki (1988) reviews this literature. He lists a series of 'accounting studies' whose goal it is to come up with an estimate of the production cost advantage of a Japanese car assembler; see for example Cole and Yakushiji (1984, Chapter 7) and most recently Womack et al. (1990). They report the following weighted averages of plant productivity: in a Japanese-owned plant in Japan it takes 16.8 hours to build a vehicle; Japanese transplants in North America take 20.9 hours; and U.S. plants take 24.9 hours. The six Japanese transplants studied achieved quality levels five percent below Japanese plants and about 30 percent better than the average for 42 Big Three assembly plants; quality was defined as defects per 100 cars traceable to the assembly plant as reported by the owner in the first three months of use.

TABLE 1 **U.S. transplant motor vehicle assembly plants**

Company	Plant Location	Launch Date	1991 Capacity [in 1000]	1991 Production [in 1000]
Honda	Marysville, OH	1982	360	451
	East Liberty, OH	1989	150	
Nissan	Smyrna, TN	1983	250	134
Toyota	Georgetown, KY	1988	218	188
GM-Toyota [NUMMI]	Fremont, CA	1984	240	207
Chrysler-Mitsub. [DIAMOND-STAR]	Normal, IL	1988	240	154
Mazda	Flat Rock, MI	1987	240	165
Ford-Nissan	Avon Lake, OH	1992	135 in'93	N.A.
Isuzu-Fuji [Subaru-Isuzu Automotive]	Lafayette, IN	1989	120	58
Total			1,818	1,357

- Data source: Miller and Winter 1991; Ward's Automotive Yearbook 1990 and 1992
- Capacity measured as straight-time assembly capacity; Nissan, Ford-Nissan, Subaru-Isuzu capacity includes cars, trucks and vans; all other capacity is cars.
- Honda and Toyota also manufacture engines in the U.S.; Honda's 1991 capacity is 500,000, Toyota's is 300,000.

TABLE 2 **Market shares - U.S. new car sales**

	1991	1990	1989	1988	1987	1986
Big Three*	52.2	58.9	63.5	64.9	63.6	67.0
Transplants	17.8	15.2	7.9	6.0	5.3	4.7
Imports	24.9	25.8	28.5	29.1	31.1	28.3

Source: Ward's Automotive Yearbook 1990, p.18 and 1992, p.22; Miller and Winter 1991, p.28 * Big Three data do not include any captive transplant production

auto manufacturers need to be taken into account (see in particular Cusumano 1985, chapter 4).

A recent econometric study by Fuss and Waverman (1985) concludes that cost and efficiency differences between U.S. and Japanese car assemblers are in large part accounted for by differences in the level of capacity utilization. Once they adjust for that and incorporate a yen-dollar exchange rate that is adjusted for purchasing power, the authors find that the Japanese efficiency advantage in 1980 was at 5.2% of unit cost. In trying to explain this efficiency gap, Aoki and others focus on organizational differences

TABLE 3 **Japanese transplant car production in the U.S.**
[in 1000]

	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982
Honda	451.2	435.4	361.7	366.4	324.1	234.2	145.3	138.6	55.3	1.5
Nissan	133.5	95.8	115.6	109.9	117.3	65.1	43.8	--	--	--
Toyota	187.7	218.2	151.2	18.5	--	--	--	--	--	--
Mazda	165.3	184.4	216.2	167.2	4.2	--	--	--	--	--
Diamond-Star	153.9	148.4	90.7	2.4	--	--	--	--	--	--
NUMMI	206.6	205.3	192.2	130.0	187.4	205.8	64.6	--	--	--
Sub.Isuzu	57.9	32.5	2.6	--	--	--	--	--	--	--
Total	1,356	1,320	1,130.2	794.4	633.0	509.1	253.7	138.6	55.3	1.5
% of Big Three Prod.	33.2	27.7	19.8	12.6	9.9	7.0	3.3	1.9	0.9	0

Source: Ward's Automotive Yearbook 1992, p.16

between U.S. and Japanese car manufacturers.[6] Aoki (1988) suggests that the productivityadvantage of Japanese car assemblers can be explained by different methods of organizing and coordinating production that allow a speedier and more timely horizontal coordination between shops and a subsequent reduction in costly inventory. Eckard (1984) argues that the strategic use of quasi-integration by Japanese auto manufacturers represents an important source of their competitive advantage.

This project focuses on an empirical test of the possible effects of just-in-time manufacturing on the determinants of vertical integration. For that purpose a new data set was obtained directly from three U.S. automobile manufacturers.

The paper is organized as follows: Chapter I contrasts the two different manufacturing systems of interest in this study: the Fordist system and the just-in-time system. It focuses on the differences in assembler-supplier relationships within each manufacturing system. Furthermore, evidence is reported on how the arrival of JIT manufacturing effected sourcing relationships in the U.S. auto industry. In the remainder of the paper I analyze the influence of just-in-time manufacturing on the determinants of vertical integration within the framework of transaction cost theory. In Chapter II the empirical literature on transaction cost theory is reviewed. The theoretical framework and a hypothesis regarding the effect of the paradigm shift in the manufacturing system on the determinants of vertical integration are developed in Chapter III. The hypothesis is

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[6]"... it appears that it is in the organization of production itself that Japanese producers realize a significant share of their cost advantage compared with foreign competitors"(Schonberger 1982, 208).

tested with new data, specifically obtained for this project. Chapter IV describes the data set and discusses the results of the empirical tests. Summary and conclusions follow in Chapter V.

I. CHANGE IN THE MANUFACTURING PARADIGM: EVIDENCE FROM THE U.S. AUTOMOBILE INDUSTRY

By means of stylized facts this chapter introduces the two different manufacturing systems of interest in this study: the 'Fordist' paradigm, the dominant manufacturing system of mass production in North America from 1950 to 1980, and a new manufacturing paradigm, the so-called the just-in-time [JIT] paradigm that originated in Japan. The following analysis focuses on the relationship between assembler and supplier in each production system and, in particular, on changes in these relationships brought about by the introduction of JIT manufacturing techniques to the United States. The intention of this comparison is to introduce general differences between two manufacturing systems rather than to give an accurate description of a particular existing production system. The point of this exercise is to set the stage for an exploration of the theoretical implications of JIT manufacturing techniques for the structure of vertical relationships.[1] Examples used in this chapter refer to the automobile industry; the scope of the analysis, however, is not limited to this particular industry.

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[1]It is beyond the scope of this study to discuss the historical development of manufacturing systems; on that topic see: Abernathy 1978; Carlsson 1984; Cusumano 1988; Helper 1990.

The manufacture of automobiles is a complex undertaking. From the original market assessment to the launch of a new product it can take anywhere between 7.5 to 15 years (MIT Commission 1989, 29). One important aspect of this process is the planning and execution of the actual assembly of an automobile. I first introduce two major manufacturing systems and then go on to describe recent changes in the U.S. automobile industry that are related to the introduction of JIT manufacturing techniques.

A. THE FORDIST MANUFACTURING SYSTEM

In this section I characterize the system of mass production prevalent in Europe and North America between 1950 and 1980, known as the 'mature' Fordist production system. This approach to manufacturing successfully combined Henry Ford's invention of the moving assembly line with Taylorist principles of work organization.[2] Today the stylized manufacturing system to be presented in this section is mostly obsolete, due to many changes that were implemented during the 1980's. But it will be useful as a reference point to be contrasted later with the JIT manufacturing paradigm. In particular since all the empirical studies reviewed in the following chapter use data from a time when Fordism was the dominant paradigm.

Fordism is based on two principles: the Taylorist philosophy of separation of intellectual and manual work and the specialization of work activities in easily learned, repetitive work steps. The logic of the Fordist manufacturing system makes it crucial to

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[2]After Frederick Taylor, whose book, *The Principles of Scientific Management* (New York 1911) systematically laid out the concepts of job simplification and the 'one best way' for a worker to accomplish any factory task.

keep the assembly line running. The whole production system is geared to the mass production of a limited number of models.[3] Each worker has one or two tasks, repeated over and over. Skilled specialists set up and maintain machines; but the goal is always the same: to keep machines running.

In Detroit stamping of the body parts from sheet steel was located in gigantic centralized stamping facilities. Individual press lines could often be dedicated to a single part - say a front right fender on a high volume product such as the basic Chevrolet. The press would stamp out these parts continuously with as little down time as possible and the parts would be shipped by rail to the many regional assembly plants where they were welded together to produce a car body. Changing the stamping dies in this system was often very time consuming - as many as three shifts were needed to move heavy dies out of the press line and to install the dies for another part. However, that was not very important because dies were changed only a few times a year (MIT Commission 1989, 20-21).

The manufacture of complex products like cars or TVs, makes it necessary to balance the flow of various parts and subassemblies into the main assembly process. According to the Fordist approach the products are 'pushed' through the assembly process according to plan - requiring relatively large buffer stocks of inventory. These are set up at the various steps of production, just in case something goes wrong. But large buffer stocks reduce the incentive to resolve the source of occurring problems by delaying recognition of defects, disguising the interdependencies in production, and hiding from workers the way their actions affect the system as a whole. Since problems are "buried in buffer stocks", extensive testing is required in order to sort out defective products (Cohen and Zysman 1987, 139).

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[3]The following anecdote serves to illustrate the logic of the Fordist system: Henry Ford once said that his customers could order a Model T in any color they want - so long as it's black (Luria 1990a, 130).

Analyzing the degree of backward integration associated with Fordist manufacturing, one finds that the U.S. auto manufacturers have historically procured most of the parts and components from their own parts divisions. The value added/sales ratio for GM, Ford and Chrysler is reported to be 48, 39 and 36 percent respectively (Luria 1990b; Eckard 1984). Compared to all of manufacturing, the degree of vertical integration in the automobile industry, as measured by the ratio of value added to sales, was only at or below the average (Scherrer 1991, 217).[4]

These sourcing relations were supplemented by purchases from independent suppliers in arms-length transactions. A car assembler typically dealt with 1,000 to 2,500 suppliers directly (Womack et al. 1990, 146). The contracts with the 'independents' usually did not run for longer than a year. The assembler relied on hierarchical coordination of information and control over technology in order to solve the complex task of manufacturing cars.[5] Womack et al.(1990) describe how one car assembler company dealt with its suppliers regarding the development of a new car. First, for each part that goes into the car, detailed engineering drawings are produced at the central engineering office of the car assembler. Potential suppliers are then called in to submit bids according to the engineering specifications provided by the car assembler.[6] The

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[4]The ratio for all of manufacturing was 43.1 % in 1976 (see White 1982, 414).

[5]See Helper (1990) p. 159, who characterizes this as an 'exit' supplier relationship; i.e. the customer's response to problems with a supplier company is to find a new one.

[6]These are generally bids for short-term contracts, lasting a year or less.

central piece of information with regard to awarding a contract is the price per part; in addition, a specified quality target and delivery schedule has to be met.[7]

According to Womack et al. (1990), a key aspect of this bidding process of awarding contracts is the fact that a supplier has an incentive to only share the bid price per part with the car assembler.[8] "By holding back information on how they plan to make the part and on their internal efficiency, they believe they are maximizing their ability to hide profits from the assembler"(Womack et al., 142). There exists a low flow of information between the assembler and the suppliers and practically no flow of information from the suppliers back to the assembler. "The latter is partly because suppliers have not been encouraged to develop engineering staffs and independent product technologies"(MIT Commission 1989, 34). Having been awarded a contract, the supplier then is to submit a prototype part. These parts are subsequently tested by the assembler. Unless changes are found to be necessary, volume production can begin. Otherwise, necessary changes are communicated to the supplier.

In the case of quality control the following relationship between assembler and supplier is observed during production.[9] The actual quality inspection usually takes place

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[7]The quality target is usually specified as an upper limit of unacceptable parts; e.g. the number of bad parts per 1,000.

[8]In such an environment the assumption of non-observability of the supplier's production cost by its downstream consumer - often employed in principal agent models - seems to be particularly useful. For a more recent example see Lewis and Sappington (1991).

[9]Focussing on the issue of quality control serves two purposes: it allows us to demonstrate fundamental differences between the Fordist and the JIT manufacturing system; furthermore, it illustrates the kind of vertical relations employed by each manufacturing system.

upon delivery to the assembly plant. If fewer than the pre-specified maximum of bad parts are found in one batch, these are either tossed out or sent back for credit.[10] If, however, a quality problem becomes apparent to the auto manufacturer, it is strictly the supplier's responsibility to find its cause and correct it. Because of the lack of communication mentioned above, it is quite difficult for the car assembler to trace and correct defects in delivered parts. Therefore this system requires "enormous staffs to manage"(MIT Commission 1989, 34).

To summarize, under the Fordist manufacturing regime, vertical relationships promote competition among suppliers based on the price at which a part can be supplied. Quality conditions are incorporated into the contract by means of a minimum quality constraint.

B. THE JUST-IN-TIME MANUFACTURING SYSTEM

The just-in-time [JIT] manufacturing system originated at Toyota Motor Company in Japan and has since been implemented at the other Japanese auto manufacturers as well as in a variety of different industries.[11] The concept of JIT production represents a

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[10]The following statement shows the almost 'casual' attitude towards defects: "In the United States defective supplier parts have typically been treated as a kind of random error and discarded without any effort to learn from them"(Dertouzos et al. 1989, 100).

[11]Eiji Toyoda visited Ford's River Rouge plant in Detroit in the year 1950; based on his observations there, he and Toyota's production engineer, Taiichi Ohno, developed a new approach to automobile production (Cusumano 1985, 230). For that reason some authors refer to this production system as the Toyota production system; see for example: Krafcik 1988, 42; Holmes 1987, 42; Cusumano 1985, 230-235. See Monden (1983) for a detailed description of the Toyota production system.

fundamental change in the nature of manufacturing. Its basic idea is to maintain a continuous flow of products in factories in order to adapt production flexibly to changes in demand. Thus it is often referred to as a system of flexible mass production. The objective of JIT is to produce "only necessary items in a necessary quantity at a necessary time"(Monden 1983, vi). In order to apply that approach, one of the two principles of Fordism was changed: standardization of work tasks is still very much part of JIT, but these tasks are now being performed by a work team in a manner enabling each member of the team to do any of the team's tasks (MIT Commission 1989, 23). Toyota discovered in the early 1950s that a smaller number of workers, each capable of doing several jobs, can turn out cars using less inventory, less investment, and committing fewer mistakes.

In recent years a considerable literature has emerged, comparing the traditional (i.e. Fordist) approach to manufacturing to the modern, JIT approach (see e.g. Schonberger 1982; Piore and Sabel 1984; Cohen and Zysman 1987; Hall 1987; Aoki 1990; Womack et al. 1990). There seems to be a consensus that with JIT manufacturing a new paradigm has emerged (see Milgrom et al. 1991, Milgrom and Roberts 1990)[12]: In contrast to the traditional manufacturing firm, the 'modern' firm frequently:

- makes greater use of flexible, programmable equipment and of computer-aided design and manufacturing technologies
- has fewer job classifications

[12]"Henry Ford's soul-destroying, wealth-creating assembly lines are out of date. Most of the things factories make now - be they cars, cameras or candlesticks - come in small batches designed to gratify fleeting market whims" ('The Factory of the Future', The Economist April 5 1986, 83).

- offers more varieties of its major products and/or updates its product lines more frequently
- emphasizes quality at all stages of the production process
- produces in small and medium batches
- puts more emphasis on speed in order processing, production and delivery
- holds much lower inventories for intermediate and finished goods
- overlaps design, product, and process engineering to speed the introduction of new products
- relies on subcontractors to supply a greater proportion of the total value added.

Contrary to the 'Fordist' philosophy, the JIT approach to manufacturing is based on the view that inventory is more often a source of costs and problems than it is a solution to them. With lower in-process inventories, problems with the quality of a particular operation become visible faster and are not 'hidden' in large buffers stocks of inventory.[13] This philosophy has many implications: For example the entire manufacturing process has to be designed such that small batches can be produced and idle processes can be reduced. It is important to provide flexibility and quick set-up capability in a factory, e.g. by reducing the time needed to change dies. With lower inventories, tool and equipment maintenance become more important. As a result, JIT manufacturing requires a different process flow design and layout within a plant (see

[13]According to the logic of the Fordist system it is of crucial importance to keep the assembly line running; large buffer stocks of inventory are therefore required 'just in case' something goes wrong. That is why the Fordist system is also referred to as the 'just-in-case' approach to manufacturing.

Stalk Jr. 1988, 47).[14] Furthermore, JIT has implications for technology choices, marketing strategies, personnel policies, internal communication and supplier relations (Milgrom et al. 1991).[15]

The ramifications of JIT manufacturing for subcontracting relationships are the central focus of this study. In order to understand these, the operational coordination that is typical for JIT manufacturing needs to be examined. Aoki (1988) compares generalized versions of the Japanese modern manufacturing paradigm to the North-American manufacturing paradigm; as one of the key differences he identifies intershop coordination and workshop organization. At the American firm, "intershop coordination becomes the specialized function of hierarchically ordered administrative offices"(Aoki 1988, 21). By contrast, a conspicuous feature of the Japanese assembly factory is the lack of a central office to control and expedite the flow of materials among shops. He discusses the role of the so-called kanban system as providing integrated control over production, inventory, and quality:[16]

The term *kanban* traditionally refers to a block of wood bearing the trademark of a merchant shop, but in the present context it refers to a card placed in a vinyl envelope. In implementing the daily production schedule, the final assembly line places a production-ordering *kanban* for each type of part or half-product (engine, transmission,

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[14]Jacobs Vehicle Equipment Co., a heavy-duty engine brake manufacturer in Bloomfield, Conn., reduced its floor space devoted to manufacturing by half, i.e. from 240,000 sq ft to 120,000 sq ft, as a result of the introduction of JIT manufacturing techniques. "Workers ... now play basketball, volleyball, and ping pong before and after work in a 60,000 sq ft indoor recreation area that once housed production equipment and excess inventory"(Industry Week Sept 18 1989, 26).

[15]It took Toyota some 20 years to 'work out' this new approach to manufacturing (Aoki 1988, 24; Cusumano 1988, 34-35).

[16]The kanban system is also referred to as the 'zero inventory' or 'just-in-time' method.

body, head lamp, etc.) on a post adjacent to the relevant inventory store whenever it withdraws its inventory. This *kanban* specifies the kind and quantity of withdrawal as well as time of delivery for its replenishment. The upstream shop supplying the part or half-product collects the *kanban* from the post at regular intervals, say, a few times a day. This *kanban* functions as an ordering form and is returned to the inventory store together with actual delivery at a specified time. Thus the *kanban* plays the dual role of order form and delivery notice. The shop that receives the *kanban* from the final assembly line in turn dispatches its own *kanban* order forms to shops located immediately upstream, and, through the circular flow of *kanban*, the chain of bilateral order-delivery links between directly interconnected shops extends to the outside suppliers who are involved in long-term transactions with the final assembly manufacturer.
Upstream shops are supposed to adapt their production according to demands by their downstream shops, as indicated by the *kanban*, and are bound neither to respond to the predetermined command of the administrative office, which may become quickly outdated because of unexpected factors occurring during the interim period of planning, nor to smooth out their production streams according to their own convenience, nor to pursue the maximum use of their machines in isolation. In this sense, one of the important characteristics of the *kanban* system may be defined by saying that the downstream shop "pulls" the operation of the upstream shop rather than that the supply of the latter "pushes" the operation of the former. Through the chain of the circular flow of the *kanban*, the entire system is made directly responsive to market demands. In contrast, the traditional approach of the American automobile industry has been to produce outputs according to a market "forecast" and then to adjust prices - by means of rebates, discounts, and options - to levels at which actual markets will absorb the outputs (Aoki 1988, 22-23).

This description of the just-in-time system shows it to be a mechanism of coordination that allows for the production of goods as complex as an automobile while keeping the amount of in-process inventory as low as possible. That is quite different from the hierarchical coordination found in Fordist manufacturing. This difference extends to the various manufacturing functions. For example, quality control is performed in the following way:

The downstream shop can and should refuse to accept on the spot the delivery of any defective supply from the upstream shop. Quality checks can be made at each stage of the production stream rather than at an inspection post situated at the end of the assembly line, and a bug can be removed from the system quickly (Aoki 1988, 23-24).

In other words, "the just-in-time system permits a shift of quality control from a staff function to the line manufacturing operation"(Cohen and Zysman 1987, 166).

The operational coordination of JIT manufacturing described above typically extends beyond corporate boundaries (Aoki 1988, 215). Subcontracting currently accounts for over a third of Japanese firms' total manufacturing costs, up from less than 20 percent in the 1960s (The Economist August 31 1991, 56). In turn, the value added/sales ratio for Japanese auto assemblers ranges from 15 to 20 percent (Eckard 1984). That has implications for the structure of vertical relationships: As compared to the U.S., a car assembler in Japan deals directly with only a relatively small number of first-tier suppliers. Most of these supplier companies are neither wholly integrated internal parts divisions nor fully independent suppliers. In what is referred to as a quasi-integrated relationship, Japanese auto manufacturers often hold significant equity shares in these companies (Eckard 1984).[17] The first-tier suppliers design and deliver whole vehicle systems, like seats, instrument panels, and brakes. They, in turn, deal with a second tier of suppliers and so on.[18] These relationships are more specific and longer-term than

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[17]Eckard's definition of quasi-integration differs from the one used in this study (see p.3).

[18]This aspect of the Japanese automobile industry is referred to as a tiered supplier base. "According to a survey by the Agency for Small- and Medium-Sized Enterprises conducted in 1977, an unnamed prime manufacturer of automobiles (possibly Toyota) had direct relations with 122 first-tier suppliers and indirect relations with 5,437 second-tier suppliers and 41,703 third-tier suppliers. After we adjust for double counting, we find that this manufacturer stood at the apex of a stratified group with a membership of 35,768 suppliers"(Aoki 1988, 204-205). In Japan, a car assembler directly deals with fewer than 300 supplier companies, compared with 1,000 to 2,500 at Western mass producers (Womack et al. 1990, 146; MIT Commission 1989, 54).

under the Fordist system. The contract between the prime contracting firm and its subcontractor is normally written for the duration of a particular model, say, a four-year period. The prime contracting firm guarantees not to switch suppliers or to start producing the item itself within this period (Asanuma 1985).[19] This seems to be made possible by the existence of powerful market incentives in these vertical relationships.[20] Specifically, quality serves as a signal of commitment to a relationship. An increase in the quality of a supplier's output will make a renewal of that particular contract more likely.

Such a subcontracting arrangement is argued to be advantageous compared to the Fordist system; Aoki (1988) refers to a gain in informational efficiency. "The most important aspect of this complex network of vertical inter-firm relationships is its function as a means of communication and coordination"(Eckard 1984). In particular, information is disseminated beyond the corporate boundary of the prime manufacturer without the intervention of a single 'controlling tower'. Furthermore, within the general framework of knowledge sharing, day to day monitoring, i.e. routine problem solving, can be delegated to subcontractors (Aoki 1986, 975). As part of the JIT manufacturing system, quality control functions can be performed by upstream suppliers. As a result, there are

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[19]In Helper's (1990) analysis, this is referred to as a 'voice' supplier relationship; i.e. the customer's response is to work with a particular supplier until problems are corrected.

[20]Williamson (1985) ascribes the lower extent of vertical integration in Japan to hazards of trading less severe due to "cultural and institutional checks on opportunism". See Kawasaki and McMillan (1987) and Asanuma (1985 and 1989) on the design of contracts in Japanese subcontracting.

But the successful export of the JIT manufacturing system to North America casts doubt on that explanation. One needs to focus on the structural differences in the underlying manufacturing system in order to understand the differences in vertical integration.

no sizeable stocks of inventories that allow quality defects and production problems to remain unnoticed for some time. In addition, the Japanese car assembler insists on total conformity to standards. "All of the Japanese assemblers and their first-tier component suppliers periodically audit the manufacturing practices of their suppliers and subsuppliers and take it as their right to make suggestions and demand improvements. Moreover, the assemblers and the first-tier suppliers organize their suppliers and subsuppliers into study groups for the purpose of encouraging them to share knowledge of improved techniques. The result is that new techniques pioneered by one firm diffuse very quickly across an assembler's entire supplier base"(Dertouzos et al. 1989, 101).[21] "Successful autonomous quality control at the level of the subcontractor enables the prime manufacturer to abolish specialized inspector jobs and to reduce the costly discarding of finished or in-process products at the downstream end of the production process"(Aoki 1988, 215). The larger extent of coordination that is typical for JIT manufacturing translates into savings on monitoring costs for the auto manufacturer because fewer personnel are needed for planning and monitoring.[22] Aoki argues that since the long-term relationship between assembler and supplier is maintainable only if it is beneficial to both parties, "subcontractors would take greater care in cost control and quality control of their production as compared to in-house supply divisions"(Aoki 1986, 974). That is supported by a recent article in the publication "The Economist", where it is reported that the

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[21]It is also not uncommon for first-tier suppliers to assign staff members - so-called resident design engineers - to the assembler's development team two to three years prior to production (Womack et al. 1990, 146).

[22]"With fewer suppliers and simpler design and manufacturing processes, GM officials believe the company shouldn't need as many accountants, purchasing agents, or factory supervisors"(Wall Street Journal February 05 1991, A3).

primary motive of Japanese firms for subcontracting is to improve the quality and efficiency of their manufacturing processes.[23]

C. CHANGING SUPPLIER RELATIONS IN THE U.S. AUTOMOBILE INDUSTRY - IMPLICATIONS OF THE INTRODUCTION OF JUST-IN-TIME MANUFACTURING

In reaction to the success of primarily their Japanese competitors, U.S. automobile manufacturers have attempted to fundamentally transform their approach to the production of automobiles. That transformation has become visible in changes in manufacturing techniques, industrial relations and supplier relations. The following section attempts to document the changes in the manufacturing system, and the related changes in the assembler-supplier relations.[24] JIT manufacturing has received considerable attention by U.S. and European companies. Managers in North America and Europe appreciate the significance of JIT manufacturing for the competitiveness for their respective companies. For example, the New York Times reports that in 1991 alone, 20,000 manufacturing executives and production engineers visited the Toyota plant in Georgetown, Kentucky,

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[23]"The Ins and Outs of Outing", The Economist August 31 1991, 54-55.

[24]For changes in industrial relations see Katz et al. (1987) and Herzenberg (1991). Katz et al. report that auto manufacturers "are clearly counting on changes in industrial relations to improve their competitiveness." They test for the economic effect of shop floor practices and find that "differences in industrial relations contribute significantly to differences in plant productivity." Their data was measured at 53 plants of a major U.S. automobile manufacturer. They also report that there is "not sufficient data available to assess the contribution of specific shop floor practices for Japanese plants as well as for transplants." For recent evidence on the relevance of industrial relations see the Wall Street Journal August 29 1991, A1.

"convinced what is happening [there] can change the American way of manufacturing products"(New York Times, May 5 1992, A1).

The Wall Street Journal reports on a General Motors car plant in Oklahoma City where key aspects of the JIT manufacturing paradigm have been introduced:

Now, small batches of raw parts arrive at the start of the welding line once an hour. The line's three work stations are linked together by an overhead conveyor able to carry only six parts from one welding machine to another. When workers at the first station complete their part of the work on six wheel wells, they wait for the next station to take them off the conveyor before they make another six. There are no backup supplies and nowhere to stack half-finished parts.
The way the plant has adopted the just-in-time system of running on minimal inventories constitutes only part, albeit an important part, of the overall lean system that GM is trying to implement. This lean approach seeks to remove all 'safety nets' - including backup machines and backup quality-control workers - because they often create waste and delay remedies for underlying manufacturing problems. Lacking any stock, for example, the workers must act fast when machines break down. They pull a cord that triggers a siren and a flashing light to alert repair workers (Wall Street Journal August 29 1991, A1).

In a different report, the same newspaper illustrates the changes that were implemented at a U.S. automotive supplier company. Bumper Works, Illinois, a small supplier of lightweight pick-up truck bumpers received assistance from Toyota Motor Manufacturing Inc. as it tried to become one of its suppliers. Toyota assisted Bumper works in cutting the time it takes to change dies in the metal stamping presses from 90 minutes or more to less than 22 minutes. Only then was Bumper Works flexible enough to make 20 different bumper models each day (that was one of Toyota's requirements). On a more general scale, the entire layout of the supplier's plant underwent a major reorganization. The goal of the JIT approach "is for a piece of raw steel to come in one end of [the plant's] building and go out the other side the same day as a finished bumper. With the old layout, bumpers would be stamped, ride on forklifts to a storage area at the far end of the plant and - days later - return to the weld stations. Now, bumpers go from presses to welding with just a brief stop in between." The plant also introduced the kanban system: "Bins of parts now are labeled, so it is easier to identify what's going where. When a batch of Toyota bumpers is shipped, a card is returned to the press operators, and they bang out more. [Bumper Works'] employees now schedule their own work rather than wait for a supervisor's direction"(Wall Street Journal September 9 1991, A1).

Yet another piece of anecdotal evidence relates to a Chrysler plant: "At its Belvidere, Illinois, plant, parts inventories are used up, on average, every 2.5 working days - a performance matching the best Japanese standards"(Wall Street Journal November 11 1990, A1).[25]

Related to the changes in the manufacturing system itself were major changes in the assembler-supplier relationships. The automobile manufacturers reduced the extent of in-house operations by cutting the number of supplier companies they were dealing with. The remaining vertical relationships became more long-term.

The introduction of these changes has been furthered by the increasing number of Japanese transplants and Japanese parts transplants in the U.S. as discussed in the Introduction. However, the emphasis on closer, yet contractual vertical relationships cannot be well explained by standard transaction cost theory arguments. Closer relationships, one could argue, introduce a higher degree of asset specificity and therefore

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[25]For the same time period, during which the above mentioned changes in the U.S. approach to manufacturing automobiles occurred, substantial increases in labor productivity and quality in the assembly plants of established U.S. automobile producers are being reported (Herzenberg 1991, 68-72).

lead to more vertical integration. Below I summarize the anecdotal evidence on the changes in the characteristics of vertical relationships ascribed to the introduction of JIT manufacturing. Based on these observations I submit a theoretical explanation of the changes in supplier relationships in Chapter III. Several developments can be distinguished (see Womack et al. 1990, 156 forward; Helper 1991; Herzenberg 1991, 44-49).[26]

Helper's (1991) survey data show that suppliers now are more likely to provide detailed information to their customers than just a few years ago. Most notable was the dramatic increase in **information exchange** on statistical process control (SPC) charts[27]: In 1984, 16 percent of the respondents had provided that kind of information to their customers, while in 1989 this share had increased to 92 percent. This is, at least in part, due to efforts of the car assemblers to diffuse quality-monitoring techniques to the supplier level.[28] Helper also reports a statistically significant increase in the number of visits to the supplier with the purpose of providing technical assistance (p. 19). The

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[26]"Where once contracts were short term, suppliers were numerous, and competition was almost solely price-based, now contracts are increasingly long term, sole sourcing is becoming more common, and competition is based on quality, delivery, and engineering as well as price"(Helper 1991, 15).

"...GM wants to change the way it does business with suppliers. It wants parts makers to work under long-term contracts that call for price reductions over the life of a car, and it wants fewer companies shipping parts to GM plants"(Wall Street Journal February 05 1991, A3).

[27]"Statistical Process Control (SPC) is a technique for generating continuous reductions in defect rates. It involves taking samples of output, recording the results on 'control charts', analyzing the charts to determine the causes of defects, and redesigning product and process to eliminate those causes" (Helper 1991, 27).

[28]"The Big Three have sought to reduce costs and engage suppliers in their quality programs by making suppliers responsible for testing subsystems -- and certifying that the systems meet the automakers' specifications"(New York Times May 26 1991, F5).

central importance of quality becomes visible by ranking the criteria used by car assemblers for the selection of supplier companies: in 1984, price, delivery, and quality were the most important; in 1989 the order had changed to quality, delivery, and price. Quality is also an important criterion for a supplier's ability to continue to do business with the auto assembler. "Once the supplier is chosen, the assembler closely monitors its dependability and quality record. The winners of the various quality award programs [now established at each of the Big Three] are more likely to receive new business in the future..."(Scherrer 1991, 224).

The average **length of contracts** is reported to have increased from 1.2 years in 1984 to 2.3 years in 1989 (Helper 1991, 19). During the same time period the percentage of contracts that covered a time period longer than three years rose from 4 percent to 40 percent.

Changes in assembler-supplier relationships have become visible as well in a decrease of the **number of suppliers** a car assembler was dealing with. Womack et al. (1990) report the following number of suppliers per assembly plant: 170 for a Japanese plant in Japan, 238 for a Japanese transplant in North America, and 509 for a Big Three plant.[29] General Motors is reported to have reduced the number of its supplier shipping locations per plant from 650-700 in the mid-1980s to about 400 today (Ward's Auto World January 1991, 27). Chrysler Corporation uses 230 parts and materials suppliers (and 285 shipping points) on its new LH platform. That compares to 456 suppliers (and

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[29]The same study refers to three ways according to which a car assembler can reduce the number of suppliers it is dealing with: introduction of a 'tier system' by directly dealing mostly with 'system' suppliers, reduction of the number of parts in components, and single-sourcing of parts that previously had multiple suppliers (Womack et al. 1990, 158).

626 shipping points) for the current New Yorker produced in Belvidere, IL (1992 Ward's Automotive yearbook, p.53).[30] Yet vertically integrated relationships have been replaced in many cases by market-based transactions. "The apparent contradiction between an increase in out-sourcing and a reduction in the number of suppliers can be explained in light of the push for modular assembly"(Scherrer 1991, 220). An increase in outsourcing alone would increase the number of supplier companies for each manufacturer as well. Auto manufacturers, however, were at the same time limiting their direct contacts to suppliers of primarily 'subsystems' like seats or dashboards.

Another aspect of changing relationships between car assemblers and their suppliers becomes visible in terms of the **locational pattern of supplier operations**. "A just-in-time system functions most effectively where the supplying and the receiving plants are in reasonably close proximity"(Estall 1985, 130). Mair et al. (1988) analyze the effect of JIT manufacturing on the locational pattern of supplier operations for Japanese transplants in North America.[31] They find the existing geographical patterns of transplant locations to be a direct result of the desire of Japanese automobile producers to transfer the JIT manufacturing techniques to North America. "The major concern in location

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[30]The phenomenon of a reduction of the supplier base is visible not just in the automobile industry. The Wall Street Journal reports that "companies around the country are cutting back the number of suppliers they use-largely small businesses-by as much as 90 percent. They are demanding higher levels of service and product quality from the survivors. And they are willing to pay a premium on the theory that getting things right initially is cheaper in the long run." "Since the early 1980s, Xerox has reduced its supplier base to about 500 from 5,000 and has seen its reject rates on parts go down by a factor of 13"(Wall Street Journal August 16 1991, B1).

[31]At the date of their study that meant 12 transplant assembly plants and about 250 transplant component factories. Practically all the transplant assembler and supplier sites analyzed by Mair et al. were so-called 'greenfield' sites; i.e. plants that were built at new locations within the last decade.

selection has been implementation of just-in-time manufacturing techniques"(p. 352). Rubenstein (1988) and Rubenstein and Reid (1987) analyze the changing supplier distribution of American motor-vehicle parts suppliers. Their sample consists of about 1,000 suppliers from Ohio. They cannot establish a clear-cut JIT effect on location, yet they find the long-term locational pattern of auto supplier companies, that prevailed until the 1970s, to have changed. With the introduction of a tiered supplier structure, cooperation and longer-term contracts between car assemblers and suppliers, first-tier suppliers are found to locate new plants near their customers (Rubenstein and Reid 1987, 42).[32] On the other hand, the pressure to reduce costs leads to geographical dispersion, especially for the lower tier suppliers (Rubenstein 1988, 294); that often means setting up shop in a non-unionized rural area, or even in a low-wage foreign country.[33]

In this chapter I have shown on an anecdotal level how the introduction of JIT manufacturing affects the structure of vertical relationships. The examples above will serve as illustrations in the remainder of the paper where I analyze the influence of JIT manufacturing on the structure of vertical relationships within the framework of transaction cost theory. Based on this theoretical framework I derive a hypothesis

[32] In 1987, Ohio-based Dana Corporation announced plans to spend more than $400 million in order to build about 30 small plants [i.e. 100-200 employees] by 1996; these plans are specifically being built around flexible manufacturing cells and are located nearby Dana customers (Metalworking News 1987, in: Luria 1990, 144-145).

[33] This search for low-wage operations has been most evident in labor-intensive parts and among smaller suppliers. "Emphasis on low costs has contributed to the deunionization of the parts industry and the movement of operations to Mexican maquiladoras"(Herzenberg 1991, 45).

concerning the effect of the paradigm shift in the manufacturing system on the determinants of vertical integration. The hypothesis is then tested with new data, specifically obtained for this project.

II. LITERATURE REVIEW

The relevant transaction cost theory literature is introduced in this chapter. After some brief remarks on the development of transaction cost theory I review the evidence from previous empirical work on the influence of various determinants on the structure of vertical relationships.

A. GENERAL REMARKS

The seminal article in the field of transaction cost theory is Ronald H. Coase's 'The Nature of the Firm'. Coase (1937) tries to explain the factors that affect the choice between transactions within a firm and transactions outside a firm. Standard microeconomic theory assumes that resources are allocated according to the price mechanism. Yet this mechanism can only explain transactions that take place outside the firm. "Within a firm, these market transactions are eliminated and in place of the complicated market structure with exchange transactions is substituted the entrepreneur-coordinator, who directs production." Therefore, according to Coase, "our task is to attempt to discover why a firm emerges at all in a specialized exchange economy." He argues that "the main reason why it is profitable to establish a firm would seem to be that there is a cost of using the price mechanism." In his seminal article Coase introduced the concept of transaction costs in order to explain the existence of firms in a market economy. Transaction costs include most costs associated with conducting economic activity other than actual production costs; e.g. costs of coordinating interdependent activities, exchange of information and of writing, monitoring, and enforcing contracts.

Coase argued that certain costs of using the market can be saved by forming an organization and allowing some authority to direct the resources. Therefore, comparative differences in transaction costs can explain when firms choose to procure in the market and, alternatively, when they produce the required inputs themselves. "The question always is, will it pay to bring an extra exchange transaction under the organizing authority?"

For the first 30 years after its publication, though, Coase's article had very little influence on other economists' work.[1] But within the last 20 years the concept of transaction cost has been extended and refined.[2] Williamson has developed Coase's approach into a theory of institutional choice: transaction cost theory "focuses expressly on the comparative efficacy with which alternative governance structures manage transactions during contract execution"(Williamson 1990, 67). The paradigm problem of this approach is the 'make-or-buy' decision of the firm. According to Riordan and Williamson (1985, 365), transaction cost economics regards the transaction as the basic unit of analysis and holds that the organization of economic activity is largely understood

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[1]In November 1970, Coase referred to his 1937 paper as "much cited and little used"(Coase 1988, 33).

[2]See especially Williamson (1975) and (1985).

in transaction cost economizing terms. Such economies are realized by matching governance structures with the attributes of transactions.[3] "The principal dimensions with respect to which transactions differ are asset specificity, uncertainty, and frequency"(Williamson 1985, 52). Of these, Williamson argues, asset specificity is the most important one and distinguishes transaction cost economics from other treatments of economic organization.

Asset specificity refers to a situation where one or both parties to a transaction have made investments such that the value of an exchange is greatest when it occurs between these two firms rather than with other firms (Perry 1989). Williamson distinguishes five types of asset specificity: *Site specificity* refers to a situation where buyer and seller are in a 'cheek-by-jowl' relation with one another. The specificity aspect is explained by an asset immobility condition. *Physical asset specificity* arises when one or both parties to the transaction make investments in equipment and machinery that involve design characteristics specific to the transaction and have lower values in alternative uses; e.g. specialized dies that are required to produce a particular component. *Human-capital specificity* (or *human asset specificity*) is a consequence of investment in and accumulation of human capital specific to a particular relationship. *Dedicated assets* are discrete investments in general purpose plant that are made at the behest of a particular customer. The *brand name capital* is also classified as a type of asset specificity.

[3]Joskow (1985, 36) refers to a continuum of potential governance structures for vertical relationships ranging from vertical integration to market relationships.

At the core of transaction cost theory is the argument that a higher degree of asset specificity leads to increased occurrence of vertically integrated transactions (the theory is explained in more detail in section III.A.). During the last 15 years empirical tests of that theory have received particular attention.

B. EMPIRICAL STUDIES IN TRANSACTION COST THEORY

Hypotheses generated by the transaction cost theory framework have repeatedly been tested empirically. "Unfortunately, the level of detail at which the theory operates has made rigorous applications difficult"(Masten 1984, 407). In addition, transaction costs themselves are quite difficult to observe and measure. In empirical work the choice of organizational form is therefore usually related to characteristics observable at the level of transactions, such as the degree of asset specificity, the level of uncertainty and complexity. Furthermore, the information requirements can be moderated by restricting attention to a single industry. This reduces the need for absolute measures for variables like human or physical asset specificity and permits qualitative tests based on ordinal rankings of the characteristics of transactions. Therefore, most of the empirical work concentrates on specific industries; within an industry the analysis focuses on particular transactions. Hypotheses are usually tested by estimating qualitative choice models such as probit and logit.[4]

[4]Alternatively, if one can obtain data for the actual transaction costs of the organizational form chosen it is possible to estimate the full structure of organization cost (see Masten et al. 1991).

This section provides an overview of the empirical evidence on the determinants of vertical integration. None of the studies reviewed considered the possible effects of manufacturing techniques on the structure of vertical relationships; in addition, they are based on the application of Fordist manufacturing techniques. In the next chapter I augment the theoretical argumentation of transaction cost theory in order to account for the influence of JIT manufacturing.

Monteverde and Teece (1982a) test whether transaction cost theory can explain the pattern of vertical integration in the U.S. automobile industry. According to their interpretation of transaction cost theory, the car manufacturer integrates the production of a particular component when the production process generates specialized, nonpatentable know-how (see III.A.). In order to test this hypothesis, Monteverde and Teece obtained data on a set of 133 automotive components from Ford and General Motors. The data are from 1976 and are characterized by the authors as a representative picture of the degree of vertical integration at that point in time, since they refer to "most of the major items that go into a complete vehicle."

The dependent variable is dichotomous and represents the choice between vertical integration and market procurement. An observation consists of a particular automotive component; it is counted as produced in-house if 80 percent or more is produced by the automobile manufacturer. The binomial probit model estimated includes the following explanatory variables. The degree of human asset specificity is measured by the amount of applications engineering effort, i.e. development cost, that went into the development of each component. This way the authors intend to measure the specialized know-how and skills generated by the production process. The authors argue that the degree of human asset specificity involved in the production of an automotive part is primarily the result of developing that part. Since the actual development costs are of proprietary nature, the authors obtained a measure of relative engineering costs from a design engineer employed at one of the automobile manufacturers. Engineering costs are measured qualitatively on a 10-point scale; this measurement is treated as a continuous variable. In order to check for the reliability of these ratings, the authors obtained engineering cost ratings from a different design engineer.[5] In addition, three control variables are defined. These are dummy variables that account for generic (vs specific) parts, manufacturer-specific effects (Ford vs GM), and 'subsystem effects'.[6] The components are grouped into six different automobile subsystems, based on the degree of technical interrelatedness.

The results show all variables except the subsystem dummies to be significant in explaining the pattern of backward vertical integration. Specifically, a higher degree of human asset specificity is found to increase the occurrence of vertical integration. The contribution of this paper is to show that, in an environment of Fordist manufacturing with its short-term vertical relationships, transactions that are characterized by a high degree of human asset specificity tend to be vertically integrated. Yet, while Monteverde and Teece (1982a) test if the pattern of vertical integration is influenced by the condition

[5]The authors report that the two sets of ratings share a correlation coefficient of 0.8.

[6]The information on which parts are considered to be generic was obtained from a replacement parts wholesaler.

of human asset specificity, their study cannot address possible effects of a shift in the underlying manufacturing paradigm that was yet to come.[7]

The introduction of JIT manufacturing techniques in North America that occurred since the Monteverde and Teece study provides an opportunity to test for the existence of additional, manufacturing-related determinants of the structure of vertical integration as well as a change in the influence of the degree of human asset specificity.

According to transaction cost theory, once an investment that is specific to a particular transaction has been made, so-called quasi-rents are created (see III.A.).[8] These are potentially appropriable by the other party to the transaction. **Monteverde and Teece (1982b)** argue that this appropriation potential can be attenuated by means of a quasi-integrated relationship between up- and downstream firm, if the quasi-rents are mainly associated with physical capital.[9]

The authors empirically test for the relationship between the size of quasi-rents and the occurrence of quasi-integration. They obtained data on automotive components that required specialized tooling for low cost production from two divisions of a major U.S. automotive supplier. The dependent variable is a dummy that measures the existence of quasi-integration. The linear probability model includes only one explanatory variable:

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[7]That is particularly interesting given that the authors point out that the Japanese automobile industry is less integrated than the U.S. industry. But they fail to refer to structural differences in manufacturing as a possible explanation.

[8]The concept of quasi-rent refers to the value of an asset in excess of its value in its next best use.

[9]An example of a quasi-integrated relationship that is referred to in the literature is the case of General Motors and A O Smith, its major supplier of passenger car frames for about 50 years. The specific physical assets used by A O Smith for the manufacture of the frames are owned by General Motors (see Coase 1988).

a proxy for the size of quasi-rents. It is obtained by multiplying the dollar cost of the tools and dies involved in the production of each component by the degree of specialization of that tooling. The latter aspect is measured by the percentage of the original tooling cost required to convert the tooling to its next best use.

Monteverde and Teece find a positive and significant relation between the size of quasi-rents and the occurrence of quasi-integration to exist. They interpret that as supporting the hypothesis that the existence of quasi-rents associated with physical capital leads to quasi-integrated vertical relationships. In other words, Monteverde and Teece argue that under the Fordist manufacturing system the occurrence of an intermediate-type governance structure, quasi-integration, depends on the size of quasi-rents present in a transaction. But the empirical test applied by the authors is not very strong. Their linear probability model includes only one explanatory variable, and the sample tested is very small; it consists of 28 observations.

Central to the theory of transaction costs is the role of asset specificity. **Spiller (1985)** tests its influence on the choice of governance structure with a set of data on vertical mergers. According to the transaction cost rationale, the gains from a merger are the governance costs that can be saved by internalizing transactions. The governance costs are, in turn, related to the magnitude of the specific assets involved in the transaction (see III.A.). Therefore, Spiller expects total gains from mergers to increase with the degree of asset specificity.[10] As a proxy for the degree of asset specificity he includes a measure of the degree of site specificity. His study is interesting because of its novel approach to

[10]The methodology used by the author to evaluate the gains of a merger is based on the capital asset pricing model.

measuring site specificity. The sample includes data on 29 vertical mergers. In addition to several other explanatory variables, the author defines three types of proximity measures: a dummy variable that indicates whether or not the merged firms have vertically related plants in the same state; a measure of the actual distance [in miles] between plants; and, in order to account for the location pattern of the industry in general, the actual distance multiplied by the percentage of the upstream industry's sales which are shipped to distances shorter than, or similar to, the specific distance between the plants of the merging firms. The location pattern variable accounts for the possibility that the actual distance between the merged plants may not be a sufficient statistic of site specificity. Spiller reports that a comparison between his measure of the location pattern of the industry and the actual distance between the plants of interest shows the latter to be a reasonable measure of site specificity. He estimates two equations derived from the capital asset pricing model by means of nonlinear least squares and finds an increase in the distance between related plants (i.e. a decrease in asset specificity) to significantly reduce the total gains from a merger. That supports his hypothesis that an increase in the degree of asset specificity leads to an increase in the gains from mergers due to transaction cost savings, resulting from internalized transactions. This finding confirms the importance of the condition of asset specificity as hypothesized by transaction cost theory.

Joskow (1985) analyzes the structure of vertical integration between electric utilities and coal suppliers for a sample of 200 coal contracts. In this mostly descriptive paper the author focuses on a subset of so-called mine-mouth plants: these are power plants built adjacent to coal reserves from which coal will be mined for these plants.[11] The power plants are deliberately located next to the coal mine, therefore mine-mouth plants exhibit a high degree of site specificity. Usually the coal burning plant is designed to burn the particular types of coal located in the adjacent reserves; this characterizes a high degree of physical asset specificity. And finally, a mine-mouth plant consists of dedicated assets: the mine would not be built but for the promise of purchases from the adjacent plant, and the plant would not be built but for the availability of coal from the adjacent mine. Therefore, Joskow argues, mine-mouth plants are prime candidates for either vertical integration or complex long-term contracts. In fact, Joskow finds vertical integration to be much more likely for a mine-mouth plant than other coal burning plants. In addition, the incentives of parties to commit to long-term contracts were found to be larger for the set of contracts analyzed: the mine-mouth plants that were not vertically integrated chose contracts of considerably longer duration than the other utilities in the sample.

In his 1987 paper, Joskow formally tests if relationship-specific investments are important in determining the duration of coal contracts negotiated between coal suppliers and electric utilities. His data set includes approximately 300 coal supply contracts. The dependent variable measures the length of the contract between utility and coal supplier. Joskow includes the above-mentioned three categories of asset specificity by means of the

[11]Joskow points out that the definition of a mine-mouth plant is at least partially subjective and that no general list of such plants appears to exist. According to his operational definition, mine-mouth plants are plants "that were deliberately located adjacent to specific coal reserves in order to exploit these reserves to generate electricity and where the adjacent mining facilities were built on reliance on these plants"(Joskow 1985, 77). But the author does not provide an operational definition of the concept of 'adjacent location'.

following variables: a mine-mouth dummy indicates influence of site specificity; a supply side region dummy accounts for locally different characteristics of coal produced in the U.S., which in turn indicate the extent of physical asset specificity of the consuming plant; and a measure of the annual quantity of coal delivered is supposed to indicate how dedicated supplier and consumer assets are to a given contractual relationship. The author reports various specifications estimated by means of OLS and maximum likelihood; across specifications he finds an increase in relationship-specific investments to lead to longer contract terms.

Joskow's study shows that there can be a fairly wide range of contractual agreements that differ from the reference point of spot market relationships. However, the importance of long-term contracts, some of which run over 50 years, in the case of coal mining and power generation is probably atypical for the American industry. What Joskow does not look at is at what point the condition of asset specificity becomes important enough in order to render vertical integration to be preferred to a contractual solution.

Masten (1984) analyzes the make-or-buy decisions of an aerospace firm for the components of a large system (it consisted of 1,887 component specifications) that it had contracted to provide to the government. His data set was obtained by means of a questionnaire; it consists of 34 individual observations. The author analyzes the data by means of a dichotomous probit model. The independent variables are two separate measures of asset specificity and one measure of complexity. In order to capture the degree of human asset specificity, the degree of 'design specificity' for each component is obtained by means of a three-point scale. This variable measures the input design as a proxy for specificity; it distinguishes highly specialized, somewhat specialized, and relatively standard items. A dummy variable represents the effect of site specificity; it is set equal to one if it is considered important to locate up- and downstream facilities close to each other. In order to account for uncertainty on the production side, the complexity of a transaction is represented by a dummy variable. Masten expects complexity to favor internal organization over contractual exchange, due to the ability of internal organization to adapt to changing circumstance in sequential fashion (see III.A.). Asset specificity is expected to favor internal organization as well, reflecting the greater potential for opportunistic behavior in idiosyncratic transactions.

Based on the econometric results the author concludes that the occurrence of vertical integration increases significantly for components that require specialized design and are fairly complex; both the degree of human asset specificity and the degree of complexity in a transaction lead to vertical integration.

The objective of **Masten et al. (1989)** is to test the relative influence of different types of asset specificity on the observed pattern of vertical integration. They suspect investments in specialized technical know-how (i.e. the degree of human asset specificity) to have a stronger influence on the decision to integrate production within the firm than those in specialized physical capital. That is based on the argument that in the presence of transaction-specific physical assets quasi-rents can be eliminated by owning the assets without internalizing production (see III.A.). The authors test data for the U.S. auto industry, obtained directly from Ford, General Motors, and Chrysler. The sample includes a total of 118 automotive components that were produced during the three years prior to the study. The dependent variable is measured as the percentage of each component that is manufactured in-house. This variable contains more information than the dichotomous variable used by Monteverde and Teece (1982a); but it falls short of accounting for intermediate-type vertical relationships. Yet the authors acknowledge that quasi-integrated relationships are common practice in the U.S. auto-industry. In fact, they suggest at the end of their paper to obtain better data on the full range of governance mechanisms. The independent variables measure three different aspects of asset specificity (these are all measured qualitatively on a 10-point scale) and represent company-specific effects by means of two dummy variables. The degree of human asset specificity is measured by a rating of the engineering cost incurred in developing that part; this proxy for transaction-specific technical know-how is identical to the one used by Monteverde and Teece (1982a). The degree of physical asset specificity is measured by the extent to which the production of a component requires physical assets that are specific to one particular automobile manufacturer. Finally, the extent of site specificity characterizing the production of a component is measured by the importance of locating the upstream production close to subsequent stages of production.

The results of OLS, two-limit tobit and logit models find only the degree of human asset specificity to significantly influence (i.e. increase) the occurrence of vertical integration. The coefficient on the site specificity variable is negative but insignificant. The authors conclude that both the type and degree of asset specificity effect the structure of vertical relationships.

Masten et al. (1989) confirmed a significant influence of the degree of human asset specificity on the firm's decision to vertically integrate; that influence had first been shown by Monteverde and Teece (1982a). But they did not produce evidence concerning the second part of their hypothesis which states that the presence of physical asset specificity leads to quasi-integration. All one can infer from their results is that the degree of physical asset specificity does not lead to vertical integration. That result does not contradict Joskow's (1985) finding of a significant influence of the degree of physical asset specificity on the length of a contract. Unlike in Masten et al. (1989), Joskow's model did not estimate the occurrence of vertical integration but the length of a contractual relationship.

In addition, one might expect their data to already have been affected by the introduction of JIT manufacturing (see Chapter I). Independent suppliers may have decided to locate closer to the automobile plant in order to support JIT manufacturing. But like all the others, this study does not explicitly account for the underlying manufacturing system.

Lieberman (1991) assesses demand variability and transaction costs as factors jointly affecting the likelihood of backward integration. A logit analysis of backward integration is performed using data on producers of 34 organic chemical products. His data set includes 203 observations. A dichotomous dependent variable measures the existence of backward integration. Several of the right-hand side variables relate to transaction cost theory: Asset specificity is measured by means of two different variables: the total fixed investment cost of the firm's downstream plant, and a dummy variable that relates to the type of transport facilities required. Because large fixed investments in pipeline facilities are generally required to ship gases between plants, that kind of investment is often highly specific to a particular vertical relationship. Therefore the dummy variable is set to one if the upstream input is a gas. Liquids, on the other hand, can be shipped in railroad tank cars. In addition, a measure of supplier concentration and the cost of the upstream input (as a fraction of total production cost) are included. The authors test a set of hypotheses derived from transaction cost theory (four hypotheses implied by theoretical studies of demand variability are tested as well; accordingly the logit model includes additional independent variables). The results confirm that transaction costs and demand variability are both important determinants of integration in the chemicals manufacturing sector. With respect to transaction costs, the likelihood of vertical integration was found to increase with asset specificity, measured as both the investment cost of plant and the potential need for inter-plant pipelines.

Masten et al. (1991) focus primarily on the role of internal organization costs on integration decisions. The authors test data that were obtained from a large naval shipbuilder for one particular shipbuilding project. The data set consists of 74 observations. The dependent variable is dichotomous. The set of independent variables includes proxies for human asset specificity (measured by the degree to which skills of workers are specific to a particular application) and physical asset specificity (the degree to which facilities used in the production process are specific to a given application). In addition, the authors include rankings of the importance of having the task performed on schedule (they refer to that as 'temporal specificity') and of the complexity of the component, a ranking of the amount of engineering effort involved in developing the component, as well as an index of the similarity of tasks (measured by the relative labor/capital intensity of a production process). The rankings for these variables were obtained from an engineer involved in the shipbuilding project analyzed.[12] Unlike in the studies reviewed above, the authors were able to collect data on the costs of internal organization: for the components produced in-house they measured the costs of planning, directing, and oversight as the product of the number of management hours and the management wage rate. These data enable them to estimate the full structure of organization cost.

In a first stage the authors estimate the 'make or buy' decision as a dichotomous probit model. They find the occurrence of vertical integration to increase with the degree of human asset specificity, temporal specificity, and complexity; for the latter variable they consistently find a quadratic influence on the choice of governance structure. Dissimilarity across activities is found to lead to less vertical integration.

In a second step the authors estimate a censored structural model by means of the actual estimates of the costs of internal organization. The findings generally confirm the results from stage one; in addition, however, Masten et al. find the effect of the degree of human asset specificity on the decision to vertically integrate to be a result of a reduction of the costs of internal organization rather than an increase in the costs of market organization. They conclude that it is important to pay attention to the level of internal organization costs.

Their study is concerned with the choice of governance structure as exhibited in a particular construction project rather than in data relating to mass production. Therefore it is less important to reflect on the manufacturing technology being used. Their measure

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[12]In order to check for the reliability of these evaluations, the authors obtained a second set of rankings from a retired engineer of the shipbuilding company. The correlations between the two sets of responses for each variable ranged from .19 to .73.

of temporal specificity captures the 'critical path' activities of the shipbuilding project. The effect of that variable on the choice of governance structure might be enhanced by the fact that practically each of the ships built is unique; a characteristic of large construction projects.

The following two papers tested transaction cost theory for the case of forward integration. Both of them analyze 'make or buy' decisions located in the marketing function of the firm. Insofar they are only indirectly relevant to the analysis of this paper.

Anderson and Schmittlein (1984) use data from the electronic components industry in order to test a model derived from transaction cost theory. In particular, the authors look at the integration of the marketing function 'personal selling' as measured by the reliance on either employee sales personnel (i.e. direct sales people) or independent sales agents (manufacturers' representatives) to market products to customers. Direct sales people are employees of a single firm and are paid a salary or salary plus incentive payment; manufacturers' representatives are organized as separate firms and represent many different manufacturers. The authors argue that the choice between these two marketing organizations is influenced by the degree of human asset specificity involved in the transaction. The data set consists of 145 observations; these were obtained by means of a questionnaire from sales managers of 16 different companies. The authors estimate a dichotomous logit model. As explanatory variables they include proxies for human asset specificity (measured as an average of the standardized response to six different questions), and uncertainty, measured as both environmental unpredictability and as the difficulty of evaluating the performance of individual salespeople. In addition, variables for the density of customers in a salesperson's territory (as a measure of the frequency of transactions) and company size (in order to account for scale economies) are included. Both the degree of human asset specificity and the degree of 'internal' uncertainty are found to be significant determinants of vertical integration.

In an extension of Anderson and Schmittlein (1984), **John and Weitz (1988)** examine forward integration in industrial marketing channels. The authors obtained their data from sales managers from a cross section of 87 industrial goods manufacturers. Their paper is interesting because they estimate a multinomial logit model. It is apparently common for industrial goods manufacturers to sell their goods through both indirect and direct sales channels.[13] Accordingly, the authors define three categories of 'channel use': direct, indirect, and mixed. A good is defined to be distributed through both channels if less than 90 percent of its sales volume occurs through either the direct or indirect sales channel. The following independent variables are included: the degree of human asset specificity is measured as the time period required for a newly hired person with prior experience to become familiar with the sales job; environmental uncertainty is a composite of the responses to five different questions; behavioral uncertainty is measured as the time that typically elapses from the time of the initial contact with the customer to the placement of the order. A large value means that it is difficult to evaluate the individual contribution of a salesperson to a particular sale; that indicates a high degree of uncertainty. In addition, two scale variables are included: the annual sales for the product line of interest in a given company, and the density of customers in a salesperson's territory.

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[13]Using a direct sales channel, the firm retains ownership of the product until it reaches the end-user; all the various indirect channels (distributors, wholesalers, retailers) involve downstream firms that take title to the product.

The authors find their measure of human asset specificity, both measures of uncertainty and the density of customers to increase the likelihood of vertical integration. The results of the multinomial logit model are robust to estimation of a model where the dependent variable is instead defined as the percentage of firm's sales going through the direct channel.

The previous section provided an overview of the empirical evidence regarding the determinants of vertical integration, given the application of Fordist manufacturing techniques. It was consistently found that vertical relationships characterized by a high degree of **asset specificity** are less likely to be organized in the form of spot market relationships. In these cases either long-term contractual relations or vertical integration are chosen as governance structures. Of the different types of asset specificity it is the degree of *human asset specificity* that exerts the strongest influence on the occurrence of vertical integration. This was firmly established for both forward and backward integration, as well as with manufacturing and non-manufacturing data. It has further been shown that the condition of *physical asset specificity* does not increase the occurrence of vertical integration. Monteverde and Teece offer some empirical support for the argument that opportunism-potential that is based on the existence of specific physical assets can be attenuated by means of quasi-integration. Several of the empirical studies reviewed above mention in passing that they encountered such quasi-integrated relationships in the data collection process. Furthermore, there exists no support for a separate influence of the condition of *site specificity* on the decision to vertically integrate. That is not surprising in a situation where a manufacturer has short-term relationships with many different supplier companies.

However, none of the tests of transaction cost theory for data obtained from manufacturing explicitly accounted for the characteristics of the manufacturing system used. Williamson (1985), for example, suggested that within the logic of a production system the decision to integrate is rarely due to technological determination. That, of course, does not address the potential effects of the recent change in the production system (see Chapter I).

The business-strategy type literature, notably studies conducted during the last five years under the guidance of the International Motor Vehicle Project at MIT (see Womack et al. 1990 and references cited therein), analyzes the difference in Fordist and JIT manufacturing in great detail. But this literature focuses on issues of competitiveness and corporate strategy and not on effects of a change in the manufacturing paradigm on the structure of an industry.

My study is motivated by the shift from Fordist to JIT manufacturing. The introduction of JIT manufacturing provides a unique opportunity to test for the effects of a change in the production system on the structure of vertical relationships. I first augment the theory of the choice of governance structures in order to derive a hypothesis on the effects of a change in the production system on the determinants of vertical integration. In order to be able to test for JIT effects, characteristics of JIT manufacturing are measured and included in the model specification chosen. In addition to variables measuring JIT effects, 'traditional' determinants of governance structure are included as well. The hypothesis of a structural change in the determinants of vertical relationships is tested for a new set of data, obtained directly from three U.S. automobile manufacturers.

Practically all the previous empirical tests of transaction cost theory restrict their analysis of governance structures to the simple make or buy dichotomy. However, intermediate forms of vertical relationships, often referred to as quasi-integration, have been known to exist in U.S. manufacturing. It is possible that with the introduction of JIT manufacturing they have gained new importance and prominence as a means of accommodating market relationships based on mutual commitment. I therefore collected information for three separate categories of governance structure.

III. TRANSACTION COST THEORY: DETERMINANTS OF GOVERNANCE STRUCTURE

The relevant body of transaction cost theory is introduced in this chapter. First I lay out the standard theoretical arguments regarding the determinants of governance structure. Then the hypothesis relating the effects of a structural change in the manufacturing system to the determinants of vertical integration is spelled out in detail. Finally, the chapter concludes with a presentation of how the hypothesis will be tested and a section on measurement of the variables.

A. THEORETICAL FRAMEWORK

First I present the standard theoretical framework of transaction cost theory. It serves as the basis of the empirical studies reviewed in the previous chapter; implicit is the assumption of the existence of the mature Fordist manufacturing system. Then I present a theoretical explanation of the effects of JIT manufacturing on the choice of governance structure.

1. STANDARD TRANSACTION COST THEORY ARGUMENTS

The contribution of transaction cost theory has been to show that contracting is not a costless activity but involves transaction costs. With regard to procurement decisions the theory relates individual 'make-or-buy' choices to certain characteristics of the transaction; that way decisions on vertical integration can be analyzed within an economic framework.[1] The underlying hypothesis states that transactors choose organizational arrangements in order to minimize the costs of governing the transaction, such as the cost of writing and enforcing contracts.[2]

Transaction cost theory distinguishes two types of vertical relationships: market-based (i.e. contractual) relationships and internal organization. It argues that the key determinant of the choice of governance structure is the extent to which efficient production requires large investments in durable, relationship-specific assets. Investments in these transaction-specific assets leave only imperfect market exchange alternatives to the parties of a transaction since assets which are specialized to a transaction represent a lower value in other uses; i.e. they create a stream of quasi-rents.[3]

To the extent that these quasi-rents are appropriable, they might become a matter of contention in a bilateral relationship. The more specialized the assets, the greater the

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[1]Procurement decisions involve a large number of considerations; e.g. design requirements; quality control; production and transportation costs; capabilities, capacities, and negotiating strength of potential suppliers relative to those of the producer himself (see Masten 1984, p.404).

[2]See Coase 1937 and 1988, Klein et al. 1978, and Williamson 1975, 1985, and 1989.

[3]Quasi-rent is the value of an asset in excess of its value in its next best use (Klein et al. 1978).

incentive for agents to attempt to influence the terms of trade through bargaining or other rent-seeking activities once the investments are in place.[4] The possibility of post-contractual opportunism creates what the literature refers to as the hold-up problem (see Goldberg 1976): one party can capture all of the appropriable quasi-rents from the other party by threatening to dissolve the relationship unless price concessions are forthcoming, as the following example from the oil industry illustrates.

> Appropriable quasi rents exist in specialized assets of oil refineries, pipelines, and oil fields. This leads to common ownership to remove the incentive for individuals to attempt to capture the rents of assets owned by someone else.
>
> Suppose several oil wells are located along a separately owned pipeline that leads to a cluster of independently owned refineries with no alternative crude supply at comparable cost. Once all the assets are in place (the wells drilled and the pipeline and refineries constructed) the oil-producing properties and the refineries are specialized to the pipeline. The portion of their value above the value to the best alternative user is an appropriable specialized quasi rent. The extent of the appropriable quasi rent is limited, in part, by the costs of entry to a potential parallel pipeline developer. Since pipelines between particular oil-producing properties and particular refineries are essentially natural monopolies, the existing pipeline owner may have a significant degree of market power.
>
> These specialized producing and refining assets are therefore 'hostage' to the pipeline owner. At the 'gathering end' of the pipeline, the monopsonist pipeline could and would purchase all its oil at the same well-head price regardless of the distance of the well from the refinery. This price could be as low as the marginal cost of getting oil out of the ground (or its reservation value for future use, if higher) and might not generate a return to the oil-well owner sufficient to recoup the initial investment of exploration and drilling. At the delivery-to-refinery end of the pipeline, the pipeline owner would be able to appropriate the 'specialized-to-the pipeline quasi rents' of the refineries. The pipeline owner could simply raise the price of crude oil at least to the price of alternative sources of supply to each refinery that are specialized to the pipeline. Given the prospects of such action, if the pipeline owner were an independent monopsonist facing the oil explorers and a monopolist to the refinery owners, everyone (explorers and refiners) would know in advance their vulnerability to rent extraction. Therefore oil-field owners and refinery owners would, through shared ownership in the pipeline, remove the possibility of subsequent rent extraction (Klein et al. 1978, p. 310-311).

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[4]According to Williamson (1989, p.138), 'contracting man' is distinguished from the orthodox conception of 'maximizing man' in two respects: bounded rationality (i.e. his cognitive competence is limited) and self-interest seeking (e.g. opportunism).

Since it is prohibitively costly to write long-term contracts which specify all obligations under all possible contingencies, the possibility of opportunistic behavior, arising after the terms of the contract are agreed upon, is argued to influence the choice of governance structure. Transaction cost theory posits that, in the presence of transaction-specific investments, governance structures will emerge ex ante to reduce the incentives of either the buyer or the seller to behave opportunistically ex post, i.e. after the governance structure is chosen. Specifically, governance structures are argued to be matched with asset specificity characteristics of transactions in a cost-minimizing fashion.

Two general types of governance structures are offered as solutions to the condition of asset specificity: vertical integration and contracts, the duration of which will depend in part on the durability of the associated investments. Vertical integration and contracts differ in terms of their ability to accommodate asset specificity conditions; the desirability of vertical integration is argued to be higher, the higher the cost of conducting transactions via market-based relationships.

The role of **contracts** is to prevent opportunism by stipulating acceptable behavior at the beginning of a relationship between two parties. Their use allows for high-powered market incentives to work in that relationship. A particular relationship between two firms is limited by the length of the contract; that provides the downstream customer with the possibility of switching supplier companies. But contracts incur expenses in both specification and enforcement that limit their usefulness. Efforts to suppress opportunism contractually are limited by the costs of writing and enforcing explicit contractual agreements. **Internal organization**, on the other hand, offers the possibility of making decisions in an adaptive, sequential manner. That reduces the need to enumerate all possible contingencies at the outset of the relationship. But these benefits of integration are limited by the loss of high-powered incentives and the increasing costs of managerial oversight as firms incorporate more activities. Accordingly, organization within the firm necessitates greater investments in monitoring and administration.

Transaction cost theory distinguishes three main forms of asset specificity: specific human capital, specific physical capital, and site-specific capital. Specific human capital is a result of investment in and accumulation of education and skills that are specific to a particular relationship, embodied for example in accountants, designers, and engineers needed to produce a particular product. Specific physical capital includes buildings and machines that can be used for one or a small number of buyers only. Suppose, in order to produce a particular part for one buyer, specific dies are needed for a machine press to turn out that part. The dies represent specific physical capital. Finally, if successive stages of a production process are located adjacent to each other, they involve site-specific capital. Obviously, in order for location to lead to specificity, some transportation costs are required.[5]

Transaction cost theory argues that the choice of governance structure for a given vertical relationship is influenced by the existing asset specificity conditions in the following way.

If a firm uses outside contractors rather than its own employees, opportunistic behavior is possible. For example, a contractor who knows that a firm is facing a deadline

[5]According to Spiller (1985, 296), transportation costs may be physical [in the sense of actually transporting goods] or informational [in the sense that close coordination of production requires personal contact].

may demand more money or lower the quality of its output to meet its own deadline. Since quasi-rents accrue to transaction-specific *human capital*, the cost of transacting across the market increases and makes it necessary to integrate production within the firm (Williamson 1985, 96). Accordingly, an increase in the degree of human asset specificity is expected to lead to an increase in vertical integration.

Referring to an example used above, if the supplier that owns the machine press also owns the dies needed to produce a particular part, i.e. the specific *physical capital*, that situation represents potential for post-contractual opportunism as well. The supplier can raise the price and the buyer may find it prohibitively expensive to switch suppliers in the short run. In the case of predominantly physical asset specificity, however, ownership of the specific assets can eliminate the hold-up problem by internalizing the quasi-rents that are the object of opportunistic behavior. But that does not require production to be governed within the firm; the buyer may own the dies and have other firms bid for provision of the machine press services.[6] Therefore, a higher degree of physical asset specificity is not expected to lead to an increase in vertical integration, but to an increase in quasi-integration.

Investments in immobile *site-specific assets* can also give rise to opportunistic behavior. For example, if the downstream company stops demanding the input provided by the closely located supplier, that company might have to relocate in order to find alternative business; but that can be extremely costly in the case of long-lived and immobile assets. Once such assets are located, the parties operate in a bilateral exchange

[6]Ownership of the specific physical asset is referred to as quasi-integration (or quasi-vertical integration).

relation for the useful life of the assets. Hence an increase in site specificity is expected to favor vertical integration over autonomous contracting since it is argued to reduce potential for opportunistic behavior (Williamson 1985, p.95).

2. HYPOTHESIS: EFFECTS OF THE INTRODUCTION OF JUST-IN-TIME MANUFACTURING ON THE DETERMINANTS OF GOVERNANCE STRUCTURE

With the introduction of the just-in-time manufacturing paradigm in the United States, the relationships between assemblers and supplier companies have begun to change. I now focus on possible consequences of JIT manufacturing on the choice of vertical relationships. By explicitly accounting for effects of mutual commitment I intend to show how market-based relationships are able to curb opportunistic behavior.

Anecdotal evidence for change in the manufacturing paradigm and its effects on vertical relationships was introduced in Chapter I. Compared to Fordist manufacturing, JIT manufacturing is characterized by a relatively high level of underlying <u>mutual commitment</u>; it becomes visible in an increase in the degree of communication and interaction between manufacturers and suppliers, resulting in more closely-knit vertical relationships. Both parties undertake credible commitments in support of their relationship and in order to promote exchange (Williamson 1983, p. 519). The supplier company changes the organization of its production such that it can produce "just-in-time", otherwise it will end up carrying large amounts of inventory for the downstream customer. In addition, it takes on responsibility for quality control and, often, research and development; both activities that were traditionally undertaken by the auto assembler. Accordingly, suppliers invest in quality control training and maintain a product-design staff. Furthermore, first-tier suppliers frequently (re-)locate their operations close to the downstream customer. The assembler, in turn, switches to modular sourcing using single suppliers for a particular automobile platform as opposed to dealing with multiple suppliers per part. In addition, it commits to longer-term relations through both longer-term contracts and the extension of informal contract-renewal promises, given continuous quality improvement by the supplier.

These investments in the relationship represent the kind of underlying commitment between up- and downstream firms typical for JIT manufacturing. Scherrer (1991) argues that the greater emphasis on long-term commitment often leads to the establishment of so-called "obligational networks" between assemblers and suppliers. These relationships involve a closer identification of interests among the firms than under strict market arrangements because each wants to stabilize and maintain the exchange relationship over time. "As a result, these arrangements offer many advantages when compared to either markets or hierarchies in dealing with uncertainty, asset specificity, and transactions requiring teamwork and small-numbers bargaining. For example, they may include flexible incentive systems, methods for adjusting costs, quantities and prices, such as open-ended escalator clauses, and complex arrangements for privately resolving disputes and making binding decisions" (Lindberg et al. 1991, p. 19). The major change from mature Fordism to JIT in terms of vertical relationships consists of a switch from short-term, arms-length relations to those based on long-term mutual commitment.[7] Evidence

[7]See Chapter I.B. and Helper (1991).

from JIT manufacturing sourcing relationships shows the mutuality of these commitments. The assembler maintains its commitment to the supplier in order to elicit its commitment regarding relation-specific investments in expertise, equipment, and research and development. By the same token, the supplier must maintain its commitment to quality, timely delivery of supplies, continual innovative efforts, and so on, if it is to secure a stable and profitable position as a contract partner.[8]

Successfully implemented JIT sourcing relationships enable both parties to benefit from the incentive advantage of market-based relationships. The assembler company is able to save monitoring costs and cut down on inventory compared to Fordist sourcing (see Chapter I, pp. 20); the supplier company is no longer exposed to annual contract bidding in its longer-term relationship with the auto assembler. This was not the case in a Fordist manufacturing environment: short-term, arms-length relationships with multiple suppliers were not designed to reward commitment. There was no incentive for sourcing relationships to continue over time.

The central question of this study is how one can relate the anecdotal evidence for a switch to contractual sourcing relations since the introduction of JIT manufacturing techniques to the transaction cost theory framework of the determinants of governance structure. Contractual agreements always raise the question of opportunism, especially in light of the existence of relationship-specific assets. With regard to the issue at hand, one might say that the potential for post-contractual opportunism could actually have increased due to the introduction of JIT manufacturing: low inventories leave the downstream company vulnerable to supply disruptions; suppliers, on the other hand, frequently adjust

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[8]Aoki (1988), p. 216.

and fine-tune their production operations and layout to a particular customer, thereby increasing their reliance on that relationship (see also Chapter I, pp.25).

In order to address the effect of mutual commitment on sourcing decisions it is therefore useful to explore the mechanisms of contract enforcement. Two ways of enforcing contracts are generally distinguished.[9] In what is known as a third-party enforcement mechanism it is ultimately the presence of a government that defines property rights and enables enforcement of private contracts. The third party provides for enforcement of explicit contractual specifications by means of a court imposed sanction. In principle, explicit contracts can prevent opportunism, however, efforts to suppress opportunism by explicit contractual agreements are limited by the costs of writing and enforcing the terms of the contract. Different from that, a private enforcement mechanism is recognized as well. A so-called implicit contractual agreement is not enforced through a third agency but merely by the threat of termination of the transactional relationship and communication of the contractual failure to the market place. "This goodwill market performance mechanism undoubtedly is a major element of the contractual alternative to vertical integration" (Klein et al. 1978, p.303). For example, "reputation", or "brand name" prevent nonperformance of a business partner by relying on the value of repeat sales a party would give up by breaking a contract. "Performance will be implicitly enforced and a hold-up will not occur if the individual facing termination expects to earn a future quasi-rent stream the present discounted value of which is greater than the immediate

[9]See Klein and Leffler (1981), pp. 615-616, and Klein (1985), pp. 594-596.

short-run gain from breaching the contractual understanding."[10] Coase (1988, p.44) points out that the implementation of longer-term contracts is commonly accompanied by informal arrangements not governed by contract. Therefore, a defrauding firm may gain immediately, but if it can be identified, future business is lost. If contractual agreements are adhered to, the contract is said to be within its self-enforcing range.[11]

The introduction of JIT manufacturing brought with it a relatively high level of mutual commitment in sourcing relationships.[12] Williamson (1983, p.528) refers to a "mutual reliance relation" where both the up- and downstream company invest in relationship-specific capital. Such relationships are characteristic for JIT manufacturing. The presence of high degrees of mutual commitment strengthens the ability to enforce contractual agreements by making hold-up threats less credible. In doing so it increases the self-enforcing range of contracts. Looked at in another way, mutual commitment affects the symmetry of the hold-up threat. The above-mentioned investments in the vertical relationship by assembler and supplier make a potential bargaining situation over

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[10]The quasi-rent stream consists of the returns on transactor-specific investments that will be lost upon termination and the increased costs of purchasing inputs or supplying services in the marketplace after the breach is communicated to others (Klein, 1985, p. 595).

Klein and Leffler (1981) analyze the effect of an implicit contract between producers and consumers regarding the quality of the product. They find that investments by the firm in brand name capital assure customers of the quality of the goods provided.

[11]Klein (1985), p. 595.

[12]Consistent with the anecdotal evidence reported in Chapter I, I treat the increase of mutual commitment in vertical relationships as exogenous to the governance decision of the firm. Mutual commitment is a characteristic of the JIT manufacturing system and as such assumed to be outside the scope of analysis of this paper.

the appropriable quasi-rents more symmetric.[13] That is different from Fordist supplier relationships, where bargaining leverage tended to be asymmetrically distributed in favor of the automobile assembler (see Chapter I). Hence, due to the introduction of high levels of mutual commitment, opportunistic behavior is less likely to occur in JIT sourcing relationships. This reliance on credible mutual commitments has gained importance and effectiveness as the introduction of JIT manufacturing gave vertical relationships a longer-term focus.[14]

From the theory outlined above it follows that the introduction of JIT manufacturing can effectively reduce the propensity for opportunistic behavior by increasing the extent of mutual commitment present in vertical relationships. Therefore I expect an increase in mutual commitment to result in a decrease in the probability of vertical integration.

In addition to the degree of mutual commitment between up- and downstream company, one needs to pay attention to the frequency with which transactions occur. The costs of setting up a vertically integrated organization, i.e. investments in monitoring and administration (see pp. 56-57), suggest the following relationship. As a transaction recurs

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[13]Monteverde (1981, pp. 64-75) shows in a simple game-theoretic model that under symmetric conditions a player attempting to exploit the trading partner is not assured of being able to make himself unambiguously better off. Hence it is in the interest of both firms to find some way of achieving the cooperative solution which promises each party a certain payoff. "Both parties will realize that covert opportunism is impossible and will likely settle, instead, into mutual cooperation where there exists symmetry in bargaining leverage."

[14]For example, in the five years between 1983 and 1988, average written contract length doubled in sourcing contracts in the U.S. auto industry (Helper 1991). Longer-term contracts are likely to increase the present discounted value of the quasi-rent stream in a particular vertical relationship relative to the one-time gain from breaking the contract.

more frequently, integration is expected to become more desirable since potential losses from not integrating, i.e. losses from opportunism and the relative disadvantage with regard to being able to make decisions adaptively, outweigh the costs of integration (Anderson and Schmittlein 1984, p. 388; Williamson 1985, p.60). Frequency of transaction is therefore a relevant dimension in determining the choice of governance structure; an increase in the frequency is expected to lead to an increase in the probability of vertical integration.

With regard to the "standard" determinants of governance structure, transaction cost theory predicts the condition of human asset specificity to increase the probability of vertical integration. The cost of transacting across the market increases and makes it necessary to integrate production within the firm (Williamson 1985, 29-30). The introduction of high levels of mutual commitment is not expected to change that relationship since there exist no contractual solutions to reduce the potential for post-contractual opportunism associated with specific human capital. The marginal effect of that variable on the probability of vertical integration is therefore expected to remain unaffected by the introduction of JIT manufacturing.

As shown earlier, potential hold-up problems in the presence of specific physical assets can be attenuated by internalizing the associated quasi-rents through ownership of the specific assets. Hence physical asset specificity is expected to lead to quasi-integration.[15] However, due to the introduction of JIT manufacturing, the marginal effect

[15] In the binomial probit model the governance structure "quasi-integration" is included in the category "no integration".

of the degree of physical asset specificity on the probability of vertical integration is expected to become smaller. That is because both the degree of mutual commitment and physical asset specificity lead to the occurrence of market-based contractual relations.

The introduction of JIT manufacturing is expected to change the standard transaction cost theory argument of a positive effect of the degree of site specificity on the incidence of vertical integration. Today, geographically close location of assembler and supplier operations is frequently a sign of mutual commitment between the two firms (see Chapter I). Consequently, one could argue that site specificity would decrease the probability of vertical integration. However, it is unlikely for relocation to have occurred to a large extent within the last decade. Site specificity is therefore expected to have no significant effect on the choice of governance structure.

I have now laid out the hypothesis of the effects of a structural change in the manufacturing paradigm on the determinants of governance structure. This question has so far not been analyzed. In order to be able to test the hypothesis, one needs empirical evidence, i.e. data that represent the current sourcing relations in U.S. automobile manufacturing (see IV.A.). The following section presents two different approaches on testing the influence of JIT manufacturing on the decision to vertically integrate.

B. OUTLINE OF HYPOTHESIS TESTS

This section provides a detailed outline of how I am going to test the hypothesis of the introduction of JIT manufacturing on the determinants of governance structure. First, I focus on the effect of JIT manufacturing on the choice of governance structure in the framework of a binomial probit model. That allows a comparison to results from previous studies. Second, I test two different ways of modeling the decision between three different categories of governance structure. The following analysis is conducted in the general framework of probability models: the probability of an event is estimated as a function of relevant parameters.

1. BINOMIAL PROBIT MODEL

First I estimate a binomial probit model. It allows a comparison of my results to the findings of previous empirical work in terms of size, direction, and significance of the determinants of governance structure.[16] By doing that, I will be able to make inferences with regard to the changes in the determinants of vertical integration brought about by the introduction of JIT manufacturing.

The objective of this study is to assess the effect of various transaction characteristics on the choice of governance structure. According to transaction cost theory,

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[16]Specifically, I refer to Monteverde and Teece (1982a) and Masten et al. (1989); both studies estimated binomial qualitative choice models with data from the U.S. automobile industry (see Chapter II).

governance structures are chosen in order to minimize transaction costs. Transaction costs are assumed to be determined in the following way:

$$T_i = \alpha + \beta X_i + \varepsilon_i \tag{1}$$

where i denotes a transaction, X represents a vector of independent variables, $\varepsilon_i \sim N(0,1)$, and ε_i and ε_j $(i \neq j)$ are independent.[17] The actual transaction costs $[T_i]$, however, are unobserved. Instead, one can observe the governance structure chosen $[Y_i]$. A binomial probit model distinguishes two different categories in the dependent variable; in the case at hand they are "vertical integration" and "contractual relation".[18] The two categories of governance structure are related to the unobserved variable, i.e. the level of transaction costs, in the following way:

$$Y_i = 1 \text{ [vertical integration] if } T_{i,\text{vertical integration}} < T_{i,\text{contract}} \tag{2}$$

$$Y_i = 0 \text{ [contractual relation] if } T_{i,\text{vertical integration}} \geq T_{i,\text{contract}}$$

Accordingly, the binomial qualitative choice model estimates

$$Y_i = \alpha + \beta X_i + \varepsilon_i. \tag{3}$$

The parameters of the independent variables can be estimated by the maximum likelihood method using the loglikelihood function

$$L = \sum_{i=1}^{n} Y_i \log F(\alpha + \beta X_i) + \sum_{i=1}^{n} (1-Y_i) \log[1 - F(\alpha + \beta X_i)] \tag{4}$$

where F represents the cumulative distribution function of the standard normal

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[17] There are numerous minor effects that are excluded from the analysis; e.g. design requirements, quality control, production and transportation costs, negotiating strength of potential suppliers relative to those of the producer himself. By the central limit theorem these combined effects are assumed to be normally distributed.

[18] The category contractual relation includes both purely contractual and quasi-integrated relationships.

distribution. The binomial probit model estimates the probability of vertical integration[19]

as $$\text{Prob}\,(Y_i = 1) = \text{Prob}\,(T_{i,\text{vertical integration}} > T_{i,\text{contract}}) = \Phi(Y_i) \tag{5}$$

where Φ denotes the standard normal distribution.

In interpreting the estimation results it is important to note that the estimated coefficients in a qualitative choice model are not meaningful by themselves. Hence it will be useful to calculate and analyze the marginal effects of the independent variables on the choice of governance structure.[20] The partial derivatives are obtained as follows:

$$\frac{\delta prob(Y=1)}{\delta x_j} = \left[\frac{1}{\sqrt{2\pi}} e^{\frac{-(x'\beta)^2}{2}}\right]\beta_j \tag{6}$$

The derivatives, reported in the following chapter, are evaluated at the means of the independent variables. Accordingly, the size of a particular derivative indicates the change in the probability of vertical integration, given a one unit increase at the mean of the corresponding independent variable.[21] In order to assess the impact of a dummy variable on the probability of vertical integration one needs to proceed differently: given the mean of the remaining independent variables, one evaluates the probability of vertical

[19]It estimates the probability of vertical integration since Y_i is set to 1 for every vertically integrated transaction.

[20]This is a useful procedure for continuous variables; the scaled qualitative variables, human asset specificity, physical asset specificity, interval, and develop, are treated as continuous variables.

[21]This assumes that the asset specificity variables are measured on a continuous scale; see Footnote 20.

integration for the value of this dummy set equal to zero and one, respectively; the difference in the probability tells about the effect of a change in the status represented by the dummy variable on the probability of vertical integration.

The binomial probit model to be estimated has the following general form:

$$\text{Prob(vertical integration)} = \alpha + \beta_1 \text{ human asset specificity} + \beta_2 \text{ physical asset specificity} + \beta_3 \text{ site specificity} + \beta_4 \text{ mutual commitment} + \beta_5 \text{ frequency} + \beta_{6\text{-}9} \text{ control variables} + \varepsilon \qquad (7)$$

As indicated above, transaction cost theory predicts that an increase in the degree of *human asset specificity* has a positive effect on the probability of vertical integration. The marginal effect of that variable is expected to remain unchanged; contractual solutions are not suited to reducing the opportunism potential due to the presence of human asset specificity. An increase in the extent of *physical asset specificity* is expected to increase the probability of no integration; i.e. the incidence of contractual vertical relationships. The opportunism potential of specific physical assets can be reduced by ownership of these assets, i.e. through quasi-integration; in the binomial probit model that case is included in the category "contractual relations". As explained above, the marginal effect of that variable is expected to decrease the probability of vertical integration, albeit to a smaller extent as compared to the Fordist environment. In the case of JIT manufacturing, an increase in the degree of *site specificity* is often associated with cooperative, contractual relations between assembly operations and suppliers. However, it is unlikely for relocation to have occurred to a large extent within the last decade. Site specificity is therefore expected to have no significant effect on the choice of governance structure.

The degree of *mutual commitment* is not directly observable; I chose to proxy it by the extent of the application of JIT delivery practices as measured by the frequency of delivery of a part [INTERVAL] (see section C. of this chapter). That variable also captures the effect of the frequency of transactions on the choice of governance structure. JIT manufacturing is characterized by relatively high levels of mutual commitment, i.e. fairly high levels of delivery frequency. Above the JIT level of INTERVAL, the degree of mutual commitment present in a vertical relationship is sufficiently large to curb opportunistic behavior.[22] Increases in mutual commitment beyond that level are expected to reduce the probability of vertical integration. However, for non-JIT levels of

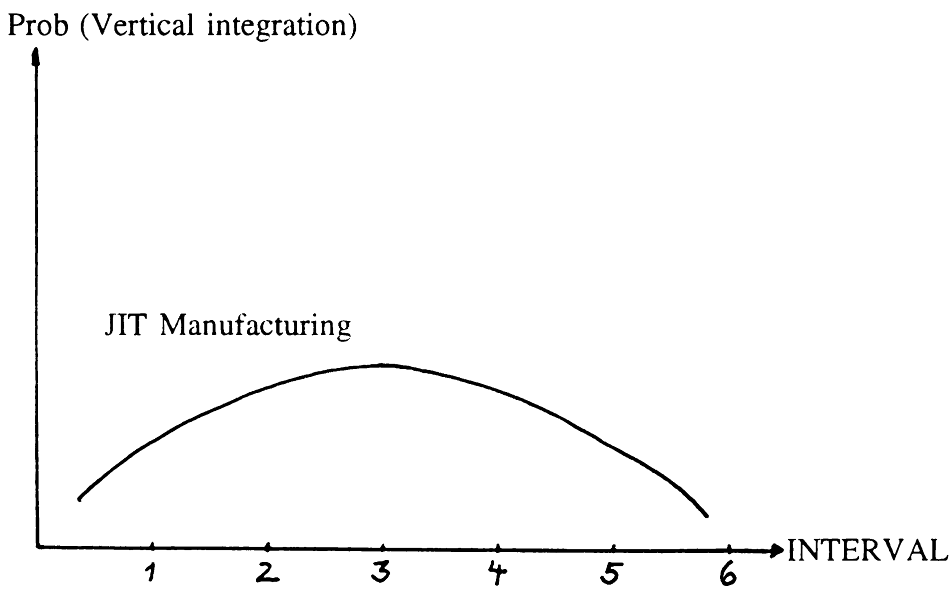

FIGURE 1 **Expected relation between changes in the variable INTERVAL and the probability of vertical integration**

[22]Except for small components, delivery frequencies of at least once a day are generally considered to be typical of JIT manufacturing; see for example Linge (1991), p.320.

INTERVAL the frequency of transactions effect is expected to dominate. An increase in the frequency of transactions is expected to reduce the costs of vertical integration relative to contractual arrangements. These transactions will be governed within the firm, i.e. the probability of vertical integration increases. Since an increase in the degree of mutual commitment is expected to decrease the probability of vertical integration, and an increase in the frequency of transactions is expected to increase the probability of vertical integration, I expect the variable INTERVAL to show a nonlinear influence on the dependent variable (see Figure 1). Table 4 presents the hypothesis of the JIT effect on the choice of governance structure as it applies to the binomial probit model. The signs reported in it specify the expected signs of the partial derivatives of the various independent variables with respect to their effect on the probability of vertical integration and no integration.

TABLE 4 **Binomial probit model - determinants of governance structure under JIT**

	Prob(contractual relation)	Prob(vertical integration)
Human asset specificity	-	+
Physical asset specificity	+	0
Site specificity	0	0
INTERVAL		
Frequency of transactions	-	+
mutual commitment	+	-

I based the hypothesis of a structural change in the determinants of vertical integration on the assumption that JIT manufacturing has indeed altered and changed the manufacturing industries, in particular the automobile industry (see Chapter I). However, what appears like a paradigm shift might not be such; in that case I expect the influence of the 'traditional' determinants of the choice of governance structure (in terms of direction and size) to remain unchanged from previous studies and the degree of mutual commitment to have no statistically significant influence on the choice of governance structure.

In order to facilitate a comparison with the results of this study, Table 5 summarizes the marginal effects on the choice of vertical integration found in closely related previous empirical work. Both the Monteverde and Teece (1982a) and the Masten et al. (1991) study estimated binomial probit models. Monteverde and Teece (1982a) were the first to empirically test a model of the determinants of vertical integration with data obtained from U.S. auto

manufacturers.[23] From information published in Masten et al. (1991) I could calculate the marginal effects reported above. Their study was based on data from a naval construction project.

[23]I am very thankful to Kirk Monteverde for providing access to his data; that way I was able to calculate the unpublished partial derivatives for Monteverde and Teece (1982a). Unfortunately I was unable to obtain similar information from Masten et al. (1989), the other empirical study testing transaction cost theory with auto industry data.

TABLE 5 **Determinants of vertical integration - partial derivatives of previous binomial probit models**

	Monteverde/Teece[a]	Masten et al.[a]
Human asset specificity	+.12**	+.17**
Physical asset specificity	N.A.	-.17*
Site specificity	N.A.	N.A.
Mutual Commitment	N.A.	N.A.

*significant at the 90% level; **significant at the 95% level. N.A. not available since variable was not included in model.
[a] In these studies the scaling of independent variables was based on a 10-point scale. In order to make the size of the calculated marginal effects comparable to my results , where variables are based on 5-point scales, I multiplied these partial derivatives by two.

As mentioned above, the only way I can test for a structural change in the determinants of vertical integration is by comparing my findings to those of previous studies. Accordingly, I focus on a comparison of the marginal effects of the independent variables.[24] In order to test for the statistical difference, I need to calculate the variance of the estimated partial derivatives. The estimated marginal effects are nonlinear functions of the parameter estimates; according to Greene (1990, pp. 679-680), the asymptotic

[24]Table 5 summarizes the results from closely related earlier studies. I am restricted to a comparison of variables that are statistically significant both prior to and after the introduction of JIT manufacturing.

variance of the estimated partials can be calculated in the following way.

$$\text{Asy. Var [estimated partial]} = \phi^2\,[I - (\beta'x)\beta x']V[I - (\beta'x)\beta x']' \tag{8}$$

where I represents the identity matrix, and V stands for the asymptotic variance of β.

However, several caveats apply to such a comparison. For example, different sampling procedures were used across studies. Monteverde and Teece left it up to the automobile manufacturers to supply them with information. In my study, on the other hand, I sampled information on a given set of automobile parts across manufacturers. In addition, each of the studies probably received its information from a different set of respondents at the automobile companies. Differences in results might be attributed to the fact that the information for the various questionnaires was provided by different individuals. However, the robustness of the rankings of the qualitative independent variables could be established for each study since correlation coefficients between the original data and a second set of rankings were reported.

2. DECISION AMONG THREE ALTERNATIVES: ORDERED PROBIT VS SEQUENTIAL PROBIT

A binomial probit model recognizes only two categories in the dependent variable. However, transaction cost theory distinguishes a variety of separate categories of governance structure (see Williamson 1985; Joskow 1985). In addition to the governance structure vertical integration, I now distinguish two different forms of contractual relationships: no integration (i.e. a 'pure' contractual relation), and quasi-integration (i.e. a contractual relation between assembler and supplier where the assembler retains title to specific equipment used by the supplier).

I first estimate a trinomial qualitative choice model; it distinguishes three categories in the dependent variable.[25] These three categories of governance structure are clearly ordered: the extent of across-the-market coordination decreases from "no integration" to "vertical integration". I therefore model the choice of governance structure by means of an ordered probit model.[26]

Similar to the binomial probit, the ordered probit model is built around a latent regression $T = \beta' x + \varepsilon$. As before, ε is assumed to be normally distributed across observations. The actual transaction costs [T] are unobserved, however the governance structure chosen [Y] is observed. In particular,

$$
\begin{aligned}
&Y = 0 \text{ [no integration]} && \text{if } T < 0 \\
&Y = 1 \text{ [quasi-integration]} && \text{if } 0 \le T \le \mu \\
&Y = 2 \text{ [vertical integration]} && \text{if } T > \mu.
\end{aligned} \tag{9}
$$

The probabilities for the three categories in the dependent variable are calculated as follows:

$$\text{Prob}[Y=0] = 1 - \Phi(\beta' x) \tag{10}$$

$$\text{Prob}[Y=1] = \Phi(\mu - \beta' x) - \Phi(-\beta' x) \tag{11}$$

[25]Note that in the binomial probit model, "no integration" and "quasi-integration" were represented by the category contractual relationships.

[26]If one was to estimate an unordered multinomial choice model instead, the information about the orderedness of the three different outcomes would be discarded.

$$\text{Prob}[Y=2] = 1 - \Phi(\mu - \beta'x) \tag{12}$$

where Φ denotes the standard normal distribution.

Distinguishing three ordered categories in the dependent variable implies the existence of two thresholds or cut points between them (see Figure 2). For estimation purposes, the first one of these thresholds is normalized to be equal to zero. The remaining threshold, symbolized by μ, is one of the parameters to be estimated by the model in conjunction with the vector of coefficients. With the exception of a three-way ordered distinction in the dependent variable, the basic structure of this model corresponds to the binomial probit discussed above.

Again, it is important to note that the marginal effects of the regressors X on the probabilities are not equal to the estimated coefficients. Hence it will be useful to calculate and analyze the marginal effects of the independent variables on the choice of governance structure.

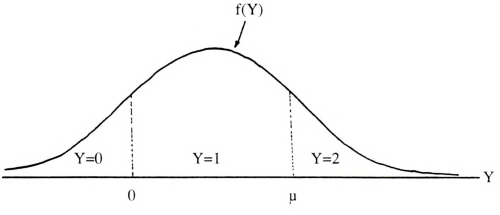

FIGURE 2 **Probabilities in the ordered probit model**

The marginal effects can be calculated according to (13) - (15), where ϕ represents the cumulative standard density.

$$\delta Prob[Y=0]/\delta x = -\phi(\beta'x)\beta \tag{13}$$

$$\delta Prob[Y=1]/\delta x = [\phi(-\beta'x) - \phi(\mu - \beta'x)]\beta \tag{14}$$

$$\delta Prob[Y=2]/\delta x = \phi(\mu - \beta'x)\beta \tag{15}$$

Figure 3 illustrates this effect. The solid curve shows the probability distribution of Y. Increasing one of the independent variables, while holding β and μ constant, is equivalent to shifting the distribution slightly to the right (see dashed line), assuming that β is positive for this variable. The effect is an unambiguous decline in the probability of no integration [Prob(Y=0)], and an unambiguous increase in the probability of vertical integration [Prob(Y=2)]. What happens to the probability of quasi-integration [Prob(Y=1)] is ambiguous; it depends on the two densities (see (14)).

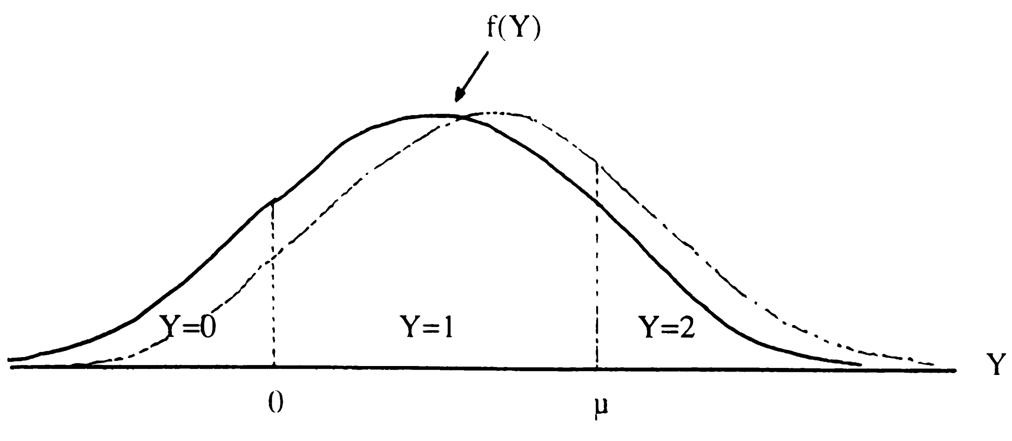

FIGURE 3 **Effects of a change in x on predicted probabilities**

According to the underlying theory, I expect the introduction of JIT manufacturing to lead to an increase in the occurrence of market-based relationships. In terms of Figure 3, I expect the size of Prob(Y=2) to shrink. However, unlike in the case of the binomial probit analysis, a lack of earlier studies applying ordered probit models to transaction cost theory data prevents me from statistically testing the hypothesis of a change in the determinants of governance structure. Nevertheless, estimating an ordered probit model can help to improve the understanding of the nature of the decision on governance structure since it utilizes information on three different categories of governance structure. In addition, it provides an opportunity to test for the effect of physical asset specificity on the governance structure quasi-integration. If the ordered probit model adequately captures the choice between the different governance structures, the results are expected to be qualitatively consistent with those from the binomial probit model.

However, the decision between the three categories of governance structure may be sequential in nature (see Figure 4). Masten et al. (1989, p.267) refer to the fact that automobile manufacturers commonly own specialized tooling even if they did not internalize production. Thus, they argue, the decision to vertically integrate can be separated from the question of ownership of the physical assets. Therefore, I also estimate a sequence of two separate binomial decisions. This approach is based on the assumption that the probability of choice at each stage of the decision is independent of the probability at the previous choice (Maddala 1983, p.50).

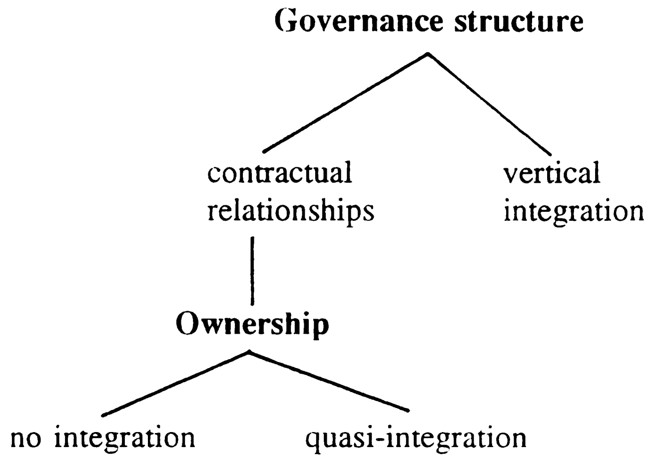

FIGURE 4 **Sequential binomial decision on governance structure**

The case of a sequential-response model is easy to analyze, because the likelihood function is maximized by maximizing the likelihood function of dichotomous choice models repeatedly. With regard to the first of the two decisions the earlier discussion of the hypothesis of a change in the determinants of governance structure applies (see section A.2. of this chapter). The second decision concerns the choice between two types of contractual relationships (no integration and quasi-integration). The set of explanatory variables is expected to influence it in the following way.

The degree of human asset specificity is one of the main determinants of vertical integration. However, the choice between two kinds of contractual relationships is not expected to be influenced by the degree of human asset specificity present in a vertical relationship; neither is a solution to the hold-up problem due to the presence of human asset specificity. Transaction cost theory generally argues that the presence of physical asset specificity leads to quasi-integration. However, I argue that its effect on the ownership decision is reduced , if not eliminated, by the presence of mutual commitment. Sufficiently high degrees of mutual commitment are able to curb opportunism and can therefore support the occurrence of pure contractual relationships, i.e. reduce the probability of quasi-integration. As in the simple binomial probit model, the degree of site specificity is not expected to affect the choice on ownership because close geographical relationships between assembler and supplier are frequently a sign of JIT manufacturing.

C. MEASUREMENT OF VARIABLES

The degree of **mutual commitment** is central to the influence of JIT manufacturing on the type of vertical relationship chosen, as I argued above. This variable, however, cannot be observed directly. There exist two possible approaches to measuring the degree of mutual commitment in a vertical relationship. One could try to quantify the size of mutual commitment by measuring the size of the investments in relationship-specific intangibles such as quality control programs or single sourcing policies. In order for such a measure to represent an accurate proxy for the extent of underlying mutual commitment one needs to obtain data from both the up- and downstream end of vertical relationships. That requires a great deal of information.

Alternatively, one could quantify the degree of mutual commitment by measuring one if its signals. In order to obtain a measure of the degree of mutual commitment I decided to focus on an indirect measurement of observable signals that are related to the JIT manufacturing system. It has been argued before that the successful implementation of JIT manufacturing techniques is characterized by a high degree of mutual commitment between up- and downstream firm. One quantifiable characteristic of manufacturing systems is the frequency of delivery for particular parts. JIT manufacturing is known for its emphasis on speedy delivery, resulting from the lack of inventory stocks and therefore the inability to buffer changes in demand. Accordingly, one could proxy mutual commitment by the extent of the application of JIT delivery practices, a high frequency of delivery being associated with the implementation of JIT and therefore a high degree of mutual commitment between up- and downstream firm.

The variable INTERVAL measures the time interval between deliveries of a part from the supplier to the assembler's consuming plant according to the following five-point scale: delivery every 0-2 hrs [1]; every 2-8 hrs [2]; every 8-24 hrs [3]; every 24-72 hrs [4]; every 72 hrs - 1 week [5]; longer than one week [6]. This scale captures the entire spectrum of possible delivery frequencies; it is quasi-linear in order to adequately reflect the underlying differences in the degree of mutual commitment associated with the various delivery intervals. The first three brackets all measure deliveries of at least once a day. Given a good road transportation system, that is considered typical for JIT manufacturing. I anticipate these delivery categories to represent a degree of mutual commitment that is sufficient to prevent post-contractual opportunism.

The classical lot size or re-order point models lay out the familiar influences that determine the optimal lot size, e.g. procurement cost, volume of sales, cost of holding inventory (see Arrow et al. 1958, pp.1-15). Ceteris paribus, the introduction of JIT is argued to reduce the lot size delivered to the downstream firm, i.e. increase the frequency of delivery. Chapman and Carter (1990) empirically test for the behavior of supplier and customer inventory under JIT; their data set refers to one automobile assembler and a sample of 21 supplier companies. They find a positive relationship between delivered lot size and customer inventory to exist; i.e. they find support for more frequent delivery of small lots from the supplier companies. The authors conclude that this finding indicates the importance of strong supplier/customer linkages in influencing inventory levels (p.47).

I argue that a higher frequency of delivery (i.e. the delivery of smaller lot sizes) signals a higher degree of mutual commitment between assembler and supplier.[27] The assembler eliminates its buffer inventory stock, and the supplier adjusts its production operations to a particular customer.

There exists some support for an incomplete adjustment to JIT manufacturing in the sense that supplier companies produce in lots that are larger than the lots they ship to the assembler (see Chapman and Carter 1990; Nishiguchi 1989; Helper 1989). However that does not dilute the signal that frequency of delivery represents in terms of the underlying degree of mutual commitment. While such an incomplete adjustment is not an example of the textbook-style application of JIT manufacturing, according to which the supplier's produced lot size would be just as small as the lot size delivered, it still represents mutual commitment to the extent that the supplier holds inventory in amounts larger than necessary for JIT production.[28,29]

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[27]A higher frequency of delivery is measured as a shorter time interval [INTERVAL] between deliveries.

[28]The commitment in that case is probably less long-term than in the case of full adjustment in the manufacturing system at the supplier company.

[29]I also defined an alternative proxy for the degree of mutual commitment [DEVELOP]; it measures the number of years during which assembler and supplier work together on producing a part prior to the start of production. Before a part goes into production, supplier and assembler need to come to an understanding about its technical features, quality standards, price, delivery schedules, etc. In order to work out an answer

As was pointed out earlier, INTERVAL also captures the effect of the frequency of transactions between up- and downstream companies on the decision of governance structure. I argue that the interval between delivery interactions indicates the **frequency of transactions** between the two parties; shorter intervals represent a higher frequency of transaction.

An additional independent variable is the degree of **human asset specificity** incorporated in the assets necessary for the production of automotive parts. Since human asset specificity is not directly observable it needs to be measured indirectly. Following Monteverde and Teece (1982a) and Masten et al. (1989), this study measures the degree of human asset specificity characterizing the production of a given automotive part by the degree of specialized and nonpatentable know-how that is generated by the production process. In order to quantify this variable I measure the engineering effort, i.e. engineering cost, that went into the development of a part. That way I can compare my results to earlier studies. Monteverde and Teece (1982a) argued that the degree of human asset specificity involved in the production of an automotive part is primarily the result of developing that part (see Chapter II, pp.36). "To the extent that a contracted product or component requires development work, it appears that the very process itself generates a first-mover advantage based upon the unique know-how impacted in the personnel of

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to the relevant questions, a significant amount of cooperation between assembler and supplier takes place in JIT relationships. For example, Chrysler Corp.'s new JA platform is supposed to go into production in 1995. Yet by 1992 every major system of that platform was already sourced (1992 Ward's Automotive Yearbook, p.53). Often the supplier has to contribute its own R&D efforts to fill in the specifics of production and design of a so-called 'black box' part. I argue that the resulting coordination efforts signal the extent of underlying mutual commitment to a vertical relationship. The more time is spent on pre-production communication between assembler and supplier, the larger is the extent of mutual commitment to that relationship.

the developing firm. ... This unique know-how creates quasi-rents which a single supplier, the one initially chosen when development is begun, may be in a position to appropriate."(Monteverde 1981, p.105) The larger the engineering effort, the greater the expected magnitude of appropriable quasi-rents. Since data on actual engineering costs are of proprietary nature, an engineering cost rating, based on a five-point scale [HAS], is used instead.

As in Masten et al. (1989), the degree of **physical asset specificity** is measured by the extent to which the physical assets used to manufacture a given part are specific to a particular automobile manufacturer. This variable is also measured in terms of a five-point scale [PAS]. The degree of physical asset specificity is considered to be low if the assets used in the production of a part can be easily adapted to serve customers in other industries and other automobile manufacturers (e.g. the production of weather stripping). It is considered to be high if these assets cannot be easily adapted to serve customers in other industries or even other automobile manufacturers (e.g. the production of a cylinder head).[30]

In terms of its measurement, the degree of **site specificity** characterizing a particular transaction is probably the most elusive of the different categories of asset specificity. Ideally, a measure of site specificity is supposed to capture the potential for opportunism that is associated with the importance of locating upstream production close to subsequent stages of the manufacturing process. But focusing on proximity exclusively

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[30]The evaluation of the automotive parts in the sample for both the human and physical asset specificity variables show a high degree of consistency across car manufacturers; for both measures the correlation of rankings ranges between 0.93 and 0.98. This leads me to believe that they are reliable evaluations.

omits other factors that also affect the degree of opportunism at stake. For example, Masten et al. (1989) point out that "the issue of opportunism by the automaker is attenuated if the assets [located close by] are easily moved"(p.270). Previous empirical studies have used two different approaches in measuring the degree of site specificity. Spiller (1985) relied on the actual distance between plants. That measure can distinguish the degree of site specificity between different transactions; on the other hand there exists the possibility of location being determined endogenously. Masten (1984) and Masten et al. (1989) measure site specificity qualitatively as the importance to locate up- and downstream facilities close to each other. Their measure avoids the endogeneity problem; yet it cannot distinguish the degree of site specificity of different suppliers of the same part. It is therefore too aggregate a definition of site specificity for my purposes.

My study proxies site specificity by the actual distance [DISTANCE] between the supplier plant and the consuming plant of the auto assembler.[31] It is measured as the distance [in road miles] between the supplying and the consuming plant. According to that proxy a larger distance corresponds to a lower degree of site specificity. It is necessary to refer to the assembler's consuming plant since the manufacture of an automobile is a very complicated process; not all the parts that go into a car are shipped directly to the assembly plant. For example, engine parts like piston rings are usually delivered to the engine plant of the car assembler.[32] The site specificity proxy is measured on a five-

[31]Inherent in this approach is the assumption that transportation costs are important.

[32]The assembled engine is then shipped to the car assembly plant. Accordingly, in the case of piston rings, the engine plant is the consuming plant. These two plants may be located very close to each other. See e.g. the GM operations in Lansing, MI, where engine and assembly plant are located just across the street from each other.

point scale. The five categories correspond to the following distances: 0-50 miles [1], 51-300 miles [2], 301-550 miles [3], 551-800 miles [4], and greater than 800 miles [5]. Category 1 allows for JIT 'satellite' plants, it represents delivery times of less than an hour. Category 5 represents parts that are shipped over distances of greater than 800 miles (most of these are actually imported parts). Within each of the mileage blocks the effect of distance on the decision to integrate is expected to be constant.[33]

In addition, the sample includes a set of **control variables**: With regard to the assembly plants in my sample, imported parts show a very low degree of site specificity. At the same time, only one of the seven imported parts is vertically integrated. In order to eliminate a possible spurious correlation between imports and the degree of site specificity I included an IMPORT dummy that is set to one if a particular part is imported.

The data set contains three dummy variables that indicate the auto manufacturer [FORD, GM and CHRYSLER]. Two of these dummies are included as right-hand side variables in the estimated models; they are expected to pick up existing differences in the scaling of the qualitative variables as well as differences in corporate strategy. Similar controls for the manufacturer were used by Monteverde and Teece (1982a) and Masten et al. (1989). In reporting the results of the estimated qualitative choice models I will not list the coefficients on the company dummies due to confidentiality reasons.

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[33]In order to account for the location pattern of potential suppliers, a measure similar to the one used by Spiller (1985) was created; it was calculated by dividing the actual distance by the ratio of (distance to the closest supplier) / (distance to actual supplier). It was found to not contribute information beyond what the DISTANCE variable already measured.

Some auto parts are not specific to a particular automobile manufacturer or a particular automobile. For these components spot market relationships are expected to operate quite well (see Monteverde 1981, p.106). Therefore I include a GENERIC dummy variable to indicate the parts that are not attractive to integration because they are common across auto manufacturers. The variable is set to one if a part is not specific to a particular auto manufacturer (see Appendix A for a list of the generic parts).

I have now presented my hypothesis and how I am going to test it. Of prime interest will be the size of the reported marginal effects of the explanatory variables. It will be useful to refer back to Table 5 for an assessment of the binomial probit analysis.

IV. EMPIRICAL ANALYSIS

This chapter first introduces the data set that was obtained for this project. It then presents the results of testing the hypothesis of a structural change in the determinants of vertical integration in a binomial probit model. In addition, evidence is presented on the choice of governance structure in an approach that distinguishes three different categories in the dependent variable.

A. DATA

The following analysis is based on a set of cross-section data obtained directly from U.S. automobile manufacturers between September 1991 and March 1992. The collection of panel data was well beyond the scope of this study.[1] However, the U.S. automobile industry has been moving rapidly toward a new equilibrium that is characterized by widespread use of the JIT manufacturing system.

[1]To my knowledge none of the empirical work in transaction cost theory uses panel data. For a study of the pattern of vertical integration around 1950 see Henrickson (1951), who analyzes the case of GM's Buick division in Flint.

None of the data necessary for this project were publicly available; they were obtained directly from several car manufacturers via questionnaire.[2]

Once contacts were established with each of the car assemblers, I chose to collect data for one particular size of car, compact cars, in order to control for possible scale effects. By doing that I eliminated possible biases that could arise from the comparison of widely differing car lines associated with different scales of production. A niche vehicle, e.g. a sporty car featuring a high performance engine, with low annual production, often sets the image for the entire line of cars of an automobile manufacturer. Since that usually means a very high level of attention is being paid to quality and technical detail, it could result in a higher degree of outsourcing as the assembler has to reach out to suppliers that can provide the latest technology. The development and production of such a vehicle often constitutes a 'trial run' in terms of relationships with possible suppliers for a future mass market model. In these cases, one would probably find an unusually close cooperation between assembler and supplier as compared to the production of a bread-and-butter, high volume automobile. I therefore decided to concentrate on data for a particular platform.

In the context of my study, 'platform' refers to the structural underbody of a car; it is a concept that defines vehicles with common wheelbase and other dimensional characteristics that would make them relatively simple to produce on a common line (Luria 1990a, 143). For example, the Buick Skylark, Oldsmobile Achieva [formerly the Calais], and Pontiac Grand Am are separate models with different bodies, yet are all 'N-

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[2]Data sources were the U.S. Big Three: Chrysler, Ford, and General Motors. Saturn Corporation declined to participate in this project.

platform' vehicles. The platform was chosen as the unit of analysis because the engineering and tooling for the vehicle's basic structure accounts for the lion's share of total product development and launch costs (MIT Commission 1989, 25).

The compact car platforms in the sample correspond to the following real-life car models: General Motors assembles the N-car at its Lansing, Michigan, plant. This platform is the basis for the Pontiac Grand Am, the Buick Skylark, and the Oldsmobile Achieva. Ford assembles its Tempo/Topaz cars at two locations: Kansas City, Missouri, and Oakville, Ontario. Chrysler assembles its two A-body cars, the Dodge Spirit and the Plymouth Acclaim, at its Newark, Delaware, plant.

The questionnaire was designed to collect information on a sample of parts and components that constitute an automobile. Monteverde and Teece (1982a) and Masten et al. (1989) enabled their contacts at the automobile manufacturers to self-select the components to be included in the sample. I did not permit self selection but chose the sample myself on the basis of a stylized definition of a compact car (see Appendix A for the list of 100 parts organized in terms of 12 subsystems). The sample used in my study consists of 30 automotive parts; its size was chosen to restrict the questionnaire (see Appendix B) to manageable size. The 30 parts in the sample were selected in order to represent the 12 subsystems as well as a range of asset specificity characteristics.[3] The decision to focus on parts (vs. subassemblies) eliminates possible bias toward in-house

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[3]I am indebted to Dan Luria for invaluable advice.

production that exists for data at the more aggregate level of subassemblies (see Luria 1990b).[4]

Data were collected at the level of the individual car assembler-supplier relationship (see Appendix B for a description of the questions asked in the questionnaire). Accordingly, each datapoint represents a particular assembler-supplier relationship. That way I can represent cases of multiple sourcing by separate datapoints.[5] Data used in previous studies did not allow for a distinction between different suppliers for a particular part.

The data gathering process was fairly complicated. The purchasing organizations of U.S. car assemblers are generally organized by vehicle subsystems. In order to be able to get all the information for the parts in the sample, I therefore had to cut across several organizational boundaries within each corporate organization. In general, I obtained my data from purchasing and engineering staff responsible for the relevant platforms.[6]

The data set consists of 89 observations; one company had two different suppliers for several parts while the other two companies could not provide information on some of the parts in the questionnaire. Of the 89 observations, 13 (14.6 %) represent the

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[4]Luria (1990b) measures the degree of in-house production in two different ways: by means of a 'value shipped' variable that gives the car assembler credit for 'make' as if all of the parts and assemblies shipped from its parts plants were added in those plants; and by means of a 'value added' variable that gives the car assembler credit only for the proportion of value added in its own parts plants. In both cases he finds the degree of in-house production to be greater at the level of subassemblies than at the level of parts and components.

[5]The questionnaire allowed for a maximum of five assembler-supplier relationships per part.

[6]The interview process and the questionnaire were in full compliance with the relevant guidelines set forth by Michigan State University.

category no integration, 28 (31.5 %) fall in the category quasi-integration, and 48 (53.9 %) fall in the category vertical integration (for descriptive statistics see Table 6).[7]

The control variables listed in Table 6 (IMPORT and GENERIC) are defined as dummy variables.[8] The remaining independent variables are based on ordinal rankings of each part in the sample relative to the others. Like previous empirical work in this field I treat these qualitative variables as continuous ones.[9] The variable means listed refer to the scales of the independent variables as defined earlier (see Chapter III.C. and Appendix B). For example, the mean of HAS for the category "No integration" corresponds to a slightly less than medium level of human asset specificity. Note that the means of DEVELOP hardly vary across governance structures. Table 7 lists the correlation coefficients among the independent variables.

Although it is not possible for me to track the influence of JIT manufacturing on the decision to vertically integrate over time, I can offer descriptive statistics of how the explanatory variables differ for parts associated with high and, respectively, low degree of mutual commitment. In order to do that I organized the sample into two subgroups, based on the values of INTERVAL. From Table 8 one can see that the data provide evidence for positive correlation between JIT and location: suppliers characterized

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[7]I have no way to establish how that compares to earlier situations characterized by Fordism. But the fact that a third of the observations represent quasi-integrated relationships is indicative of the need for a three-way distinction in the dependent variable.

[8]Ideally one would also want to include dummy variables for the different auto parts. However, I do not have enough observations available to control for parts effects.

[9]See for example Monteverde and Teece (1982 a) p.209. Given a sufficient number of datapoints, one could define separate dummy variables for n-1 categories of each scale; where n refers to the number of categories.

TABLE 6 **Means and standard deviations*, vertical integration data**

CATEGORY OF THE DEPENDENT VARIABLE

INDEPENDENT VARIABLES	No Integration	Quasi-integration	Vertical integration	ENTIRE SAMPLE
Import	0	0.21	0.02	0.08
Generic	0.38	0.50	0.25	0.35
Has	2.54 (1.61)	2.25 (.80)	3.23 (1.02)	2.82 (1.14)
Pas	1.92 (1.26)	2.18 (.94)	2.75 (.89)	2.45 (1.01)
Interval	3.00 (1.53)	3.96 (1.14)	3.15 (.74)	3.38 (1.08)
Distance	2.54 (.97)	3.25 (1.24)	2.73 (1.01)	2.87 (1.10)
Develop	2.80 (.56)	2.52 (.55)	2.74 (.72)	2.68 (.65)
Number of observations	13	28	48	89

* Standard deviation in parentheses below continuous variables.

TABLE 7 **Correlation matrix** (89 observations)

	Has	Pas	Distance	Interval	Generic	Import
Has	-					
Pas	.57	-				
Distance	-.12	-.13	-			
Interval	-.09	-.07	.58	-		
Generic	-.32	-.26	-.04	-.17	-	
Import	-.06	.08	.53	.25	-.38	-

by high mutual commitment tend to be located closer to the customer. Furthermore, these supplier relations exhibit a larger extent of pre-production communication as well. The degree of human asset specificity present in a vertical relationship does not seem to be affected by the introduction of JIT. However, JIT relationships are associated with a higher degree of physical asset specificity, and involve shorter distances to supplier operations.

TABLE 8 **Means and standard deviations by degree of mutual commitment**

	High Mutual Commitment	Low Mutual Commitment
Import	.09	.11
	(.28)	(.32)
Generic	.40	.31
	(.50)	(.47)
Has	2.80	2.76
	(1.08)	(1.28)
Pas	2.54	2.20
	(.89)	(.93)
Distance	2.31	3.49
	(1.00)	(1.00)
Develop	2.67	2.50
	(.68)	(.53)
Number of observations	35	35

Standard deviations in parentheses. Company dummies are not reported for confidentiality reasons. The left (right) column represents observations with small (large) values for DEVELOP; each column represents 2/5 of the sample; the middle 1/5 observations are omitted.

B. RESULTS

1. BINOMIAL PROBIT ANALYSIS

I first test the hypothesis of a structural change in the determinants of governance structure by means of a binomial probit model. In order to do that, I collapse the three categories of governance structure into two: the dependent variable is set to one if a supplier relationship is vertically integrated; otherwise it is set equal to zero. This way I can compare my results to the evidence on the determinants of governance structure reported in previous studies (see Table 5). The reason for this exercise is that I do not have panel data available in order to test for the hypothesized structural change in the determinants of vertical integration. By estimating the same type of model as previous studies I can at least compare the significance and direction of the determinants of vertical integration in a JIT manufacturing environment to those found to exist earlier, in a Fordist manufacturing environment.

Table 9 reports two specifications of the binomial probit model.[10] From the values of the χ^2-tests one can see that for each specification the vector of independent variables is highly significant. The explanatory power of a qualitative choice model can be calculated by the so-called R^2-analogue; like the standard R^2 it is defined to lie between 0 and 1. It is calculated as $1-[\ L\ (\hat{\Omega})/\ L\ (\hat{\omega})]$, where $L(\hat{\Omega})$ represents the

[10]The coefficients for the company-dummies are not reported due to confidentiality reasons.

maximum value of the loglikelihood function, and $L(\hat{\omega})$ the maximum value of the loglikelihood under the constraint that $\beta=0$.

Both the degree of human asset specificity and the degree of mutual commitment are consistently significant in explaining the occurrence of vertical integration.[11] The condition of human asset specificity significantly increases the incidence of vertical integration. For INTERVAL I find the expected nonlinear effect on the structure of vertical relationships to exist. A χ^2-test on $(\text{INTERVAL})^2$ yields a value of 8.54; $\chi^2_{.99}(1) = 6.635$.

The degree of site specificity present in a vertical relationship is found not to affect the choice of governance structure in equation 2. Equation 1 produces weak statistical evidence for a negative effect of the degree of site specificity on the probability of vertical integration.[12]

The marginal effects of the independent variables on the decision to vertically integrate are reported in Table 9 below the standard deviations.[13] They are evaluated

[11]Using DEVELOP instead of INTERVAL to proxy for the degree of mutual commitment in a vertical relationship, I find a linear but in most cases statistically insignificant influence on the probability of vertical integration. An increase in DEVELOP (mutual commitment) leads to a reduction in the probability of vertical integration. That suggests the following: mutual commitment by itself affects the choice of governance structure in a linear fashion. In other words, the inverse quadratic of INTERVAL is the result of it capturing two different influences on the probability of vertical integration, mutual commitment and frequency of transactions. Considering the similarity of the means of DEVELOP across governance structures (see Table 6), it is not surprising for it to be not statistically significant.

[12]The pattern of influence on the decision to integrate reported in Table 9 is robust with respect to the scaling of the qualitative independent variables; I tested both quadratic and logarithmic transformations of these variables.

[13]An evaluation of the probit model at the means of the independent variables renders 0.53 and 0.47 as the probabilities of vertical integration for equation 1 and 2, respectively.

TABLE 9 **Binomial probit analysis: probability of vertical integration**

	equation 1	equation 2
constant	-0.13**	-4.68**
	(1.05)	(2.20)
Import	-2.27**	-2.13**
	(0.94)	(0.97)
	(-0.13)	(-0.14)
Generic	-0.72**	-0.51
	(0.35)	(0.37)
	(-0.004)	(-0.02)
Has	0.33*	0.39**
	(0.17)	(0.19)
	(0.13)	(0.15)
Pas	0.22	0.11
	(0.21)	(0.24)
	(0.09)	(0.04)
Distance	0.44*	0.29
	(0.25)	(0.27)
	(0.18)	(0.12)
Interval	-0.53**	2.71**
	(0.21)	(1.37)
	(-0.21)	(-0.24)[a]
$(\text{Interval})^2$	----	-0.49**
		(0.22)
Log-likelihood	-41.73	-37.46
χ^2	39.37***	47.91***
df=	8	9
χ^2 (vs controls)	16.47***	25.01***
df=	4	5
R^2-analogue	0.32	0.39

TABLE 9 (cont'd).

Values under coefficients are the standard error and the partial derivative evaluated at the mean. [a] Includes effect of quadratic term. *significant at the 90% level; **significant at the 95% level; ***significant at the 99% level. Company dummies are not reported.

at the mean of all the independent variables. Interestingly, the marginal effect of the degree of human asset specificity corresponds almost exactly to the finding in Monteverde and Teece (1982a) and Masten et al. (1991) (see Table 5). That confirms the main finding of the empirical transaction cost literature regarding the effect of the degree on human asset specificity on the probability of vertical integration. Furthermore, in the context of my hypothesis, it suggests that the introduction of JIT has not altered the way in which human asset specificity influences the choice of governance structure (see also Table 8). That finding is robust across specifications.[14] I cannot establish statistical evidence for a difference in the marginal effect of the degree of human asset specificity, comparing the results of Monteverde and Teece (1982a) with my own. I calculated the asymptotic variance of the slope of the human asset specificity variable according to (8); the partial derivative from the Monteverde and Teece study was found to lie within the area defined by adding and subtracting two standard deviations from the estimated slope of human asset specificity in my probit model. However, the introduction of JIT manufacturing is found to shift the cumulative density function downward (see Figure 5).

The significant effect of the IMPORT dummy on the probability of vertical integration warrants a comment. In both specifications a status change of the parts in the

[14]That also applies to various specifications not reported.

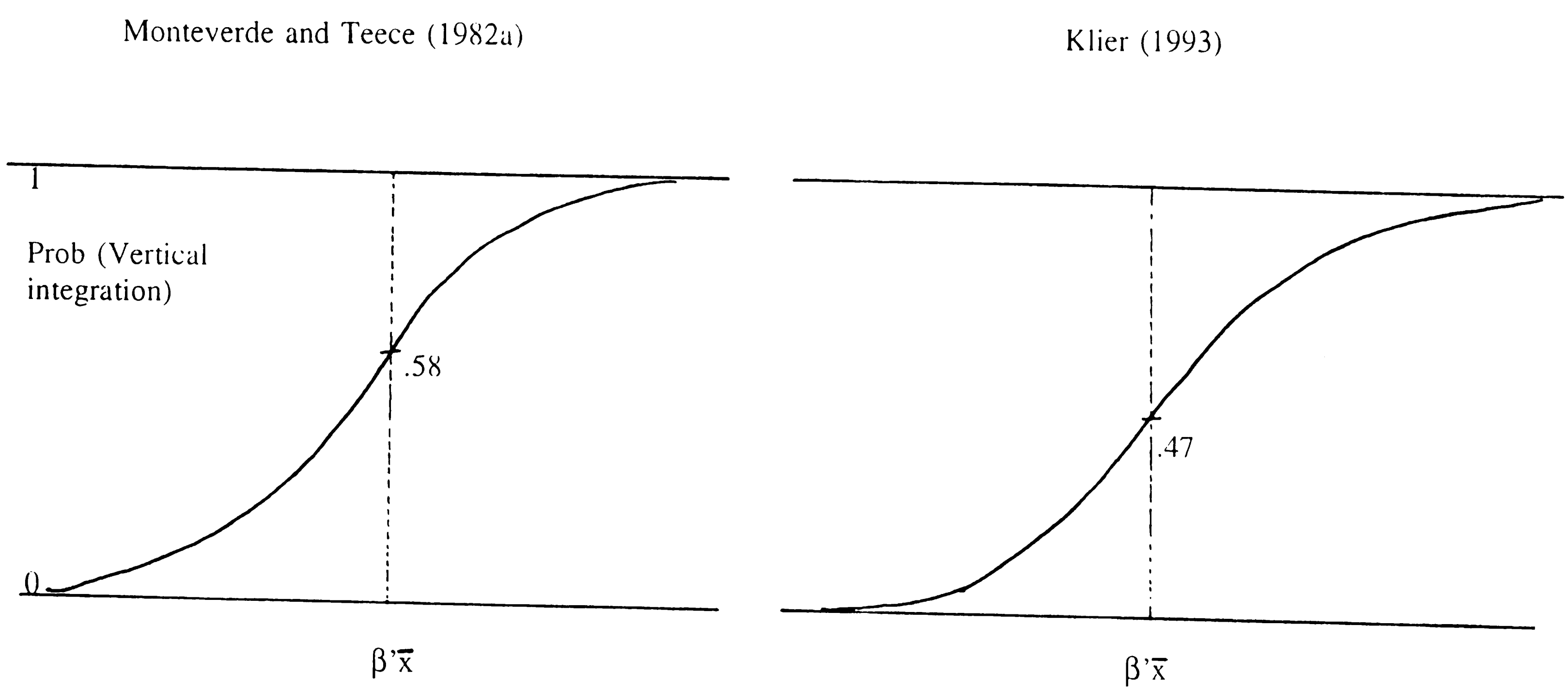

FIGURE 5 **Effect of JIT manufacturing on predicted probabilities**

sample from domestic to imported, ceteris paribus, significantly reduces the probability of vertical integration.

The partial derivative for INTERVAL reflects the nonlinear effect of that variable (see Figure 6). It is explained as a combination of two separate influences. INTERVAL proxies the degree of mutual commitment in a vertical relationship by measuring the time interval between deliveries. A decrease in INTERVAL (an increase in the degree of mutual commitment) was argued to reduce the probability of vertical integration. In addition, INTERVAL can also be interpreted as measuring the frequency of transactions between the parties. An increase in the number of interactions was argued to increase the probability of vertical integration. The peak of the influence of INTERVAL on the probability of vertical integration occurs at a value of 2.77; that value corresponds to a frequency of delivery of slightly higher than once a day. Except for small components, delivery frequencies of at least once a day are generally considered to be typical of JIT manufacturing.[15] As can be seen in Figure 6, the downward sloping section of the effect of INTERVAL on the probability of vertical integration corresponds nicely to the application of JIT manufacturing techniques. One can see that as the frequency of delivery increases beyond that level (and the degree of mutual commitment increases accordingly), the probability of vertical integration decreases.[16] Even though high levels of mutual commitment lead to the occurrence of vertical integration, the probability of vertical

[15]See for example Linge (1991), p.320.

[16]The increase in the frequency of delivery is represented in Figure 6 as a reduction in INTERVAL.

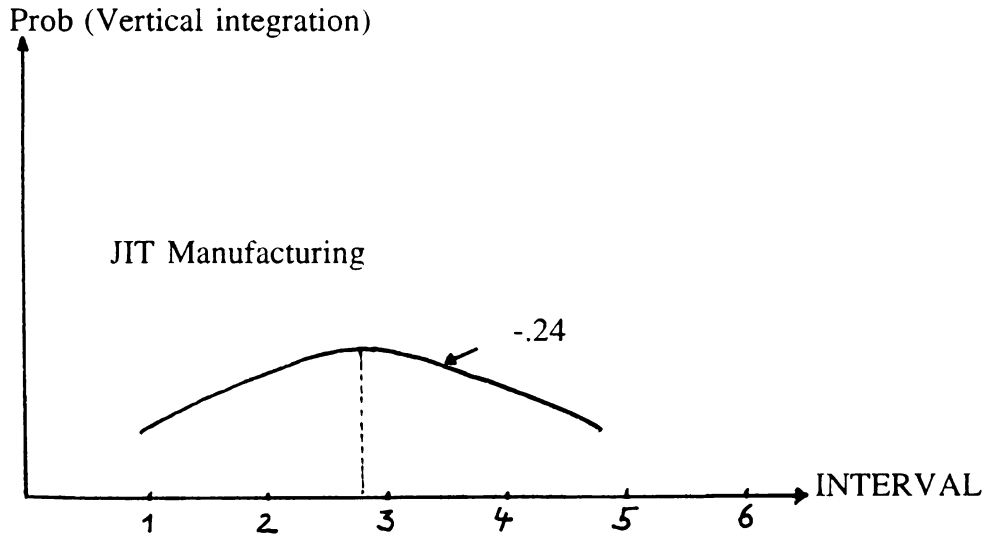

FIGURE 6 **The influence of INTERVAL on the probability of vertical integration**

integration decreases significantly once delivery frequencies increase beyond about once a day. The negative sign in the reported partial derivative is explained by the fact that themarginal effect was evaluated at the mean of INTERVAL (3.38), which is greater than the value of INTERVAL at which the peak of the nonlinear relationship occurs.

To sum up, the results of the binomial probit model support the hypothesis of a structural change in the determinants of governance structure in the following ways.

I establish the importance of the degree of mutual commitment as a new determinant of governance structure. The proxy variable, frequency of delivery, is found to be inversely quadratic related to the probability of vertical integration, reflecting the effects of both mutual commitment and frequency of transaction. Once JIT manufacturing takes hold, an increase in the frequency of delivery results in a lower probability of vertical integration. I argue that JIT manufacturing introduces mutual commitment to vertical relationships to a degree that is sufficient to curb the potential for opportunistic behavior. The range over which this effect occurs relates nicely to multiple daily deliveries, typical for JIT manufacturing.

As expected, I cannot establish evidence for a positive effect of site specificity on the probability of vertical integration. The site specificity variable is insignificant in equation 2; equation 1 contains weak evidence for a statistically significant increase in the probability of contractual relationships in the presence of site specificity.

These findings are not reconcilable with the maintained null hypothesis of no structural change in the determinants of vertical integration

Furthermore, the influence of the degree of human asset specificity on the choice of governance structure is found to be unaffected by the introduction of JIT manufacturing. Consistent with my hypothesis, the significant influence of human asset specificity is confirmed; in fact, the marginal effect of that variable does not differ statistically from that established in previous related studies.

2. ORDERED PROBIT AND SEQUENTIAL PROBIT ANALYSIS

Two specifications of an ordered probit model are reported in Table 11. In both of these the vector of independent variables is highly significant; in addition the estimated threshold parameter μ is consistently significant. It represents the threshold between the two categories quasi-integration and vertical integration; the threshold between 'no integration' and quasi-integration was normalized to zero (see Figure 2).

From Table 10 one can see that there is support for an inverse quadratic in INTERVAL. The addition of a quadratic term for this variable is statistically significant (a χ^2-test yielded a value of 11.89; $\chi^2_{.99}(1) = 6.635$).[17] As discussed in Chapter III., one needs to perform additional calculations in order to interpret the results of on ordered probit analysis. First I report the so-called base-line probabilities (see Chapter III, equations (10)-(12)) in Tables 11 and 12.[18] These estimated probabilities are reasonably close to the actual frequencies of governance structures in the sample: non-integrated relationships 14.6%, quasi-integrated relationships 31.5%, and vertically integrated relationships 53.9%. Additionally, Tables 11 and 12 list the marginal effects of the regressors on the baseline probabilities (see Chapter III.C. equations (13)-(15)).

The point of this exercise is to test whether the decision between three different governance structures can adequately be modeled by means of an ordered probit model. The results, reported in Table 10, are similar to the ones from the binomial probit model (see Table 9). The signs of the coefficients of equation 4 follow the same pattern as in estimated equation 2 (Table 9). That suggests that it is reasonable to break out quasi-integration as an intermediate category. In terms of the marginal effects of the

[17]As in the binomial probit model, I find a significant nonlinear influence of INTERVAL on the choice of governance structure. The reported marginal effects are small and negative since they were evaluated just to the right of the peak of the inverse quadratic (peak = 3.46; mean of INTERVAL = 3.38). The peak is slightly larger than the one from the binomial probit model. Including DEVELOP instead of INTERVAL as a proxy for the degree of mutual commitment in a vertical relationship, I find a linear but statistically insignificant influence on the probability of vertical integration. An increase in DEVELOP (mutual commitment) leads to a reduction in the probability of vertical integration. That suggests that mutual commitment by itself affects the choice of governance structure in a linear fashion (see also footnote 11 of this Chapter).

[18]The reported baseline probabilities are robust with regard to the specification of the model.

independent variables on the choice of governance structure. Tables 11 and 12 list the size of the partial derivatives for equation 3 and 4 respectively. Comparing Tables 12 and 9, the size of the partial derivatives for the category vertical integration is quite robust, supporting the appropriateness of an ordered probit model. However, comparing the partial derivatives for the categories "no integration" and "quasi-integration" (e.g. in Table 12), one finds them to be almost identical in size and in terms of direction. A series of t-tests rejects the hypothesis of statistically different coefficients for the no integration and quasi-integration branches. Therefore, it seems worthwhile to look at the possibility of a sequential decision that treats the two forms of contractual relationships as choices in a separate decision (see Figure 4).

TABLE 10 **Ordered probit analysis**

independent variables:	equation 3	equation 4
constant	0.54	-2.10
	(0.83)	(1.42)
Import	-0.68	-0.19
	(0.81)	(0.78)
Generic	-0.32	-0.18
	(0.31)	(0.30)
Has	0.17	0.21
	(0.14)	(0.15)
Pas	0.27*	0.18
	(0.15)	(0.19)
Distance	0.19	0.08
	(0.21)	(0.25)
Interval	-0.14	1.59*
	(0.14)	(0.84)
$(\text{Interval})^2$	---	-0.23**
		(0.11)
μ	1.16**	1.24**
	(0.20)	(0.23)
Log-likelihood	-73.80	-70.80
χ^2	26.46***	32.45***
df=	8	9
χ^2 (vs controls)	9.15*	15.14***
df=	4	5
R^2 analogue	.152	.186

TABLE 10 (cont'd).

Standard errors in parentheses. *** significant at the 99% level; ** significant at the 95% level; * significant at the 90% level. Company dummies are not reported.

TABLE 11 **Probabilities of choosing a governance structure: ordered probit model, equation 3**

	π_1 [NI]	π_2 [QI]	π_3 [VI]
BASELINE probabilities[1]	0.08	0.35	0.55
partial derivatives for dummies			
Import	-0.01	0.15	-0.15
Generic	0.06	0.07	-0.13
partial derivatives evaluated at the mean			
Has	-0.03	-0.04	0.07
Pas	-0.05*	-0.06*	0.11*
Distance	-0.03	-0.04	0.07
Interval	0.03	0.03	-0.05

[1] evaluated at the mean of all explanatory variables.
* significant at the 90% level; ** significant at the 95% level.

TABLE 12 **Probabilities of choosing a governance structure: ordered probit model, equation 4**

	π_1 [NI]	π_2 [QI]	π_3 [VI]
BASELINE probabilities[1]	0.08	0.36	0.56
partial derivatives for dummies			
Import	-0.007	0.08	-0.07
Generic	0.03	0.04	-0.07
partial derivatives evaluated at the mean			
Has	-0.03	-0.05	0.08
Pas	-0.03	-0.04	0.07
Distance	-0.01	-0.02	0.03
Interval	-0.05**	-0.08**	0.013**

[1] evaluated at the mean of all explanatory variables.
* significant at the 90% level; ** significant at the 95% level.

Table 13 shows the results of the second stage of the sequential binomial probit model. It is estimated for a reduced sample (N = 41) that excludes all observations of vertically integrated relationships. The coefficients and partial derivatives are estimates of the probability of quasi-integration.[19] Neither equation allows strong statistical inferences. A χ^2-test indicates the equation 6 is significant only at the 90% level. That might very well be due to the small sample size. Therefore, the sequential probit model cannot provide conclusive evidence with regard to the nature of the decision process.[20]

The comparison between the ordered and sequential probit model has to remain inconclusive, mainly due to the small sample size at the second stage of the second stage of the sequential decision model. However, none of the empirical findings contradict the results of the binomial probit model that was used to test the hypothesis of a change of the determinants of vertical integration. In fact, the results turn out to be remarkably robust.

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[19]Quasi-integrated vertical relationships are counted as "1" in this qualitative choice model.

[20]It is interesting, though, that INTERVAL is found to significantly influence the choice between "no integration" and "quasi-integration" in a nonlinear way.The decrease in the probability of quasi-integration for a decrease of INTERVAL (i.e. an increase in the degree of mutual commitment) could be explained by the fact that mutual commitment enlarges the self-enforcing range of "pure" contractual arrangements.

TABLE 13 **Sequential binomial probit analysis: probability of quasi-integration**

	equation 5	equation 6
constant	0.24	-3.05
	(1.47)	(2.49)
Import	6.04	6.78
	(292.8)	(289.8)
	(1.05)	(1.25)
Generic	0.74	0.81
	(0.53)	(0.55)
	(0.13)	(0.15)
Has	-0.29	-0.11
	(0.25)	(0.28)
	(-0.05)	(-0.02)
Pas	0.22	0.36
	(0.31)	(0.36)
	(0.04)	(0.07)
Distance	-0.31	-0.64
	(0.35)	(0.43)
	(-0.05)	(-0.12)
Interval	0.47*	3.02**
	(0.24)	(1.50)
	(0.08)	(0.08)[a]
$(\text{Interval})^2$	----	-0.35*
		(0.20)
Log-likelihood	-18.28	-16.46
χ^2	14.67	18.31*
df=	8	9
χ^2 (vs controls)	5.62	9.26
df=	4	5
R^2-analogue	0.29	0.36

TABLE 13 (cont'd).

Values under coefficients are the standard error and the partial derivative evaluated at the mean. [a] Includes effect of quadratic term. *significant at the 90% level; **significant at the 95% level; ***significant at the 99% level. Company dummies are not reported.

V. SUMMARY AND CONCLUSIONS

This study was motivated by the recent introduction of a new manufacturing paradigm. The manufacturing system that dominated in North America over the last 30 years, the so-called Fordist model of mass production, is being replaced by a different approach to manufacturing. The new manufacturing system is commonly referred to as just-in-time [JIT] manufacturing since it emphasizes speedy response to market conditions. It is characterized by production in small and medium batches, emphasis on quality at all stages of the production process, lower inventories for both intermediate and finished goods, and a greater reliance on subcontractors to supply a larger share of the total value added.

This study focussed on the possible effects of the introduction of the new manufacturing paradigm on the choice of governance structure. Effects of manufacturing on the structure of the firm are generally not analyzed by the industrial organization literature. That is probably related to the low frequency with which paradigm shifts in manufacturing occur. Nevertheless, the introduction of a new manufacturing system raises important questions. How did the introduction of just-in-time manufacturing influence the determinants of vertical integration? Does it affect the comparative assessment of markets and hierarchies, and thereby the resulting choice of governance structure? How well can standard asset specificity arguments, put forward by transaction cost theory, continue to explain the structure of vertical integration, given the paradigm shift in manufacturing?

In order to be able to answer these questions it was necessary to obtain data that reflect the impact of the just-in-time manufacturing system. A new data set consisting of 89 observations, measured at the individual assembler-supplier relationship, was obtained directly from the Big Three U.S. automobile manufacturers by means of a questionnaire. I chose to focus on the U.S. automobile industry since just-in-time manufacturing has had its biggest impact in automobile manufacturing to date (Scherrer 1991). In addition, the competitive environment of the automobile industry during the 1980s resulted in a relatively speedy introduction of the new manufacturing techniques into North America. The implications of this analysis, however, are by no means limited to this particular industry. The principles of just-in-time manufacturing apply to virtually every manufacturing industry; it is therefore essential to understand if and how this change in the manufacturing paradigm affected the structure of vertical integration.

According to transaction cost theory, it is the condition of asset specificity that is central to the decision on governance structures. In particular, in the presence of transaction-specific investments, governance structures are argued to emerge ex ante to reduce the incentives of either the buyer or the seller to behave opportunistically ex post. Governance structures, i.e. contracts or internal organization, are chosen in a cost-minimizing fashion according to various characteristics of a transaction.

I argue that with the introduction of JIT manufacturing, the relationship between assembler and supplier companies has begun to change, and, as a result, the determinants of vertical integration have changed as well. The major change from Fordism to JIT manufacturing in terms of supplier relationships is argued to be a switch from short-term, arms-length relations to those based on long-term mutual commitment.

The central question of this study is how one can relate the anecdotal evidence for a switch to contractual sourcing relations since the introduction of JIT manufacturing techniques to the transaction cost theory framework of the determinants of governance structure. In order to address it, I refer to the mechanisms of contract enforcement. The presence of high degrees of mutual commitment, a characteristic of JIT manufacturing, strengthens the ability to enforce contractual agreements by making hold-up threats less credible. In doing so, it increases the self-enforcing range of contracts.

First, I estimate a binomial probit model. I demonstrate the degree of mutual commitment to be a new determinant of governance structure. Its proxy variable, frequency of delivery, is consistently found to be inversely quadratic related to the probability of vertical integration. The nonlinear influence of that variable is explained by the following two effects. First, the proxy measures the degree of mutual commitment present in a vertical relationship. A greater degree of mutual commitment reduces the probability of vertical integration by the constraints it places on the potential for opportunistic behavior. In addition, the proxy variable for mutual commitment also captures the effect of the frequency of transactions on the choice of governance structure. An increase in the frequency of transactions erases the initial transaction cost advantage of market relationships and increases the probability of vertical integration. I find that in the range of multiple daily deliveries, typical for JIT manufacturing, an increase in the frequency of delivery results in a lower probability of vertical integration. JIT manufacturing introduces mutual commitment into vertical relationships to a degree that is sufficient to curb the potential for opportunistic behavior. This result is not reconcilable with the maintained null hypothesis of no structural change in the determinants of vertical integration

Furthermore, the influence of the degree of human asset specificity on the choice of governance structure is found to be unaffected by the introduction of JIT manufacturing. Consistent with my hypothesis, the significant positive influence of human asset specificity on the probability of vertical integration established in earlier studies is confirmed; as expected, the marginal effect of that variable does not differ statistically from that established in previous related studies. Rather than offering contractual solutions to reduce the potential for post-contractual opportunism, the introduction of JIT-based mutual commitment does not affect the relationship between human asset specificity and the probability of vertical integration.

In addition, I estimated two slightly different qualitative choice models that distinguish three different categories of governance in the dependent variable. The point of this exercise was to get information about the structure of the underlying decision process. The results are similar to the ones from the binomial probit model, supporting the appropriateness of a three-way distinction in the dependent variable. Since the partial derivatives of the independent variables were identical in direction and almost identical in size for the two categories no integration and quasi-integration, it seemed worthwhile to also look at the possibility of a sequential decision. A sequential probit model was used to model first the decision on governance structure (vertical integration vs contractual arrangements), and, in the second stage, the decision between two types of contracts, no integration and quasi-integration. However, the comparison between the ordered and sequential probit model had to remain inconclusive; that is mainly due to the small sample size at the second stage of the sequential decision model. But none of the empirical findings of the multinomial choice models contradict the results of the binomial probit model that was used to test the hypothesis of a change of the determinants of vertical integration. In fact, the results turn out to be remarkably robust.

It was beyond the scope of this study to investigate the forces that drive the introduction of the new manufacturing paradigm. In the Introduction I cited studies referring to related productivity advantages at the firm level. There exists, however, the possibility that both the changes in the manufacturing paradigm and in the determinants of governance structure are driven by some underlying common force.

The results presented in this study suggest the following general conclusion: JIT manufacturing influences the choice of governance structure by introducing a greater extent of mutual commitment into vertical relationships. It serves as a constraint on the potential for post-contractual opportunism and increases the range of self-enforcing contracts. The traditional influence of human asset specificity on the choice of governance structure is unaffected.

That insight, of course, has broader implications as the reported effects are likely to not be restricted to the U.S. automobile industry from which the data used in this study were obtained. The applications of JIT manufacturing are widespread and so are their consequences for the structure and competitiveness of the entire manufacturing sector.

Hollingsworth (1991), for example, points out potential implications for what he calls the institutional infrastructure: industrial relations, training of labor, antitrust rules, etc.

Since the early 1980s, it has become increasingly clear that the introduction of a new manufacturing system has ramifications that extend far beyond the shop floor. In fact, the competitiveness of companies and entire industries can be influenced by its implementation. It is therefore worthwhile asking how the institutional framework of the manufacturing industries can accommodate the special characteristics of the new manufacturing paradigm in terms of inter-firm relationships, i.e. longer-term relations between assembler and supplier based on mutual commitment. An answer to this questions bears immediate relevance to issues of economic policy. In addition, policies directed at affecting business incentives, e.g. in the realm of industrial development, need to take into account the characteristics of just-in-time manufacturing; in particular, effects on the structure of industries and firms, effects on location decisions, the demand for labor, and infrastructure needs.

APPENDICES

APPENDIX A

APPENDIX A

A STYLIZED COMPACT CAR

Subsystem:	Part:
ENGINE	Engine Assembly
	Cylinder Block
	Crankshaft
	Pistons
	Connecting Rods
	Balance Shafts
	Camshafts
	Cylinder Head*
	Valvetrain Components
	Water Pump
	Oil Pump/ Lubrication
	Intake Manifold*
	Exhaust Manifold
	Flywheel
	Piston Rings*
	Other
DRIVETRAIN	Transaxle Assembly
	Clutch Assembly
	Torque Converter*
	Transmission Case*
	CV Joint*
	Rear Differential
	Drive Shafts
	Gear Sets*

BODY STRUCTURE	Cowl, Dash Stampings Body Exterior* Bumper Assemblies Small Stampings Windshield* Frame Weather Stripping*
SEATS, TRIM	Seat Frames, Mechanicals Seat Covers* [G] Instrument Panel Interior Finish Trim Headliner/ Carpeting Rough Hardware* [G] Grille Panel Exterior Trim Mirrors* [G] Occupant Restraint* [G]
STEERING AND SUSPENSION	Steering Wheel Steering Column* Power Steering Pump Steering Gear* Front Wheel Knuckle Suspension Control Arms Springs Struts Shock Absorbers Stabilizer/ Torsion Bars Trailing Axle
FUEL DELIVERY	Fuel Tank Fuel Lines Fuel Pump Fuel Injection* Carburetor Turbocharger Engine Control Module* Gas Cap/ Filler* [G]

ENGINE ELECTRICAL	Spark Plugs Engine Wiring Harness* Distributor/ Coil* Ignition Module Starter Motor Alternator* [G] Cruise Control
EXHAUST/ EMISSION CONTROL	Exhaust Pipes Catalytic Converter* [G] Muffler* [G] Other Exhaust Parts
BRAKES/ WHEELS/ TIRES	Caliper Assembly* Drums Discs Shoes and Linings Master Cylinder Brake Tubes and Hoses Wheels* [G] Hub Caps Tires
HEATING/ VENTILATING	Condensor Compressor* Radiator Heater Core Tubing/ Hoses Engine Fan* [G]
CHASSIS/ ELECTRICAL	Battery* [G] Main Wiring Harness Small Electric Motors Electrical Inst. Controls Lamps Audio* Fuses, Switches

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Source: Luria (1990b); Andrea et al. (1988)

* Parts in the sample

[G] Generic part

APPENDIX B

APPENDIX B

DEFINITION OF VARIABLES AND QUESTIONNAIRE

For each existing relationship to a supplier, the following three categories of **governance structure** are distinguished [the term supplier refers to both inhouse parts operations and independent parts suppliers]:

Vertical Integration — The auto plant procures the part from an inhouse parts supplier

Quasi-integration — The auto plant procures the part from an independent supplier but it retains title to tooling used at the supplier plant.

No integration — The auto plant procures the part from an independent supplier. It does not supply any tooling to the supplier for the manufacturing of that part.

Human asset specificity is measured as the engineering effort [i.e. engineering cost] involved in developing a particular part. The questionnaire offered a five-point scale of engineering effort; 'no engineering effort' [1] ; 'a lot of engineering effort' [5].

Physical asset specificity is also measured according to a five-point scale:

[1] 'Low' — the facilities, assets etc. used in production of a part can be easily adapted to serve customers in other industries and other car manufacturers.

[3] 'Somewhat' — the facilities, assets, etc. used in production can be easily adapted to serve other car manufacturers.

[5] 'high' — the facilities, assets etc. used in production cannot be easily adapted to serve customers in other industries, or even other car manufacturers.

In the questionnaire, **distance** is measured as the actual distance between the consuming plant and the supplier plant. This distance is always measured in terms of road-miles. The variable employed in the qualitative choice model converts the actual distances to a five-point scale in the following way:

0-50 miles	51-300 miles	301-550 miles	551-800 miles	greater than 800 miles
[1]	[2]	[3]	[4]	[5]

Frequency of delivery is measured by the time intervals between consecutive deliveries of a part according to the following scale:

0-2 hrs	2-8 hrs.	8-24 hrs.	24-72 hrs.	72 hrs-1 week	longer than 1 week
[1]	[2]	[3]	[4]	[5]	[6]

The **length of preproduction interaction** measures -in terms of years- the time period prior to the start of production, during which the auto assembler and the supplier company work together on producing a part.

PARTS	Year Developed	Engineering Cost					Weight	Dedication					SUPPLIER	Supplier Relationship			Distance	Frequency of Delivery [in hrs.]						Develop	Potential
		1	2	3	4	5		1	2	3	4	5		VI	QI	NI		0-2	2-8	8-24	24-72	72-1wk	longer		
ENGINE																									
Cylinder Head																									
Intake Manifold																									
Piston Rings																									
DRIVETRAIN																									
Torque Converter																									

PARTS	Year Developed	Engineering Cost					Weight	Dedication					SUPPLIER	Supplier Relation-ship			Distance	Frequency of Delivery [in hrs.]						Develop	Potential
		1	2	3	4	5		1	2	3	4	5		VI	QI	NI		0-2	2-8	8-24	24-72	72-1wk	longer		
Transmission Case																									
Gear Sets																									
BODY STRUCTURE																									
Body Exterior																									
Windshield																									

PARTS	Year Developed	Engineering Cost					Weight	Dedication					SUPPLIER	Supplier Relationship			Distance	Frequency of Delivery [in hrs.]						Develop	Potential
		1	2	3	4	5		1	2	3	4	5		VI	QI	NI		0-2	2-8	8-24	24-72	72-1wk	longer		
Weather Stripping																									
SEATS/TRIM																									
Seat Covers																									
Rough Hardware																									
Mirrors																									

PARTS	Year Developed	Engineering Cost					Weight	Dedication					SUPPLIER	Supplier Relation-ship			Distance	Frequency of Delivery [in hrs.]						Develop	Potential
		1	2	3	4	5		1	2	3	4	5		VI	QI	NI		0-2	2-8	8-24	24-72	72-1wk	Longer		
Occupent Restraint																									
STEERING/ SUSPENSION																									
Steering Column																									
Steering Gear																									
CV Joint																									

PARTS	Year Developed	Engineering Cost					Weight	Dedication					SUPPLIER	Supplier Relationship			Distance	Frequency of Delivery [in hrs.]						Develop.	Potential
		1	2	3	4	5		1	2	3	4	5		VI	QI	NI		0-2	2-8	8-24	24-72	72-1wk	longer		
FUEL DELIVERY																									
Fuel Injection																									
Engine Control																									
Gas Cap/ Filler																									

PARTS	Year Developed	Engineering Cost					Weight	Dedication					SUPPLIER	Supplier Relationship			Distance	Frequency of Delivery [in hrs.]						Develop	Potential
		1	2	3	4	5		1	2	3	4	5		VI	QI	NI		0-2	2-8	8-24	24-72	72-1wk	longer		
ENGINE ELECTRICAL																									
Wiring Harness																									
Distributor/ Coil																									
Alternator																									
EXHAUST																									
Catalytic Converter																									

PARTS	Year Developed	Engineering Cost					Weight	Dedication					SUPPLIER	Supplier Relationship			Distance	Frequency of Delivery [in hrs.]						Develop	Potential
		1	2	3	4	5		1	2	3	4	5		VI	QI	NI		0-2	2-8	8-24	24-72	72-1wk	longer		
Muffler																									
BRAKES/ WHEELS																									
Caliper Assembly																									
Wheels																									
HEATING/ VENTIL.																									
Compressor																									

PARTS	Year Developed	Engineering Cost					Weight	Dedication					SUPPLIER	Supplier Relationship			Distance	Frequency of Delivery [in hrs.]						Develop	Potential
		1	2	3	4	5		1	2	3	4	5		VI	QI	NI		0-2	2-8	8-24	24-72	72-1wk	Longer		
Engine Fan																									
CHASSIS/ ELECTRICAL																									
Battery																									
Audio																									

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