Supply Chain Co-Ordination and Industry Clockspeed: an Exploratory Study

Hans Voordijk
Associate Professor,
Twente University
h.voordijk@sms.utwente.nl

Bert Meijboom
Associate Professor,
Tilburg University
b.r.meijboom@kub.nl

Henk Akkermans
Assistant Professor, Eindhoven
University of Technology
h.a.akkermans@tm.tue.nl

The increasing velocity of change, or clockspeed, in the business environment is a key challenge for firms and industries nowadays. In this study, the impact of industry and organisation clockspeed on specific mechanisms used for supply chain co-ordination is investigated from an information-processing perspective. This article addresses the differences in supply chain co-ordination strategies between firms in high-clockspeed industries and those in less turbulent environments. We translated Galbraith's generic co-ordination mechanisms into specific supply chain co-ordination strategies. Using an exploratory case study research design, we collected recent data on industry and organisation clockspeed. The main finding is that the relationship between the level of clockspeed and the extent to which 'lateral relations' are applied and activities are outsourced is an increasing function.

Our time appears to be an era of "the acceleration of just about everything" (Gleick 1999). It is becoming increasingly clear that "industry clockspeed," a concept named by Fine (1998; 2000), has a powerful impact on the way organisations are structured and managed. Mendelson and Pillai (1999) define industry clockspeed as the velocity of change in the external business environment. Fine argues that the degree to which rapid innovation is crucial for firms depends on this velocity of change, or clockspeed. The shorter the life cycles of the products that a firm sells, the more rapidly it has to invent not just new products but also new ways of organising itself. In higher clockspeed industries, the internal clockspeed of the firm—the pace of internal operations in product development and internal operations—must increase as well. Further, in most industries, clockspeed has increased over time. Business models that function well in a low-clockspeed environment may well be inadequate in a high-clockspeed environment (Ramdas and Spekman, 2000). Fisher (1997) argues that there is no single best recipe for effective supply chain management. He differentiates between efficient and responsive supply chains, based on whether the product is functional or innovative and demand is stable or not. Simchi-Levi et al. (2003, pp. 120-132) discuss the appropriate supply chain strategy for a particular product by differentiating between push, pull, and push-pull supply chains. The appropriate strategy depends on the level of demand uncertainty and the importance of economies of scale in reducing costs.

Mendelson and Pillai (1999) provide some initial empirical evidence for the validity of Fine's clockspeed hypothesis. Their major hypothesis is that 'firms in faster-moving business environments tend to accelerate their internal operations so that their operational speed is attuned to the velocity of change in their business environments' (p. 2). Mendelson and Pillai (ibid.) measured the industry and organisation clockspeed in the electronics industry. They showed that a higher industry clockspeed was associated with faster product development and manufacturing and with more frequent changes in organisational structure (elements of the internal or organisation clockspeed).

In this study, we build on the work of Mendelson and Pillai (1999) and analyse the changes in business models in response to dynamic developments in the business environments of firms, in particular in supply chain co-ordination (SCC) models. We conceptualize a supply chain as a chain of businesses including a supplier, the supplier's supplier, a customer, and the customer's customer (Voordijk, 2000; see also Mentzer et al., 2001). The central question is the extent to which supply chain co-ordination strategies in high-clockspeed industries are different from those in less turbulent environments. As such, our research places the concept of industry clockspeed against the background of existing literature on organisational design and co-ordination. The research design can be described as a multiple case study: supply chains in different industries are analysed. In these supply chains, we investigate differences in the supply chain co-ordination of materials and of information flows and the different levels of clockspeed.

The paper is structured as follows. Initially, the conceptual framework is presented. In the second section, we present the research approach, the case selection criteria, data collection methods, and the constructs of interest. In the following sections, data are presented by a case-by-case analysis of the companies and their respective supply chains. In the final sections, we develop propositions for an emerging theory by generalising beyond the case data.

The conceptual framework

It is generally recognised that nowadays, supply chains typically comprise two or more independent companies before reaching the final customer (Christopher, 1992; Maloni and Benton, 1997; Simchi-Levi et al., 2003; Voordijk, 2000). As a result, information on supply chain activities is often dispersed among several organisational units (Andersen and Segars, 2001) and may also be geographically dispersed across the globe (Meijboom and Vos, 1997). Because information is the key ingredient for co-ordinating the supply chain in a given problem situation (Douma and Schreuder, 1998), we have chosen to adopt an information processing point of view. Information processing is generally seen as the gathering, interpreting, and synthesising of information in the context of organisational decision-making (Tusman and Nadler, 1978). Most of the literature that takes an information processing perspective can be traced back to the seminal work of Galbraith (1973, 1974). Galbraith argues that the greater the task uncertainty, the greater the amount of information that must be processed by decision-makers during task execution. He defined certain "normal" co-ordination mechanisms such as rules, programs, and procedures (Galbraith 1973, p. 10) for circumstances in which this information processing can be referred up the hierarchy to a level where an overall perspective exists. Moreover, Galbraith proposed four additional co-ordination mechanisms, which he positioned as "advanced" mechanisms in the sense of relieving hierarchical lines from complex information exchange requirements. As such, they are applicable in the present situation of inter-company SCC where a formal hierarchy is lacking. In essence, Galbraith's "advanced" co-ordination mechanisms either (1) reduce the need for information processing or (2) increase the capacity to process information. We will now briefly review the four mechanisms:

> To which extent supply chain co-ordination strategies in high-clockspeed industries are different from those in less turbulent environments.

(1) The need for information processing can be reduced by increasing slack resources (Galbraith, 1973; Thompson, 1967). To illustrate, just-in-time (JIT) inventory control requires precise co-ordination. Buffer inventory is an alternative approach that removes the need to process certain information required for JIT.

(2) Information processing needs can also be reduced by creating self-contained tasks (Galbraith, 1973): a two-product firm, for example, can create two self-contained single-product divisions that have no need to communicate.

Alternatively, an organisation can increase its capacity to process information.

(3) In a hierarchical organisation, the hierarchical processing of information can be increased by investment in a vertical information system (Galbraith, 1973), such as a vendor-rating system or an advanced Enterprise Resource Planning (ERP) package. Vertical information systems are used to co-ordinate activities between the different levels of an organisation and include periodic reports and computer-based communication distributed to managers. Despite this, the type of feedback, the amount of information, and the media richness may require horizontal communications.

(4) Information-processing capacity can also be increased by creating lateral relationships (Galbraith, 1973). Lateral relationships refer to communication and co-ordination horizontally across organisations and supply chains. Direct contact, liaison persons responsible for communication, and co-ordination with other firms, and permanent teams are organisational elements that increase information-processing capacity. Electronic Data Interchange (EDI) between companies involved in the same supply chain enhances intercompany information-processing capacity too.

Research Method

The research method is based on the process of iterative triangulation (Lewis, 1998). In this section, we present the research approach, the case selection criteria, data collection methods, and the constructs of interest. In the parts following on this section, the cases are presented. In the discussion and conclusion part, we develop propositions for an emerging theory by generalizing beyond the case data.

Exploratory research approach

The central question in our research is what impact clockspeed has on SCC models. More specifically, to what extent are supply chain co-ordination strategies in low-clockspeed enviroments different from those in high-clockspeed environments? The concept of clockspeed is a relatively novel one, and one of the problems in applying it is that the levels of clockspeed and its implications have rarely been measured (Ramdas and Spekman, 2000; Mendelson and Pillai, 1999). An exception is Ramdas and Spekman (ibid.). They built on the work of Fisher (1997) and measured the performance of functional-product supply chains and innovative-product supply chains with variables comparable to the constructs Mendelson and Pillai use to measure the level of clockspeed: inventory levels, product-development time, order-processing time, quality management and customer value. They conclude that functional-product and innovative-product supply chains differ significantly in terms of information sharing, performance metrics, and the use of integrating mechanisms.
Our goal is not to provide empirical support for relationships, but rather to explore what types of relationships might be valid research objects in this context. Therefore, an exploratory research approach seems appropriate (Yin, 1994; Eisenhardt, 1989; Johnston et al., 1999).

Case Study Selection

In this case study research, manufacturing firms were investigated that were operating in industries with very different rates of innovation and different clockspeeds. Our selection of companies to study was driven by theory rather than statistical or random sampling. Industries known to have very long product life cycles are construction, soft drinks, and chemicals. Industries that are known to have very short product life cycles are semiconductors and the suppliers to this industry. The consumer electronics industry also has a high clockspeed in terms of new product development, but less so than semiconductors. Given these considerations, we selected and investigated five industries, in order of increasing clockspeed: construction, soft drinks, chemicals, consumer electronics, and semiconductors. Within these five industries, a total of six companies were investigated.

Data Collection

The data collection methods used in our case study research included both field and desk research. The first source of data was empirical. At each firm, we collected recent data on industry and organization clockspeed, along with details of models for supply chain co-ordination. Data were collected from interviews with logistics or supply chain managers of the case firms. Given the exploratory nature of the study, the interview format was semi-structured, allowing the interviewer to explore areas that opened during the discussion. We also analyzed reports of branch organisations, existing case study material, and internal company documents focusing on the rate of product and process innovations.

Research Constructs
For the empirical measurement of the concept of industry or external clockspeed, we used representative indicators taken from Mendelson and Pillai (1999):
- Product life cycle: whether a product is in the development, growth, maturity (stabilization), or decline (stagnation) phase
- Product line freshness: the percentage of revenues derived from products that have been introduced in the previous twelve months
- Product life: the total duration of the product life cycle
- Input prices: the rate of decline or increase in prices of the major inputs

The internal clockspeed (the pace of internal operations in the product development and manufacturing areas) is measured by the following variables:
- Time spent in developing a new (version of a) product
- Time interval between consecutive product redesigns
- Product ramp-up time, or time between product development and manufacture
- The number of organisational changes over the last five years

As indicators for measuring the role of the different co-ordination mechanisms of the Galbraith framework, we selected the following:
- The levels of buffer inventories of final and intermediate products are indicators of Galbraith's measure of slack.
- Although outsourcing a set of processes or even an entire organisational unit to third parties (in % of total added value) is just one form of creating self-

contained tasks (Galbraith, 1973, p. 16), it is the most common form in supply chain settings as prevalent in the present research.

- Frequency of contacts with first tier suppliers and customers is an indicator of Galbraith's measure of lateral relationships.
- Noting that information processing through vertical information systems matches with the co-ordination mechanism of hierarchy and supervision of Mintzberg (1979), the number of planning and management layers is taken as indicator.

The findings for the six case companies are summarized Table I and Table II.

Table 1
Case firms analysed

	Dycore Verwo	Vrumona	DSM	Philips Optical Storage	Philips Almelo	ASML
Employees	500	500	5000	1000	550	4400
Turnover (millions of Euros)	80	160	610	1000	100	2186
Growth rate (%)	-5	5	4	10	15-18	0
Age	6	50	100	10	40	18
Number of products	4	9	30	7	—[a]	—[a]

a. Data were not provided.

Table 2
Case results

Industry Clockspeed	**Dycore Verwo**	**Vrumona**	**DSM**	**Philips Optical Storage**	**Philips Almelo**	**ASML**
Product life cycle (phase)	Stabilisation	Stabilisation	Stabilisation	Growth	Develop-ment	Stagnation
Product line freshness (%)	0	5	7	20	100	100
Lifetime (year)	25	10-50	10-15	10	4 to 5	1.5
Input prices	Stable	Stable	Dependent on oil price	-30%	Stable	Stable
Internal Clockspeed						
Product innovation (years)	4-5	2	2-3	2	0.5	1
Product redesign	4-5 years	6 months	10-15 years	3-6 months	9-12 months	0
Ramp-up time	2 months to 3 years	2 months	2-3 years	2 months	0	0
Number of organisational changes (over five years)	3	2	0	2	1	—[a]
Slack						
Final stock (weeks)	2	2	8-16	4	0	0
Intermediate stock (weeks)	0	4	—[a]	6	0	—[a]
Self-contained tasks						
Outsourcing (%)	Limited	10	Limited	10	70	90
Lateral relations						
Frequency of contacts with first-tier suppliers and customers (focus)	Limited (customer)	Limited (customer)	Limited (customer)	Intensive (suppliers)	Intensive (suppliers/customers)	Intensive (suppliers/customers)
Vertical information systems						
Number of management levels	3	3	2	3	3	—[a]
Number of planning levels	3	5	2	3	—[a]	3
Planning staff (%)	3.5	1	—[a]	—[a]	3.5	—[a]

a. Data were not provided.

Dycore Verwo

Dycore Verwo is a producer of prefabricated concrete floor elements. The company is part of the Irish Cement-Roadstone Holdings (CRH). With an annual turnover of € 80 million, Dycore Verwo is one of the largest prefab producers in the Netherlands. Dycore's 500 employees are spread among the four Dutch branches. Floor elements make the largest contribution to turnover. Dycore Verwo is the second largest producer of this product in the Netherlands. The market of prefab floor elements is quite stable. The case study was restricted to this product.

Industry Clockspeed

The floor element was introduced about 25 years ago and is now in the stabilisation phase. The market is not growing because housing production is stagnant. Product line freshness is very low. The product assortment has hardly changed in the past 20 years. Raw material costs are about 25%-30% of the sales price and are fairly stable.

Internal Clockspeed

The development of a new product or the redesign of an already existing product takes four to five years. The ramp-up time can be anything from two months to three years; sometimes a new factory has to be built, as was the case for the introduction of self-condensing concrete. When a new product is introduced, the organisation particularly sees changes in the drawing office and the planning division. There have been three organisational changes over the last five years, mainly due to mergers and acquisitions.

Co-ordination Mechanisms

Prefab elements that have been made on order for a specific project are stocked at the production site near the factory for at least two weeks. This stocking of prefab elements is the major buffer for changes in the outside world. The frequency of contacts with suppliers is minimal. However, in the case of customers, the company tries to maintain good contacts. The manufacturer and contractor – the most important customer of the manufacturer – meet each other regularly in order to discuss existing and coming projects. There are three levels of management, and 20 workers (3.5%) are involved in planning activities. There are also three levels of planning: the assembly planning of prefab elements is input for the production planning and the resource planning in the factory. Dycore outsources hardly any activities.

Vrumona

Vrumona is the soft drink division of Heineken N.V. and is part of a process industry. It has about 500 employees and an estimated turnover of € 160 million. Vrumona primarily uses water and fruit juices as inputs for its production process. Further, the bottling of the soft drinks is an important step in the production process given that the products differ not only in flavor but also with respect to packaging; which can include cans; 20 cl, 1.0 l, and 1.5 l bottles; and special packages. The market for soft drinks is growing 5% yearly because of a general increase in consumer preference for non-alcoholic drinks.

Industry Clockspeed

Most of the soft drinks are in the stabilisation phase. The product line freshness is about 5%. New flavours are designed and developed for a long lifespan: the life of new products is expected to be from 10 to 50 years. Raw material costs are fairly stable for soft drink production.

Internal Clockspeed

Product renewal is implemented relatively easily in the factory: ramp-up time is about two months. The production machines are flexible and can be modified to produce a new and/or different flavour easily and simply. However, the costs of introducing a new brand are high. The time needed to renew a product is about six months, but to introduce a new brand, one needs about two years to achieve product familiarity. The firm has gone through two major reorganisations last five years.

Co-ordination Mechanisms

Given the stable demand for its products, Vrumona does not have high stock levels. Finished products are in stock for about two weeks (intermediate stocks are about four weeks). Vrumona used to run at 98% of capacity and was thus very vulnerable to breakdowns. Recent production expansion has reduced this vulnerability. The customers (such as Albert Heijn, the major Dutch food retail chain) are very powerful, and therefore it is crucial to have direct contact. The firm has three management levels. There are five levels involved in planning, and five employees carry out the planning tasks (1% of the total number of employees). The amount of outsourcing is small.

DSM

DSM is an international concern with worldwide interests in life-science products, high-grade synthetics, polymers, and industrial chemicals. The case study pertains to high-grade synthetics, known within DSM as the Performance Materials cluster. This cluster consists of the following business groups: DSM Elastomers, DSM Engineering Plastics, and DSM Coating Designs. The case study is restricted to products of the Elastomers business group. The turnover of this group is 610 million, and it employs about 5000 workers. Elastomers include the synthetic rubbers that are used in cars and tyres, several industrial products, and additives for motor oil. The most important market for DSM Elastomers is the automobile industry, but the building and construction markets are also of great importance.

Industry Clockspeed

The Elastomers product group is in its stabilisation phase. Elastomer sales grow by 4% a year. On average, two new products are introduced each year. With 30 products on the European market, product freshness is about 7% a year. On average, product life is 10 to 15 years. Key raw materials make up 50% of the cost price. The price is to an extent dependent on the price of oil.

Internal Clockspeed

The development of a new product takes about two to three years, with a similar amount of time needed to introduce the product to the market. Product redesign intervals are about 10 to 15 years. The organisation of the business group does not have to be changed drastically when new products are produced. The ramp-up time is two to three years when a new factory has to be built.

Co-ordination Mechanisms

The group retains 8 to 16 weeks' stock at all times and, in principle, there is no over-capacity. There are two major layers of management: a central sales/operations level draws up the company's planning at concern level, and planning also takes place at the business unit level for directing factory operations. DSM provides its own raw materials.

Philips Optical Storage

The Optical Storage business group is part of Philips Components and can be separated into three markets: the Consumer Electronics market (CE market), the Data market, and the Automotives market. The business group has existed since 1992, when Philips created the CE division. In 1995, the data division was added, followed by the automotives division in 1998, following the sale of Philips Car-radio. The case study is, however, restricted to the CE market. The business group has a turnover of 1 billion and is expected to achieve a growth of 10% per year. The Philips Optical Storage group produces optical readout equipment for CDs and DVDs.

Industry Clockspeed

In the CE market, the DVD player and DVD recorder are end products. The product line freshness is about 20%, and the product life cycle of these products is about ten years. The DVD player is still in its growth phase, or perhaps at the start of its maturity phase. The DVD recorder is in the initiation phase, or possibly at the start of the expansion phase. Due to the improved production of components and evolution in the design, input prices decrease 30% per year.

Internal Clockspeed

The life of the products is around 10 years. The development of a new product takes about two years. Philips redesigns products by making minimal adjustments and improvements in design. These redesigns take place every three to six months, with a ramp-up time of two months. From time to time, large changes to the initial design are made. There have been two major reorganisations last five years.

Co-ordination Mechanisms

Philips generally assembles components into end products but, when ordered, these can also be semi-manufactured products. End products will be in stock for four weeks, semi-manufactured products for six weeks. Because innovations come mainly from its suppliers, having good contact with them is important for Philips Optical Storage. The three management levels match with the three levels of planning.

Philips Almelo

Philips Almelo, a division of the Philips Enabling Technologies Group, manufactures modules for application in the chip industry. Philips Almelo was established 40 years ago and has about 550 employees. Modules (or parts of machines) are produced for use in the chip industry or semiconductor industry, where Philips has two large active customers, ASML and ASMI. Module costs vary but are usually around 45,000. Turnover last year was about 100 million. However, the semiconductor industry is very cyclic, and after strong growth in recent years, the industry is now seeing a downward trend. Average growth of turnover is however around 15% to 18% a year.

Industry Clockspeed

Given the fast technological development, every module produced is a new version of the product. Most modules are permanently in the development phase. Product line freshness is very high. The life span is about 4 to 5 years. The most important raw materials are metals and electronics, for which the prices are fairly stable.

Internal Clockspeed

The development of new modules takes about half a year. There is no time distinction between development and production. When a module is produced, it will be redesigned or restyled after 9 to 12 months. Closer partnerships with customers have been developed. As a result, a recent development is that large customers have their own place in the organisation: the customer group.

Co-ordination Mechanisms

There is no stock of semi-manufactured or final products in the production process. When a module is finished, it is transported to the customer. There was significant reserve capacity at the time of the research, but with an upward trend in trade, this will soon turn into a situation of under-capacity. There are intensive contacts with both customers and suppliers, and even with the customers of their customers and the suppliers of their suppliers due to the customer-specific characteristics of the products. There are three levels of management in the business unit, and 15 to 20 employees work as planners. Seventy percent of the work is outsourced.

ASML

ASML was founded in 1984. The company focuses on the development, production, marketing, and maintenance of advanced semiconductor-producing machines. Its direct competitors are Nikon and Canon. About 50 regional sales and service centres around the world provide service to customers. At the end of 2000, ASML had about 4400 employees. In 2001, its turnover was 2186 million and its profits were 347 million. The market in which ASML operates sees strong fluctuations in demand. In 2000, ASML introduced the Twinscan™ AT 700, a series of machines for producing wafers. A wafer is the base on which a chip can be produced.

Industry Clockspeed

The Twinscan™ AT 700 series has a lifecycle of one and a half years. Production and sales of ASML have a product line freshness of 100%. Every three to four months, a new product is introduced to the market. The developments in the industry in which ASML operates are so fast that products older than one year do not exist. ASML products are in the stagnation or stabilisation phases. The market is growing little, if at all. There is a replacement demand for ASML's products. The prices of raw materials hardly fluctuate.

Internal Clockspeed

At ASML, two things have to be distinguished: time needed for the development of a platform for a series, and product development time. About two and a half years are needed for the development of a platform such as the "Twinscan 700", and then, based on this platform, other products are developed. These have a development time of about a year. A clear ramp-up time is difficult to identify because a prototype and a pilot are developed simultaneously. ASML's systems have a modular construction and, hence, new developments can be implemented quickly and easily while delivery time as well as installation time are minimised.

Co-ordination Mechanisms

There is no stock of products in the company. Planning is made at three levels: "rough planning" at concern level, "start planning" (volume and mix of products, six to nine months before production), and materials and production planning (a day before production). ASML relies to a large extent on the outsourcing of production activities to spread the risks of market fluctuations.

Discussion

In this section, we will combine data from our case studies with the four co-ordination strategies proposed by Galbraith. We differentiate between the case firms active in a relatively lower clockspeed environment—Dycore, Vrumona, and DSM—and those active in a higher clockspeed environment—Philips Optical Storage, Philips Almelo, and ASML. The different levels of clockspeed are related to the different mix of supply chain co-ordination mechanisms used by the firms analysed.

It would appear from the cases we have analysed that there is a positive relationship between clockspeed and the emphasis placed upon lateral relationships. Creating lateral relations with suppliers and customers increases the information processing capacity, in terms of Galbraith's terminology. In the cases with a relatively low clockspeed (Dycore, Vrumona, and DSM), lateral relations do not play an important role. No intensive relations exist with the suppliers of these firms. The opposite appeared to be the case in those companies where the clockspeed is higher (Philips Optical Storage, Philips Almelo, and ASML). For these case companies, lateral relations are particularly important for innovations in the final product because such innovations originate from suppliers. Lateral relations with customers are considered necessary for finding out what the actual demands and experiences of users are.

We operationalised self-contained tasks as the percentage of production that is outsourced to third parties. Again, it would seem that there is a relationship with industry clockspeed: in higher clockspeed environments, the percentage of production that is outsourced to third parties is greater. In the three companies studied with lower industry clockspeeds, only a limited number of production activities were outsourced. In the two companies with extremely high clockspeed environments (Philips Almelo and ASML), the level of outsourcing is very high. In this situation, outsourcing is a way to deal with fast changing market demands. Information about expected sales is provided as quickly as possible to suppliers and manufacturers upstream.

In the cases analysed, the relationship between clockspeed and slack was considerably less clear. Slack was operationalised as the number of weeks of inventory and work in process in a company. In two cases with a low clockspeed—Dycore and Vrumona—slack is low because of the high predictability of the demand. For DSM, however, slack is high because interrupting the manufacturing process is more expensive than maintaining high stock levels. For all three cases in the high clockspeed environment, the level of slack is low because of the fast changing market demands. In order to prevent stock becoming obsolescent, the production process is very flexible and many production activities have been outsourced. Slack is avoided by maximising outsourcing.

When analysing the results from the case firms, we found no clear relationship between clockspeed and the number of hierarchical levels. As long as clockspeeds are low, there is little need for a high number of management levels. The number of management levels is also not high in the semiconductor industry, because the pace of change is too high to accommodate complex planning procedures. Here it may well be that company size and age dominate clockspeed concerns. This could be the topic of further in-depth research.

Conclusion

The main reason for conducting this empirical research was that we considered it important and worthwhile to try and link two important theoretical concepts that appear to be very relevant for supply chain management: Galbraith's co-ordination mechanisms for complex organisations and Fine's concept of industry clockspeed driving supply chain design.

Interestingly, even with only a few cases, there seems to be a clear relationship between the clockspeed level and the use of lateral relations and self-contained tasks (as opposed to outsourcing) on the other. When clockspeed is low, lateral relations with suppliers and customers are seemingly less important. Similarly, not many activities are outsourced when clockspeed is low. The opposite is true in a high clockspeed environment: lateral relations are important, and many activities are outsourced. This development is consistent with Fine's double helix: increasing clockspeed seems to drive vertically integrated supply chains towards disintegration. It would appear that there is a positive correlation between the percentage of production that is outsourced to third parties (an increasing level of self-contained tasks from a SCC perspective) and the extent to which 'lateral relations' are applied. One can conclude that there is a demand for increasing information capacity when clockspeed increases.

Unsurprisingly, we did not achieve a perfect fit in other aspects of this exploratory research design: the patterns for the two other co-ordination mechanisms are different from what would be predicted by theory. When analysing the relationship between clockspeed and slack, market demand characteristics appear to determine the level of slack more directly than clockspeed. Similarly, when analysing the relation between clockspeed and the number of hierarchical levels, the organisational flexibility required, or the size and age of the firm seem to determine this number more directly than clockspeed.

If the relationships discussed above are upheld in empirical testing, it will imply that the use of lateral relations and outsourcing that is appropriate for a given firm depends strongly on the relative level of clockspeed it is experiencing. What may be appropriate co-ordination models for one industry may be counterproductive for firms in another. As clockspeed gradually increases over time, different companies appear to follow the similar growth path of Fine's double helix. Throughout this process, outsourcing levels and the importance of lateral relations with suppliers and consumers increase. The present research provides new evidence suggesting that clockspeed is an important construct for supply chain managers to consider when designing their supply chain.

References

Andersen, T.J. & Segars, A.H. 2001. The impact of IT on decision structure and firm performance: evidence from the textile and apparel industry. Information and Management, 39: 85-100.

Christopher, M. 1992. Logistics and Supply Chain Management, Pitman Publishing: London.

Douma, S. & Schreuder, H. 1998. Economic approaches to organizations, 2nd edition, Prentice Hall Europe: London.

Eisenhardt, K.M. 1989. Building Theories from Case Study Research. Academy of Management Journal, 14 (4): 532-550.

Fine, C.H. 2000. Clockspeed-based strategies for supply chain design. Production and Operations Management, 9 (3): 213-221.

Fine, C.H. 1998. Clockspeed - Winning Industry Control in the Age of Temporary Advantage, Perseus Books: Reading MA.

Fisher, M.L. 1997. What is the right supply chain for your product? Harvard Business Review, 75 (2): 105-117.

Galbraith, J.R. 1977. Organization Design, Addison-Wesley: Reading MA.

Galbraith, J.R. 1974. Organisation design: an information processing view. Interfaces, 4 (3): 28-36.

Gleick, J. 1999. Faster: the acceleration of just about everything, Pantheon Books: New York.

Johnston, W.J., Leach, M.P., & Liu, A.H. 1999. Theory Testing Using Case Studies in Business-to-Business Research. Industrial Marketing Management, 28 (3), 201-213.

Lewis, M.W. 1998. Iterative triangulation: a theory development process using existing case studies. Journal of Operations Management, 16 (4): 455-469.

Maloni, M.J. & Benton, W.C. 1997. Supply chain partnerships: Opportunities for operations research. European Journal of Operational Research, 101: 419-429.

Meijboom, B.R. & Vos, B. 1997. International manufacturing and location decisions: balancing configuration and co-ordination aspects. International Journal of Operations and Production Management, 17 (8): 790-805.

Mendelson, H. & Pillai, R.R. 1999. Industry clockspeed: measurement and operational implications. Manufacturing and Service Industry Management, 1 (1): 1-20.

Mentzer, J.T., De Witt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D., & Zacharia, Z.G. 2001. Defining Supply Chain Management. Journal of Business Logistics, 22 (2): 1-25.

Mintzberg, H. 1979. The structuring of organizations. Prentice Hall: Englewood Cliffs NJ.

Ramdas, K. & Spekman, R.E. 2000. Chains or Shackles: Understanding What Drives Supply-Chain Performance. Interfaces, 30 (4): 3-21.

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. 2003. Designing & Managing the Supply Chain, 2nd edition, Irwin McGraw-Hill: Boston.

Thompson, J.D. 1967. Organizations in action, 2nd edition, McGraw-Hill: New York.

Tusman, M.L. & Nadler, D.A. 1978. Information Processing as an Integrating Concept in Organizational Design. Academy of Management Review, 3 (3): 613-624.

Voordijk, H. 2000. The Changing Logistical System of the Building Materials Supply Chain. International Journal of Operations and Production Management, 20 (7): 823-841.

Yin, R.K. 1994. Case study research: Design and methods. SAGE Publications: Newbury Park CA.