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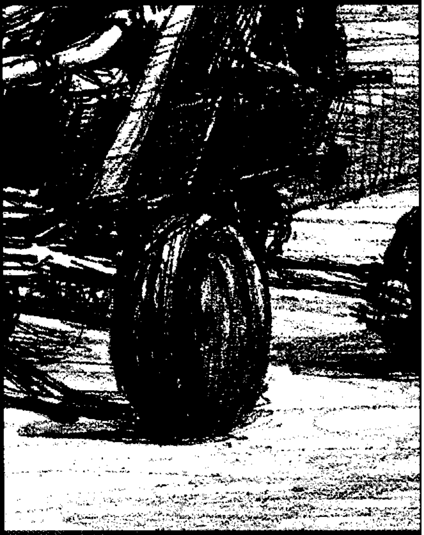

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Time-based logistics

an analysis of the relevance, causes and impacts

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Prof. dr. ir. R.E.C.M. van der Heijden
Prof. dr. A.I.J.M. van der Hoorn

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Preface

> *'During the climatic month before World War I broke out, diplomats agonized over five ultimatums with ever shorter time limits, all threatening war if demands were not met. The delivery of the Austrian ultimatum to Serbia was itself influenced by the availability of new speedy communication and transportation. After the Austrian ambassador delivered the ultimatum, he demanded a response in 48 hours. The Serbian minister protested that his government was on vacation and therefore a quick response was impossible. The Austrian ambassador replied: the return of the ministers in the age of railways, telegraphs and telephones in a land of that size could only be a matter of a few hours'* [Kern 1996].

If you read the above anecdote again, and thereby assume that the *Austrian ambassador-Serbian minister* relationship represents a *customer-supplier relationship*, and if you replaced the word *ultimatum* by *customer order*, then you can roughly discern what today's logistics landscape looks like. Although the position of railways and telegraphs has long been taken over by trucks and e-mail, the story shows that impatience is of all times, and that technological advances provide ever smaller margins for delays and excuses. Firms that do not comply with their customer's time standards will clearly not evoke war, but could lose a battle or two in today's competitive environment.

This dissertation, which was funded by the Transport Research Centre (AVV) and the Cornelis Lely Stichting, includes an analysis of the trend towards logistics acceleration, the sources of haste, and the impacts of so-called time-based strategies on both the logistics organisation of the companies involved and the demand for transport on the macro-level.

I derived great pleasure from conducting this research project. This is closely correlated to the persons who surrounded me in the last five years. First of all, I would like to thank my supervisors Rob van der Heijden and Toon van der Hoorn for their constructive and pleasant way of supporting me during the research and writing process. The mix of scientific experience, genuine interest and also pragmatism greatly helped me to carry out the research project smoothly and learn a lot on the way. I hope to continue our co-operation in one way or the other in the future!

Various other persons have also helped me in shaping the dissertation in its current form. I am grateful to Bart Kuipers for his competent advice and his contagious enthusiasm, Eric Molin for introducing and guiding me in the world of conjoint analysis, Hens Runhaar for being a critical reader of draft versions of this dissertation, Lori Tavasszy for his analytic view and creative solutions, and Stef Weijers for providing important inputs during the first years of my research. Furthermore, my research project would have failed if it were not for the almost 75 logistics managers who have been prepared to share their practical knowledge with me over the years.

I thank all of my colleagues of the Transport Policy and Logistics Organisation (TLO) group at Delft University for generating such a pleasant working atmosphere. My 'Zaal F' roommates also made work fun and therefore deserve the exclusive right to call me 'Gait'. The physical appearance of this book was very much improved by the efforts of Birgit Akkerhuis (responsible for the fine cover illustrations) and my twin brother Jan-Willem Muilerman (responsible for the perfect reproduction of these illustrations), while Mirjam Miedema of TRAIL excellently supported me in getting this dissertation printed.

Finally, there is a group of persons who formed the necessary 'home front' during the whole production process of my dissertation. I am very much indebted to the 'Muilermensen' in Markelo, Wilfred and Jorien in Schiedam and Alex in Den Haag for hosting me as a Dutch-Austrian guest worker. Thanks for your hospitality! Without doubt however, my girlfriend Pia Kremslehner suffered the most from my writing activities. I cannot sufficiently express my gratitude in words for putting up with a part-time workaholic, for your English corrections, for your innovative logistics solutions, but most of all, for providing a home in the broadest sense of the word. I realise that every page in this book corresponds with at least six hours not spent with you. May the reader be aware of that whenever he/she turns a page.

Gert-Jan Muilerman Wien, January 2001

Contents

1

What's the hurry?

During the 1980s and 1990s, time has become a major issue in the world of business logistics. This is due to the emergence of so-called time-based strategies, an umbrella term for business strategies that emphasise the importance of fast, frequent and reliable logistics services, in order to improve organisational performance (e.g. in terms of revenue generation or cost reduction).

With the introduction of time-based management principles, several questions arise. For instance, what caused the emergence of time as a crucial logistics resource? What are the impacts of time-based strategies on the logistics choice behaviour of individual companies? What is the combined impact of these micro-level decisions on the societal level (e.g. on the demand for transport)? In this first chapter, and in the remaining of this dissertation, we will address some of these and other questions. We will introduce our problem statement in the following two sections, while the goal and research questions of this dissertation are specified in section 1.3. A brief description of the research approach concludes this chapter.

1.1 TIME AND THE CULTURE OF SPEED

The way time is perceived and valued in our society has undergone major changes in the course of time. We observe public discussions about unlimited opening hours of shops and the round-the-clock economy, limited temporal accessibility of inner cities and appeals to 'decelerate' our lives [see e.g. Volkskrant, 1999; Trouw, 1997]. These observations indicate that something is going on with respect to our perception of time.

Schwarz [1997] for example claims that speed has become an omnipresent feature of modern culture: speed has become so obvious, that we cannot imagine progress without going faster. Tarski [1987] also mentions this economic nature of time:

> *For man, it is a useful commodity, and one of his limited resources (...) The significance of the value of time increases in proportion to the acceleration of economic life and of social development (...) The acceleration of all actions, resulting in haste, is a prevalent tendency today* [Tarski, 1987, p.3].

Through technological innovations that are potentially time-saving, such as faster modes of transportation and information technology, people tend to accelerate their pace of life. Zoll [1988] describes this phenomenon of speed creating more speed as follows:

> *Alles geht jetzt schneller als früher; wir sparen Zeit beim Transport von Menschen, von Gütern und Informationen, wir sparen Zeit beim Einkaufen und bei der Hausarbeit, sogar beim Essen (fast food). Wir gewinnen Unmengen an Zeit, haben aber weniger als je zuvor* [Zoll, 1988].

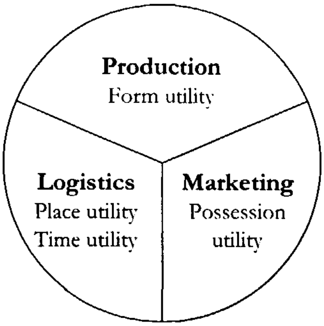
According to this principle, acceleration does not create more spare time, but even faster time requirements. An explanation for this can be found in a process of habituation followed by reallocation: people get used to fast performance levels very quickly, and use the time gained for alternative purposes. This principle of *faster means more* is applicable to many situations in our daily life. We tend to allocate time savings to alternative activities, and thereby try to improve our productivity. As we shall see, this phenomenon appears to be all the more important within the field of business logistics, which is the scope of this dissertation. The following section shows how time has always been an issue in the world of business logistics, but that it has gained extra attention in recent years, due to strategic developments.

1.2 THE NEW ROLE OF TIME IN LOGISTICS

The layperson's description of logistics as provided by Coyle *et al.* [1992], contains several components relevant to our discussion here. According to this definition, logistics is described as ensuring the availability of the right product, in the right quantity and the right condition, at the right place, at the right time, for the right customer, at the right costs. In other words, as Christopher [in: Cooper, 1994] explains, effective logistics management is the core capability to achieve reduced costs and optimal customer satisfaction at the same time. Furthermore, customer satisfaction is achieved by providing value or utility to customers.

Place and time utility

Coyle *et al.* [1992] identify four principal types of economic utility that add value to a product or service: form, possession, place and time utility (see Figure 1-1). Form utility is mainly added to goods through manufacturing processes (but is also conceivable through value added logistics activities), while marketing processes, such as promotion and sales efforts, create demand for a certain product, i.e. create possession utility. Place utility (providing the product at the right place) and time utility (providing the product at the right time) are mainly created by performing the basic logistics activities of *moving* and *storing* goods.



Source: Coyle *et al.* [1992]

FIGURE 1-1 **FOUR TYPES OF ECONOMIC UTILITY**

Logistics creates place utility primarily through transportation, but also by holding inventory at the point of demand. Conversely, time utility is mainly created by storing goods until customers demand them, but can also be attained by transportation activities [Coyle *et al.*, 1992; Fawcett and Fawcett, 1995]. It should be noted that, with the emergence of activities such as value-added-logistics or rolling stocks, the suggested departmental and functional boundaries increasingly become blurred.

From the above, it appears that time has always been at the heart of logistics: providing goods at the right place and at the right time (fast enough, precisely on time, at the right time of day, regularly) is what logistics is all about. Then, *what is 'new' about the role of time in logistics*, as this section's title suggests? Before we can answer this question, we have to look at characteristics of goods and distinguish between different types of goods with respect to their time-sensitivity.

Time-sensitivity and physical characteristics of goods

All goods are susceptible to the influence of time in the long run. However, some goods are relatively more sensitive to deterioration, and subsequently to loss of value. Tarski [1987] identifies different types of time-sensitive goods: perishable commodities, livestock and valuable goods.

First, *perishable commodities* are fresh food products, flowers, certain drugs, etcetera. Extended delivery times of perishable goods are associated either with loss of quality or with additional costs to prevent such a loss from happening (e.g. refrigeration). Second, the physical condition of *living animals* is for example greatly affected by the time spent in the transportation process. Livestock can therefore not be handled without some kind of time pressure. Third, *valuable goods* such as diamonds are not so much affected by physical deterioration during a certain span of time, but are subject to financial risks, and should therefore not be kept in the logistics pipeline longer than necessary. High insurance costs or high amounts of frozen capital are indications of time-sensitivity in those cases.

These three categories of time-sensitive goods are based on the physical characteristics of the goods themselves. In the following, we will see that time-sensitivity is not only dependent on the physical nature of goods: the value of time can be influenced by strategic factors as well.

Perishable demand

A fourth category of time-sensitive goods is formed by commodities that are liable to become dated, such as newspapers and fashion wear. These goods are not perishable themselves (the paper of the newspaper and the fabric of the clothes will last for years), but these commodities face *perishable demand.* If they are not delivered within a certain time, it is simply too late. Possession utility for these products decreases with time: after a certain point, no customer is prepared to pay a price for the goods involved any longer. Special cases of these commodities are *emergency goods.* Examples include spare parts for a production facility or water in the event of a forest fire. The goods themselves may not be perishable, living or valuable, but falling short of these emergency goods stands for high alternative costs within the processes that depend on them (e.g. reducing downtime of the production facility, extinguishing the fire). These alternative costs result in time-sensitivity.

Time-based strategies creating time-sensitivity

The common characteristic of spare parts and newspapers is a certain degree of *deliberate time-sensitivity*: the subsequent links in the logistics chain have agreed upon timely delivery of the goods and high costs (production losses or lost sales) are incurred if fast or reliable distribution is lacking. Time-sensitivity and chain dependency are mainly a matter of choice and business strategy in those cases.

Following this line of thought, an increasing number of companies have *chosen* to be time-sensitive in recent years. This is exemplified by the emergence of *time-based competition*: a business strategy that is built on the premise that time, like costs, is manageable and a source of competitive advantage throughout every process in business organisations [Business Week, August 31, 1992]. Business organisations are increasingly applying strategies called *time-based management*, *lean manufacturing*, *high-speed management*, *cycle-time compression*, *fast cycle time*, *agile manufacturing*, etcetera [see Stalk and Hout, 1990; James-Moore and Gibbons, 1997; Jones, 1993; Lalonde and Masters, 1994; Meyer, 1993; Vernadat, 1999].

Time-based strategies are defined in a number of ways. However, all of the suggested definitions in the literature assign a crucial role to customer service. Meyer [1993] defines time-based strategies as the ongoing ability of identifying, satisfying and being paid for meeting customer needs faster than anyone else. Stalk and Hout [1990] summarise the rationale for companies engaging in time-based competition as follows:

> *Time-based competitors are offering greater varieties of products and services, at lower costs and in less time than their more pedestrian competitors* [Stalk and Hout, 1990, p.1].

Operational examples of time-based strategies include *just-in-time* production techniques and *efficient consumer response* distribution.

Jones [1993] and Maskell [1991] assert that time-based strategies are being applied at a broader scale nowadays:

> *Markets based on fashion styles (such as women's apparel) have always been under this type of time pressure. However, in today's business climate all industries are feeling the need to compete in time* [Jones, 1993, p.2].

Peters [1991] claims that the trend marks 'every nook and cranny' of virtually every industry. Hum and Sim [1996] assert that time-based competition has emerged as *the* competitive paradigm of the nineties, while a Delphi study among 200 European logistics experts [Cranfield University, 1994] forecasts that implementation of time-based strategies will have grown significantly by the year 2001. The emergence of these strategies is explained by Meyer [1993] through factors such as the accelerating pace of technology development and the dramatic increase in global competition, whereas Christopher [in: Cooper, 1994] concentrates on the shortening of product life cycles and the drive for inventory reductions.

A number of successful companies is discussed in the American textbooks on time-based competition [Stalk and Hout, 1990; Jones, 1993; Maskell, 1991]. Their success is among others attributed to the implementation of time-based strategies. However, it is striking to see that the same limited number of examples is repeatedly being quoted. It appears that the examples of successful time-based competitors are mainly concentrated in sectors such as the automotive, consumer electronics, drugs, fast food and clothing industry.

We will not go into the details of time-based competition here (see the next chapter), but revert to the question posed at the beginning of this section: *what is 'new' about the role of time in logistics?* The perception and value of time have changed due to the increasing implementation of time-based strategies: as a result of the deliberate time-sensitivity mentioned before, time-sensitivity has increased for a number of goods, previously not seriously affected by time pressure. As is maintained above, the kind of time pressure that was originally reserved for products such as fashion wear, is now being copied in all kinds of other business segments. Peters [1991] calls this the 'fashionizing' of business, while The Economist [1996] uses the heading 'selling PCs like bananas' to describe approximately the same phenomenon. It is this development that will be in the centre of our attention in this dissertation, and it is this type of goods that represents the new role of time in logistics.

1.3 PROBLEM STATEMENT

So far, we have been observing changes in the role of time in society, and more specifically, in logistics. We continue posing a second question, namely, *what is the problem?* In order to formulate an adequate answer to this question, we will start theorising about the impacts of time-based strategies on logistics chains by adopting a time-space perspective. Subsequently, we will quote some concerns raised by several authors, about the conceivable detrimental influence of time-based strategies on freight transport volumes: implementation of time-based strategies could lead to more frequent and faster transport processes, which are almost only achievable through an increased use of road and air transport. To support this reasoning we will include a brief overview of important freight transport trends in the Netherlands. Finally, we will conclude this section by formulating the goal and research questions of this dissertation.

Time-space prisms

Within the behavioural approach of human geography, Hägerstrand [1970] developed the idea of time-space prisms. Time-space prisms were used by Hägerstrand to portray spatial behaviour of individuals. This way of depicting space and time can also be used to illustrate and introduce the problem area of our research on the 'behaviour' of logistics chains under increasing time pressure. Figure 1-2 provides a hypothetical illustration of a simple logistics chain, consisting of two factories and one distribution centre.

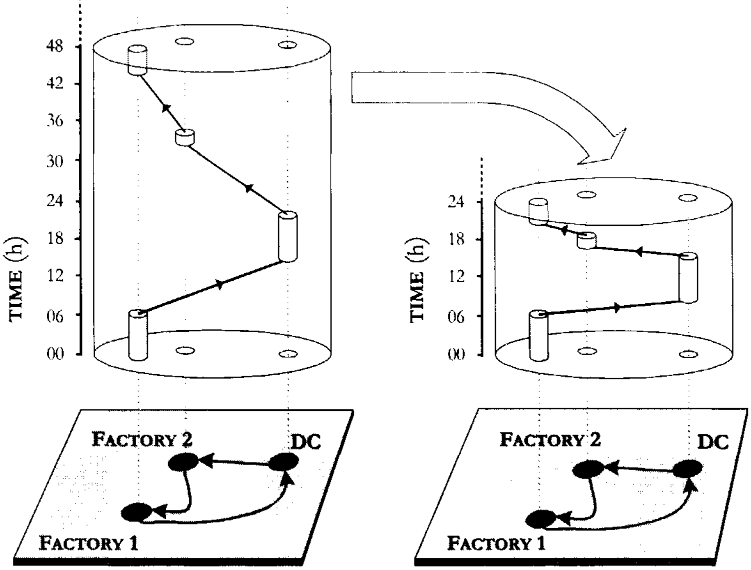


FIGURE 1-2 **POTENTIAL IMPACT OF INCREASING TIME PRESSURE**

We first concentrate on the left part of Figure 1-2. Let us say that factory 1 produces plastic cups with printed decorations. The plastic cup producer has one supplier (factory 2) who is responsible for the decorative prints. The actual freight movements of this logistics chain are represented by the arrows in Figure 1-2. Factory 1 sends its semi-finished products (i.e. the unprinted cups) to the distribution centre (DC) of its carrier. This carrier consolidates the semi-finished products with other shipments and finally transports the unprinted cups to factory 2. After the prints have been added, the cups are returned to factory 1 for final processing (e.g. packaging).

The entire logistics chain from raw materials to finished products lasts 48 hours. The small cylinders represent the duration of each process (producing cups, consolidating shipments, printing and packaging). The first production process at factory 1 takes for example 6 hours to be completed. The lines connecting the cylinders again represent freight flows. The gradient of each of these lines reflects the needed transport speed, in order to achieve the required 48-hour lead time.

The right part of Figure 1-2 demonstrates one possible alternative, in case the total lead time should be reduced from 48 to 24 hours, for example as a result of the implementation of the time-based strategies discussed in the previous section. We will discuss other alternatives later (see next chapter), but for now let us assume a situation where the duration of the respective production processes cannot be cut back and where inventories of (semi)finished products are not available: all processes are sequential, instead of parallel.

The consequences are shown in the right part of Figure 1-2. Only the transportation processes are compressed. This is reflected by the decreasing gradients of the lines connecting the production processes. As can be deduced from Figure 1-2, increasing time pressure could lead to accelerated transport processes. The next sub-section will show that this theoretical option of transport acceleration is not mere theory: it is at least partially put into practice, and thereby creates negative side effects as well.

Logistics acceleration: the fast lane to congestion?

Kern [1996] mentions that environmentalists remind us of the peril of growth and the increasing demand for speed. Freight transport volumes on the roads and in the air could rise through a growing demand for increased transport frequency and speed. Consequently, negative external effects of transport activities could also be aggravated. Cooper [1991] argues that just-in-time (JIT) concepts mean an extensive use of the public road network:

> *Smaller vehicles are being used to carry the same amount of goods as a single large vehicle. The result is more fuel used, more visual intrusion, more pollution. JIT leads to more road transport practices which are overwhelmingly hostile to the environment* [Cooper, 1991, p.107].

This argument is clarified by environmental expert Sachs of the Wuppertal Institute [1996]. Sachs elaborates the principle of 'faster means more', which we discussed in section 1.1:

> *Across the board, from mobility to communication, from production to entertainment, timed saved has been turned into more distance, more output, more appointments, more activities.* (...) *Acceleration is therefore the surest way to the next congestion.* [Sachs, 1996, p.5].

Various other studies show what consequences time-based strategies and associated just-in-time concepts could have for freight transport [McKinnon, 1994; NEA&Cranfield, 1994; Cooper, 1991; Läpple, 1994; Garreau *et al.*, 1991]. The consequences can be grouped in two categories. First, a general trend is the *decrease of average shipment sizes.* Smaller shipment sizes are a consequence of the need for shorter lead times and the need to deliver exactly the right amount of goods at the prescribed time. Inventory levels are consistently reduced, which causes a need for fast and frequent transport. This in turn creates additional traffic. McKinnon [1994] briefly discusses the development of road traffic growth through the years:

> *Over the past ten years, the shortening of order lead times and an increase in the amount of sub-contracting have begun to make a significant contribution to traffic growth* [McKinnon, 1994, p.1].

A survey carried out by NEA&Cranfield [1994], encompassing six Western European industry sectors, revealed that, for example in the chemical processing industry, the move towards just-in-time production methods had resulted in declining order sizes and increased shipment frequencies. Chapuis *et al.* [1993] share this conclusion in a study for the European Commission.

Second, partly because of the need to reduce shipment sizes, time-based strategies often lead to the choice for *faster modes of transportation* (i.e. road haulage and air transport). As is asserted by Läpple [1994]:

> *Economic development and the introduction of new logistics concepts, such as just-in-time production and stocks on wheels, have led to a clear increase in road traffic in recent years* [Läpple, 1994, p.22].

Garreau *et al.* [1991] showed that, as a result of the implementation of just-in-time concepts, 75 per cent of American companies appeared to have changed their use of transportation modes for both inbound and outbound shipments. The railways were the biggest losers in this respect, with truck and air transport winning. Timeliness and responsiveness were found to be the most important criteria for modal choice.

Although opinions about the influence of time-based strategies do not seem to diverge very much, there are some contrasting views. First of all, time-based strategies may also have beneficial environmental consequences, for, as we shall see in the next chapter, time-based strategies are concentrated on the elimination of all wasteful activities, and therefore also on superfluous transport. A study by PriceWaterhouse & Coopers for example concluded that continuous inventory replenishment could lead to a considerable drop of backorders and return flows [Logistiek.nl, 1998]. Furthermore, as McKinnon [1994] suggests, the extra traffic generated by smaller shipment sizes is being compensated by extra freight consolidation efforts through the use of 'supply houses'. The argument is that many factories do not have the capacity to receive goods in small consignments all day long after all. For this reason, Blok *et al.* [1993] estimate that the implementation of just-in-time concepts could eventually contribute to a reduction in freight transport demand.

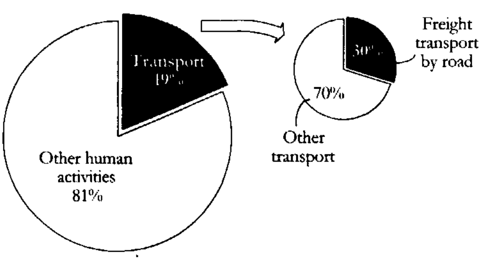
Freight transport policy goals

From the above, it appears that it is unclear whether time, or rather the need for accelerating transport, represents a significant contribution to further growth of freight transport volumes. However, if we are to believe the first group of authors, time-based strategies and their external effects could be conflicting with freight transport policy goals. We will investigate this question in this dissertation.

The Dutch policy goals with respect to freight transport are formulated in the policy document *Transport in Balans* (TiB) [Ministry of Transport, 1996]. This document contains three policy objectives. First, transport policy initiatives should support sustainable modes of transportation, such as rail, inland waterway transport and shortsea shipping. Second, environmental pollution through road traffic should be reduced. For example, one of the exhausts of fuel engines, carbon dioxide (CO_2), is an important contributor to the greenhouse effect. Third, the accessibility of economic centres for freight transport by road has to be improved.

Policy efforts are ultimately aimed at reducing the negative external effects of road transport (e.g. emissions of carbon dioxide (CO_2), nitrous oxides (NO_x), sulphur dioxide (SO_2), visual intrusion, noise nuisance, congestion, etcetera) through improving technical performance of engines and through improving the efficiency of road transport (reduction in kilometres) [Ministry of Transport, 1996].

Although freight transport is not the only source of emissions, it constitutes an important contribution to CO_2 emissions (see Figure 1-3). Transportation activities (passengers and freight) cover 19% of all CO_2 emissions by human activities in the Netherlands (figures of 1996) [Merkus and Ruyssenaars, 1998], while freight transport by road, within the transport segment, is responsible for 30 per cent of emissions (figures of 1997) [AVV, 1998a].



Source: Merkus and Ruyssenaars [1998] and AVV [1998a]

FIGURE 1-3 **CONTRIBUTION OF FREIGHT TRANSPORT TO CO_2 EMISSIONS**

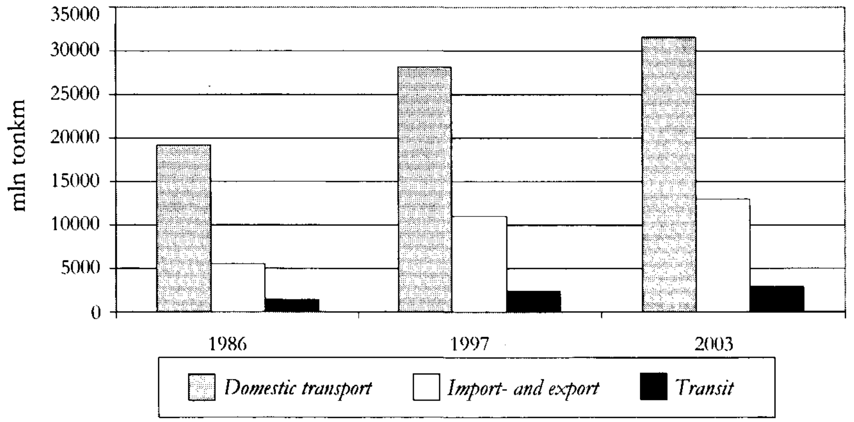
The freight transport policy objectives are translated into three quantified goals with respect to the development of road transport between the years 1994 and 2010 [Ministry of Transport, 1996]:

- Reduction in domestic tonnes-kilometres by 5 per cent (distances >50 km).
- Reduction in import and export volumes (tonkm) by 10 per cent.
- Reduction in transit volumes (tonkm) by 40 per cent.

Additionally, two goals are determined with regard to vehicle-kilometres and modal shift: the growth rate of road vehicle-kilometres should be reduced by 10 per cent, and 50 mln tonnes should be shifted from road to rail, inland waterways and shortsea shipping.

Actual freight transport trends

When these goals are compared with actual freight transport trends, a clear discrepancy can be seen. Figure 1-4 summarises the development of road transport volumes in three sub-categories: domestic, import/export and transit traffic.



Source: AVV [1998b]

FIGURE 1-4 ROAD TRANSPORT VOLUMES IN THE NETHERLANDS, 1986-2003

A significant rise in tonnes-kilometres is discernible in all sub-categories. Between 1986 and 1997 domestic tonnes-kilometres by road went up 47%, import and export flows more than doubled, while transit transport rose by 74%. Furthermore, even in the most conservative scenario, AVV [1998b] predicts that tonnes-kilometres will continue to rise respectively by 12%, 18% and 20%

between 1997 and 2003. Road vehicle-kilometres will equally increase by 7% (domestic kilometres), 16% (import and export) and 17% (transit). In other words, the actual and predicted trends are nowhere near the required policy goals. Consequently, the objectives of reducing emissions of harmful exhausts and congestion are not achieved.

Determinants of freight transport growth

The failure of achieving freight transport policy goals can however not solely be attributed to the emergence of time-based strategies. Not only is the influence of time-based strategies at least ambiguous, so it appears from the contrasting opinions in the literature, there are also numerous other determinants of freight transport growth. Ortúzar and Willumsen [1994] provide among others the following determinants of freight transport demand:

- *Locational factors*: the demand for freight transport exists due to separate locations of raw materials, production processes and consumers.
- *Physical factors*: the characteristics of raw materials and finished products influence the way in which they can be transported.
- *Dynamic factors*: seasonal variations in product demand and changes in consumer's tastes affect transport volumes.
- *Pricing factors*: the price of transport determines the feasibility of transport alternatives.
- *Operational factors*: the size of a firm, its geographical structure and its logistics strategy also determine the use of different modes of transportation and shipping strategies.

Holzapfel [1995] concentrates on the locational determinants, by claiming that the traffic growth in goods transport is not so much due to increases in quantities transported, but to the growth of transport distances. Bleijenberg [1998] likewise mainly attributes freight transport growth to geographical factors: a growing number of links in logistics chains, a rising number of shipments and consequently an increase of transport distances.

Lakshmanan and Han [1997] assert that the demand for freight transport is influenced by the level of economic growth (gross domestic product), the industrial structure of GDP, the geographic distribution pattern of the production system, and the characteristics of the production logistic system (e.g. stock buffers vs just-in-time). The Dutch Raad voor Verkeer en Waterstaat [1998] produces a comparable list of factors. Additionally, it stresses the influence of product innovations (miniaturisation of products, packaging innovations), the increasing degree of outsourcing and finally logistics concepts as important determinants of freight transport demand.

A recent empirical research project, initiated by the European Commission and carried out by ten European research institutes and universities revealed that logistics factors mainly determine the increasing demand for freight transport by road in recent years [NEI, 1998]. According to this study, economic growth alone insufficiently explains the substantial growth of freight transport by road in the European Union during the last 15 years. In Chapter 4, we will further pay attention to the determinants of freight transport growth that are relevant to our discussion.

Time for time policy?

The contribution of logistics strategies, such as time-based competition, to freight transport growth can be considered being part of what Ortúzar and Willumsen [1994] label 'operational factors', or what NEI [1998] calls 'logistics factors'. The growing importance of time in logistics decision-making, as is exemplified by the emergence of time-based strategies, could contain important clues as to how further freight transport developments can be directed towards the freight transport policy goals. If time plays a substantial role in logistics decision-making, and if logistics factors are important determinants of freight transport growth, then further policy attention for time factors and logistics choice behaviour is justified. Current policy initiatives in the TiB-report [Ministry of Transport, 1996] concentrate on:

- *Locational factors*: e.g. land-use planning.
- *Infrastructural measures*: e.g. construction and maintenance.
- *Regulation*: e.g. driving times decree, prohibition of overtaking by trucks.
- *Financial support*: e.g. funding research and development.
- *Promotion.and communication*: e.g. efficiency scans of logistics chains.

Furthermore, pricing factors are also incorporated in transport policy plans: motor vehicle taxes and diesel taxes are already employed, while recurrent announcements for the introduction of road pricing are made. However, as is put forward by De Wit and Van Gent [1996] price-sensitivity of the demand for freight transport could have decreased as a consequence of logistics trends such as just-in-time production. In those cases, 'time policies' might be a useful addition to current policy-making.

The Ministry of Transport already implements so-called efficiency scans; voluntary quick scans to identify potential efficiency improvements in a company's transport organisation. Although these scans reflect more attention for logistics decision-making of individual companies, the potential of these policy options is not explicitly integrated into current freight transport policy-making. Parkes and Thrift [1980] already observed this shortcoming in the eighties:

> *We have land use planning, but seldom time use planning, although some transportation planning may be an exception. (...) Relocation of the times of recurrent events makes it possible to cope with spatial problems, such as*

> *congestion, which might otherwise be treated using only spatial solutions* [Parkes and Thrift, 1980, p.108].

Another more general problem connected with (freight) transport policy is the uncertainty about the effectiveness of proposed policy tactics. Promising policy tactics can fail due to unanticipated side effects and unexpected behavioural responses by the target population to the policy measure. This is partly explained by wrong assumptions made by policy makers [Salomon and Mokhtarian, 1997], and partly by the omission of a proper behavioural test of proposed policy initiatives [Michon, 1989]. Therefore, information about the behavioural response of individuals or companies to specific policy initiatives is often lacking [Rand, 1995].

To sum up the problem areas and knowledge lacunae that we have discussed in this section, we will formulate the goal and research questions of this dissertation.

Research goal and research questions

From the evidence in the literature, we concluded that it is unclear to what extent time-based strategies contribute to a further growth of freight transport volumes. With this dissertation, we will try to unravel freight transport developments by providing a *transportation demand analysis*, as defined by Kanafani [1983]: understanding the determinants of the demand and the manner they interact and affect the evolution of traffic volumes.

The specific determinants we will concentrate on are changes in logistics choice behaviour and the way these are affected by the implementation of time-based strategies. We will thus treat deliberate time-sensitivity as *one* of the determinants of transport growth and try to analyse as to what extent this factor ultimately affects traffic volumes and how it interacts with other determinants of freight transport demand. Consequently, an analysis model should be constructed that complies with this goal.

Furthermore, we showed that current governmental policy efforts might not sufficiently take into account the new role of time in logistics. This dissertation should therefore result in suggestions for freight transport policy tactics, based on the demand analysis. In summary, we define the research goal for this dissertation as follows:

Research goal

Analyse the relevance, causes and micro-impacts of time-based strategies and their macro-impacts on the demand for freight transport, and formulate freight transport policy implications based on the analysis.

This research goal can be broken down into five elements: relevance, causes, micro-impacts, macro-impacts and policy implications. Let us in turn discuss each of these elements by means of five research questions.

Research question 1: relevance

In which business industries does time-based competition appear as an important trend?

We first want to explore the importance and relevance of time-based strategies for different business sectors in the Netherlands: in which sectors can the *deliberate time-sensitivity* mentioned before be observed? Some authors have suggested that the 'fashionizing' of business marks every nook and cranny of virtually every industry [Peters, 1991; Jones, 1993], but it is remarkable that the examples of successful time-based competitors are mainly concentrated in sectors such as consumer electronics, automotive, fast food, drugs and clothing industry [Stalk and Hout, 1990; Jones, 1993; Maskell, 1991]. Moreover, empirical proof is generally based on Northern American studies. Therefore, an exploration of the relevance of time-based strategies for the European, and specifically the Dutch, context is required.

Research question 2: causes

What caused the emergence of time-based competition in these economic sectors?

If the goal of our research is to analyse the causes of the emergence of time-based strategies, we need to look at the context of increasing logistics time-sensitivity. These 'sources of haste' could eventually provide important clues and points of leverage for formulating policy tactics to control the possible growth of freight transport volumes resulting from time-based strategies.

Research question 3: micro-impacts

What are the micro-impacts of time-based strategies on logistics choice behaviour?

However, before we can conclude whether these policy tactics are necessary, we need to analyse the influence of increasing time pressure on logistics choice behaviour. In other words, we want to know which practical methods are used by companies that engage in time-based competition to achieve lead time reductions. The scientific challenge arising from this research question is to develop a model capable of systematically analysing the causes and impacts of time-based strategies.

Research question 4: macro-impacts

What macro-impacts do these changes in logistics choice behaviour have?

If changes in the logistics choice behaviour of individual companies (i.e. at the micro-level) do occur as a consequence of implementing time-based strategies, and if we want to know what the impacts of these micro-level impacts are on the macro-level (in terms of demand for freight transport), we need to clarify what the combined effect of these changes in individual logistics choice behaviour is. This implies a translation of micro trends to a more general macro-level.

Coleman [1990] claims that analysis of macro-level system behaviour is equal to explaining the behaviour of the system by recourse of the behaviour of its parts. He continues:

> *Since the system's behaviour is in fact a resultant of the actions of its component parts, knowledge of how the actions of these parts combine to produce systemic behaviour can be expected to give greater predictability than will explanation based on statistical relations of surface characteristics of the system* [Coleman, 1990, p.3].

The scientific endeavour of this research question therefore is to build an explanatory bridge between the observed changes in micro-level logistics choice behaviour and macro-level changes in the demand for freight transport.

Research question 5: policy implications

If macro-level demand for freight transport increases as a result of the implementation of time-based strategies, what suggestions for freight transport policy can be made?

If the results of the analysis show that the implementation of time-based strategies leads to increased demand for freight transport, we want to be able to give suggestions for effective policy tactics. Based on the analysis of causes, micro-impacts and macro-impacts of time-based strategies, we need to formulate and test policy tactics that take into account the mechanisms of logistics choice behaviour revealed by the analysis. These policy tactics should contribute to a reduction in freight transport demand through influencing the mechanisms of logistics choice behaviour. In practice, information about the behavioural response of individuals or companies to policy initiatives is often lacking [Rand, 1995; Salomon and Mokhtarian, 1997]. This dissertation aims to provide insight in the practical responses that are adopted by companies in case suggested policy initiatives were implemented.

In summary, the scope of this dissertation is depicted in Figure 1-5. The research questions that are to be investigated are reflected by this figure (e.g. Q2 reflects research question 2). Eventually, we want to analyse the impacts of time-based logistics choice behaviour on the macro-level demand for freight transport. Furthermore, we want to identify the possible points of leverage for policy tactics by a close examination of logistics choice behaviour and its determinants.

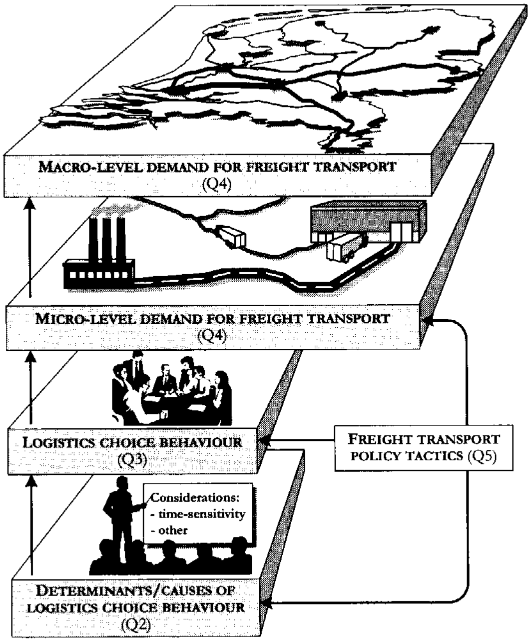


FIGURE 1-5 **SCOPE OF RESEARCH**

1.4 APPROACH AND OUTLINE

The scope of our research will be transformed into a research approach in this section. We will adopt the empirical cycle as our research approach, because the problem statement of this dissertation mainly requires observations and analyses based on real-life problems. Verschuren [1992] identifies five stages within an empirical cycle (Figure 1-6): observation, induction, deduction, testing and evaluation. These stages will be used as a guideline for the approach of this dissertation.

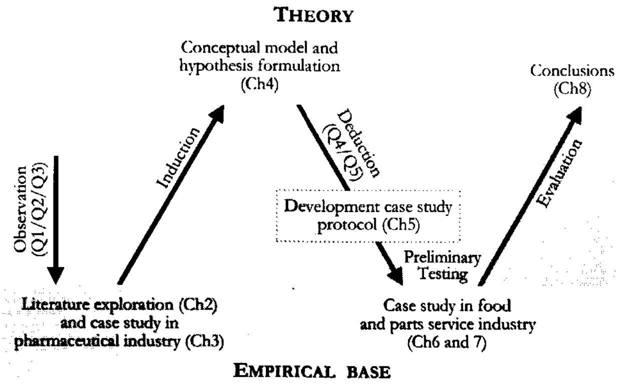


FIGURE 1-6 EMPIRICAL CYCLE

Let us discuss each of these stages and simultaneously refer to the chapters in question.

Observation

Research questions Q1, Q2 and Q3 call for observations from an empirical base. We want to observe the relevance, causes and micro-impacts of the emergence of time-based strategies. The main focus of these research questions is on changes in logistics choice behaviour of individual companies in different economic sectors (micro-level observations). Observations for this stage are made by means of an exploration of logistics literature and by executing case studies among companies in the Dutch pharmaceutical industry. The reasons why we chose the pharmaceutical industry as an exploratory case study will be discussed in Chapter 3. The aim of the case study research is to interpret, typify and describe changes in logistics choice behaviour under increasing time pressure. Results of these research activities are discussed in Chapter 2 and 3 respectively.

Induction

The observations in Chapter 2 and 3 lead to the construction of a descriptive conceptual model in Chapter 4. This model summarises the observed impacts on logistics choice behaviour, due to the implementation of time-based strategies, and the effects they have on the demand for freight transport (Q4). Additionally, we will discern and define different levels of logistics choice behaviour in this chapter.

Deduction

The second part of Chapter 4 contains a set of hypotheses deduced from the conceptual model. This set of hypotheses deals with statements about conceivably effective policy measures (Q5) in the form of policy scenarios. These hypotheses are both based on the conceptual model and on results of a workshop with freight transport policy-makers. The central aim of this workshop was to generate and formulate time policy tactics that could contribute to the realisation of the freight transport policy objectives discussed in section 1.3.

Preliminary testing

A methodology is developed that enables us to test the above hypotheses. To this end, we have combined different research methods in an integrated case study protocol, which will be discussed in Chapter 5. The case study methodology should enable us to judge whether proposed policy tactics would be effective if they were implemented in practice. Suggestions for more effective freight transport policy making would be the result of such an integrated analysis.

The preliminary testing of the hypotheses was done within the food industry and the parts service industry (Chapter 6 and 7). The justification for selecting these case study sectors is done in Chapter 6. For both industry sectors we will conclude what the new role of time in logistics means and what effects this role brings about in the macro-level demand for freight transport. Additionally, the policy implications for the food and parts service industry will be discussed.

Evaluation

The test results will be assessed in the light of the problem statement in the final chapter (Chapter 8). First, each of the research questions is reviewed. Based on the analyses of Chapter 6 and 7, we will formulate conclusions with regard to the research questions Q1 to Q5, as well as recommendations for future empirical research efforts. Second, an evaluation of the developed case study methodology is executed in this chapter. Finally, recommendations for future research efforts conclude Chapter 8.

2

Micro-impacts of time-based logistics

In the previous chapter we defined the problem statement of this dissertation. We discussed the emergence of so-called time-based strategies and the conceivable impacts these could have on the demand for freight transport. The aim of chapter 2 is to elaborate on these issues on the basis of a literature study: we will provide an overview of the micro-impacts of time-based strategies on logistics choice behaviour (research question Q3).

Section 2.1 briefly describes the factors that caused the emergence of time-based strategies, while section 2.2 contains a description of the reported characteristics of time-based strategies. Furthermore, in section 2.3 different scenarios of time-reduction will be discussed. These alternatives are illustrated by examples found in recent logistics journals. The final section (2.4) summarises the main findings of this literature study.

2.1 THE EMERGENCE OF TIME-BASED STRATEGIES

Different authors have described a development of competitive factors through the last decades [Jedd, 1994; McIlraith, 1998; Stalk, 1988; Wildschut and Wiggers, 1993]. Whereas until the 1980s product costs and product quality seemed to be the dominant competitive factors for manufacturers, time performance has gained ground ever since. It is claimed that in a time when many companies are attaining high levels of quality, fast logistics service becomes a significant differentiating factor [Jedd, 1994]. Therefore, companies have added logistics performance to the list of competitive determinants in the 1990s [McIlraith, 1998; Wilding and

Newton, 1996]. An Italian manufacturer of electromechanical devices perhaps best describes the development:

> *Price and performance open the door, service wins the order* [Logistics Europe, 1997a, p.32].

Andries and Gelders [1995] also contend that price is merely an order enabler or qualifier nowadays, not an order winner. Likewise, Vastag *et al.* [1994] contend that quality is becoming more and more an order qualifier, while order winners are time and flexibility. However, there are also authors who doubt the significance of time as a differentiating factor. Wolff [1994] discusses the so-called 'Gewöhnungseffekt', that is, customers get used to offered delivery times very quickly, and start demanding ever-faster services. Furthermore, if every company provided products within a minimum time span, it would not be a differentiating factor anymore:

> *Time-based competition alone has no future, because, if all one's competitors are also competing on time, then business becomes a race with no goal and no finish line* [IJPD&LM, 1995, p.59].

This raises the question why companies would compete on time in the first place. The reason why certain groups of customers attach additional value to faster and more reliable services is explained by Christopher [1994] through factors such as the shortening of product life cycles, customers' drive for reduced inventories and volatility of markets. The accelerating pace of technology developments such as the internet further corrodes the patience of customers. We will discuss these 'causes of haste' in more detail in the next chapter.

2.2 TIME-BASED STRATEGIES: DEFINITION OF TERMS

Time-based companies aim at offering the best customer service levels against the lowest possible costs, but so will any other commercial organisation. The distinctive feature of time-based companies is that they try to reach these goals by concentrating on time-reduction and on-time reliability. Wildschut and Wiggers [1993] define time-based strategies as the explicit and systematic reduction of time consumption in all business processes, aimed at customer satisfaction and resulting in a competitive advantage, while Hum and Sim [1996] summarise time-based strategies as compressing time in every phase of the product creation and delivery cycle. Finally, Stalk [1988] claims that strategies based on the cycle of flexible manufacturing, rapid response, expanding variety and increasing innovation are time-based.

A majority of the suggested definitions assign a crucial role to two elements: *responsiveness* to customer needs and *time-sensitivity*. Putting it simply, responsiveness and time-sensitivity are about giving customers *what* they want, *when* they want it [Stalk and Hout, 1990]. In the previous chapter, we have already touched upon time-based strategies by describing them as business strategies incorporating a certain degree of deliberate time-sensitivity. *Time-sensitivity* is defined by Vastag *et al.* [1994] as the extent to which an industry can tolerate longer and fluctuating delivery times. Rao and Young [1994] define it as a measure of the relative importance of one set of processes being performed within narrow tolerances or sequenced with another set of processes. 'Narrow tolerances' reflect requirements for speed, while 'sequenced' mirrors the need for reliability (e.g. inbound materials ought to be combined with other materials in an assembly process). Failing to meet these time requirements in any case involves significant costs (e.g. lost sales, failed production targets, etcetera). *Responsiveness* is the ability to respond in ever-shorter lead times with the greatest possible flexibility [Christopher, in: Cooper, 1994]. Responsiveness is however not just providing products as fast as possible, but also the very type of product the customers require.

Order penetration point

The element of customisation requires a different approach to product development and logistics management. This different approach can be described by the concept of *order penetration point*. The order penetration point, or *de-coupling point*, is the location in the supply chain which separates the activities based on actual customer orders (*demand-driven*) and the activities that are initiated by forecasts (*supply-driven*) [NEVEM, 1989]. Downstream the order penetration point, no inventories of finished products exist.

Due to changing customer requirements, many companies have been forced into order production instead of making-to-stock: assembly-to-order, engineer-to-order and even one-of-a-kind production [Moeller, 1996]. This evolution from demand *push* to demand *pull* is represented by a shift of the order penetration point upstream the logistics supply chain [Christopher, 1994].

Responsiveness can be achieved by moving the order penetration point upstream as far as possible, for example by using online sales data for production planning. However, a 'responsive' manufacturer who makes every product tailored to specific customer demands cannot be characterised as a time-based competitor as such. Additionally, activities downstream the order penetration point should be executed within a short period of time. For this reason, Andries and Gelders [1995] call this part of the supply chain 'the expressway'. As Davis [1987] asserts:

> *Customers use our time up until their decision to buy, after that we are using their time. Therefore we must deliver immediately. The key is the shortening of the*

elapsed interval between the customer's identified need and his, her or its fulfilment [Davis, 1987, p.14].

This means that after the customer order has entered the supply chain, every activity should be aimed at rushing the customer order downstream the supply chain. Therefore, if increasing numbers of manufacturers have decided to move to a demand pull system, it implies that larger parts of the supply chain are put under time pressure nowadays.

Time-to-market and order cycle time

In the literature, a distinction is made between the time that is needed to design and develop new products, the *time-to-market* [Faber, 1995], and the time that is needed to move an existing product through a supply chain from raw materials supplier to final customer, the *order cycle time* [Coyle *et al.*, 1992]. Responsiveness and time-sensitivity can be sought in both types of lead time, but in the light of our problem statement (see Chapter 1), we will concentrate on the latter.

The term order cycle time is usually the term that is used from the perspective of the seller. The buyer refers to the *lead time*, or *replenishment time* [Coyle *et al.*, 1992]. Sussams [1995] defines the order cycle time as the time that elapses between the moment the customer places an order until the moment he receives the order. A typical order cycle consists of the following primary processes [Coyle *et al.*, 1992; Sussams, 1995; Wentworth and Christopher, 1979]:

- *Order transmittal*: the time that elapses from the moment the buyer initiates the order until the seller receives the order.
- *Order processing*: the time needed to process the customer's order and make it ready for shipment (inventory check, transferring the order information to the dispatch area, preparing shipment documents etcetera).
- *Order preparation*: the time involved with picking and packaging the order for shipment (materials handling).
- *Order shipment*: the time that elapses from the moment the seller places the order upon the vehicle for movement until the buyer receives and unloads it. The order shipment time therefore consists of dispatch and transit time.

All of these components of the order cycle time reflect the time that is consumed by different logistics processes. However, these business processes are not the only factors that consume time: the connections *between* the different processes usually also take time, in the form of waiting times, changeovers and work-in-process (WIP) inventories. These non-value added activities are called 'waste' in time-based terminology [Maskell, 1991]. It is argued that attention should be focused on reducing waste and not so much on speeding up the primary processes themselves, because there remains a great deal of 'slack time' between the primary processes in firms' production and distribution operations [IJPD&LM, 1996; McKinnon, 1994].

The need to reduce waste calls for increased supply chain integration [Van Vliet, 1996; Wildschut and Wiggers, 1993]. For this reason, Lalonde and Masters [1994] claim that supply chain management and cycle time compression are complementary strategies. After all, as Christopher [1994] maintains, supply chain or pipeline management is concerned with removing the blockages and the fractures that occur in the pipeline and that lead to inventory build-ups and lengthened response times. Supply chain management in the form of partnerships can contribute to faster changeovers, e.g. through a higher level of standardisation of transport and materials handling equipment, as well as through integrated information systems [Van Goor and Exel, 1997].

Time-based strategies vis-à-vis JIT, ECR and QR

Whereas time-based competition is defined as a holistic approach that is to be applied to the entire supply chain from raw materials to final product [Rich and Hines, 1997], approaches such as just-in-time manufacturing (JIT), efficient consumer response (ECR) and quick response logistics (QR) are typically time-based concepts that are used in a narrower context. Figure 2-1 depicts the interrelations between time-based strategies on the one hand and JIT, ECR and QR on the other.

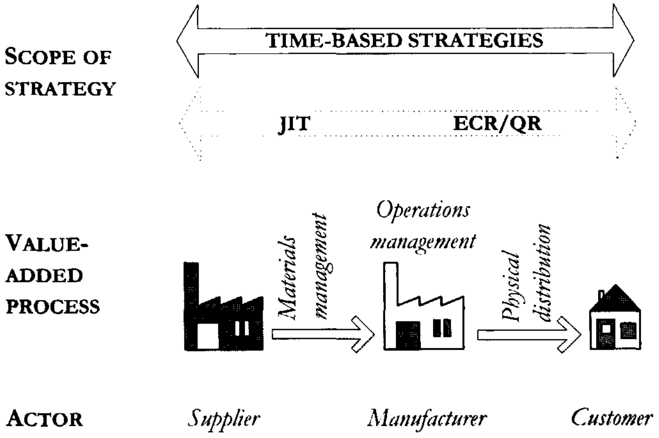


FIGURE 2-1 SCOPE OF TIME-BASED STRATEGIES

As we show with Figure 2-1, the terms used are overlapping and the boundaries between the various concepts are gradual. This is because the concepts have evolved from business practice and generally accepted definitions seem to be lacking. Nevertheless, some basic understanding about the meaning of time-based strategies, JIT, ECR and QR exists.

Time-based strategies form an integral approach, as they are aimed at the elimination of wasteful activities in the supply chain as a whole. Rich and Hines [1997] maintain that time-based competitive practices result in quick response or just-in-time manufacturing. Likewise, Hum and Sim [1996] conclude:

> *In fact, a time-based competitive strategy can be considered an application and extension of the JIT concept* (...). [Hum and Sim, 1995, p.82].

According to Fernie [1994], JIT is being applied to the materials management side of the supply chain, and QR to the 'front end' of the supply chain in distribution management. Wildschut and Wiggers [1993] also claim that JIT is mainly oriented towards materials management and production processes. QR is described in Coyle *et al.* [1992] as 'where JIT and the customer meet'. In the following sub-sections, we will discuss each of these concepts in more detail.

Just-In-Time (JIT)

The American Production and Inventory Control Society (APICS) defines just-in-time as an approach to achieving excellence in a manufacturing company based on the continuing elimination of waste [Wallace, 1987]. JIT is also called *zero-inventories*, *stockless production* and *continuous flow manufacturing* [Voss, 1987]. Through its emphasis on the elimination of non-value-added processes, JIT has become an inherent attribute of the 'lean logistics' paradigm [Das and Handfield, 1997]: time-reduction in all processes and linkages is crucial to JIT [Kalsaas, 1996; Voss, 1987].

Based on reviewed publications between 1988 and 1993, Gélinas *et al.* [1996] characterise JIT by four aspects. First, *high pervasiveness* signifies that primary processes are tightly linked together. The JIT concept is typically implemented throughout the whole organisation: because of the absence of buffer stocks, JIT cannot be practised within one process in isolation, but the various business functions need to be integrated [Spencer *et al.*, 1994].

Second, *high immediacy* stands for a shorter reaction time together with very small batch sizes. Commonly cited JIT-related improvements include reductions in customer response time [Daugherty and Spencer, 1990]. These are achieved by implementing techniques such as cellular manufacturing (autonomous workstations), setup time reduction and logistics pull scheduling [Stalk, 1988; Stank and Crum, 1997; Voss, 1987].

Third, *high internal substitutability* is achieved through the simplification of work tasks and cross-training of workers. Voss [1987] claims that JIT can only flourish under fairly uniform demand or with flexible production operations. A cross-trained workforce combined with employee decision making on the factory floor is one way of realising flexibility in work assignments [Daugherty *et al.*, 1994; Stalk, 1988]. Another way of gaining a flexible workforce is using annualised hours: workers are given time off without loss of pay during slack periods, but work longer when demand rises [Brown, 1999].

Fourth, *low external substitutability* is a consequence of the high product quality and delivery requirements imposed by a JIT-system. JIT leads to the outsourcing of non-strategic operations to suppliers and time-based evaluation systems of suppliers, such as measurement of lead times, reliability and activity-based costing (ABC) [Rich and Hines, 1997; Stank and Crum, 1997]. Fast and continuous production requires integration of suppliers, and this can only be achieved through long-term agreements with suppliers (supplier certification programmes) [Daugherty *et al.*, 1994; Gibson, 1995; Stalk, 1988; Stank and Crum, 1997; Wilson, 1998].

Efficient Consumer Response (ECR) and Quick Response (QR)

What Quick Response (QR) stands for in the textiles and apparel industry, is what efficient consumer response (ECR) represents in the food and retail industry. The US Council of Logistics Management defines ECR as ensuring that replenishment shipping activities are executed, based on constant forecasting of consumer demand at the item level, using point-of-sale data (POS) [Browne and Allen, 1997]. Likewise, the idea of QR is also based upon demand-driven replenishment, depending on availability of actual sales information across the supply chain [Christopher, in: Cooper, 1994; Inkoop&Logistiek, 1997a]. This pull model can only work by delivering in high-frequency, small drop sizes and by reducing order cycle times, otherwise buffer inventories would simply be pushed upstream the supply chain [Faber, 1995].

ECR Europe [in: Inkoop&Logistiek, 1997b] characterises the supply side of ECR by means of six elements. First, *integrated suppliers* should comply with precise delivery requirements arising from the production process of the buyer. Second, as failures usually take up a disproportionate amount of time to restore, *reliable operations* are a requirement for ECR. Third, *synchronised production* means that, as items are consumed, the manufacturing facility is immediately triggered to produce the consumed amount of products (pull scheduling). Fourth, *crossdocking* is a technique to reduce changeover times at distribution centres: the producer sorts out his products for each retail outlet and sends this combined shipment to the warehouse of the buyer. Fifth, *continuous replenishment* reflects that, as items are consumed, the seller is immediately triggered to replenish the consumed amount of products. Christopher [in: Cooper, 1994] asserts that often high-speed, smaller quantity deliveries will be made. ECR in the food industry is also characterised by increasing importance of fast and efficient distribution [Logistiek Actueel, 1998]. Sixth, *automated store ordering* consists of automatic orders based on POS data. EDI, bar coding and the use of electronic point of sale systems with laser scanners are often used as the media for these types of orders [Christopher, 1994].

2.3 TIME-REDUCTION ALTERNATIVES

JIT, ECR/QR and time-based strategies share one common characteristic: time-reduction of value-added and non-value added processes is seen as a crucial requirement. There are however numerous ways of reducing time consumption throughout the supply chain. This section explores different variants of time-reduction by means of the time-space prisms introduced in the previous chapter. These theoretical alternatives are illustrated by practical observations from a broad selection of logistics journals, in order to examine if and how these variants are put into practice.

Base scenario

A hypothetical base scenario is depicted in Figure 2-2. It displays a supply chain consisting of one original equipment manufacturer (OEM), who has two suppliers (S_1 and S_2), one distribution centre (DC) and two customers (C_1 and C_2). The arrows with broken lines show information flows (*order transmittal time*) while the solid lines reflect physical transportation of (semi-)finished goods (*order shipment time*). The vertical components of the order shipment time represent loading and unloading times (*dispatch time*). The inert processes are further decomposed into *order preparation time*, *production/storage time* and *order processing time.*

The entire order cycle takes 48 hours, from order placement until receipt by the customers. In the sub-sections below, we will presume that the two customers demand faster order cycle times and that the OEM decides to comply with those customer requirements. Let us suppose that a cycle time-reduction by 25% would be required, that is, orders should now be delivered within 36 hours, instead of 48 hours. In the following sub-sections, we will discuss several time-reduction alternatives that can be considered to comply with this requirement.

Alternative 1: Accelerate order shipment

Stank and Crum [1997] conclude that dependable and fast transportation is increasingly important to firms in a JIT environment. Morash and Ozment [1996] also maintain that the strategic use of transportation creates time value to customers. Others assert that transit time usually only represents a small proportion of the total order cycle time [McKinnon, 1994], and that dependability is generally more important than transit speed itself [AT Kearney, 1993; TNO-INRO, 1993; Stank and Crum, 1997]. Moreover, Tarski [1987] claims that the order shipment time is largely dependent on waiting time, especially on waiting for loading and/or feeder operations. However, in some instances transit speed may be of significant interest, for example in the computer industry:

> *The emphasis on speed in the computer logistics arena may at times seem a trifle obsessive, but 24 hours can really make a difference. When a product is launched companies will often have its successor almost ready, so the transit time can really make a difference* [Lewis, 1999a, p.28].

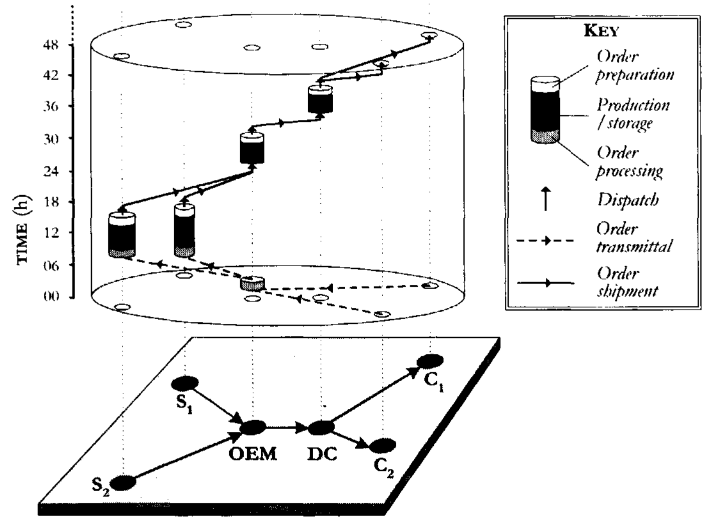


FIGURE 2-2 TIME-SPACE PRISM: BASE SCENARIO

Ng *et al.* [1997] also stress the significance of transit time because of its impact on other business processes: e.g. the transit time (and reliability) of raw materials often has strong impacts on the manufacturing process and on the customer's perception of channel performance [Ng *et al.*, 1997].

Time compression through accelerating order shipment time was already touched upon in the previous chapter. In this particular example we again assume a situation where no inventories exist and where inert process times remain unchanged. Time compression is accomplished by speeding up physical transport flows: a reduction in transit and dispatch time (see Figure 2-3). A reduction in *transit times* can be achieved by choosing faster modes of transportation, by outsourcing transport to specialised logistics service providers (LSPs) and by using advanced route planning systems.

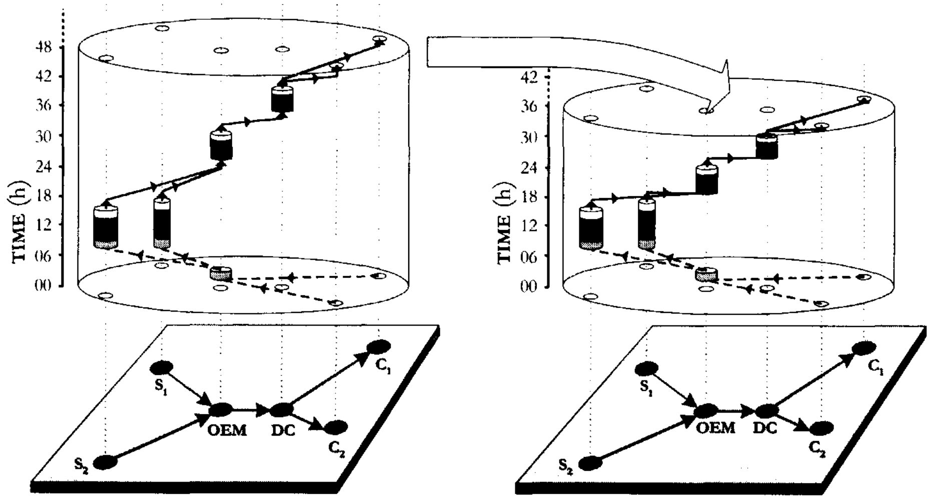


FIGURE 2-3 **ACCELERATION OF ORDER SHIPMENT**

Choose faster modes of transportation

Time-based strategies and JIT concepts ask for flexible and high-speed logistics services [NEA and Cranfield University, 1994]. In a report involving analyses of four industry sectors, Buck Consultants [1996] conclude that the importance of short order cycle times often results in a preference for the most flexible mode of transportation: road transport. Fawcett [1992] identifies the greater use of airfreight for regular shipments as a technique to reduce lead time. Therefore, the explosive growth of integrated air express transport is associated with the high time-requirements in sectors such as the computer and high-technology industry [Lewis, 1999a]. The same reasons for choosing faster modes of transportation are found in other industry sectors. For instance, the distribution of compact discs is largely carried out by express carriers such as EMS and TNT [Andriesse, 1997] and the distribution of Dutch postal mail was shifted from rail to road [Mieras, 1997]. Finally, in the clothing industry high-value goods are transported by air and for the remaining products flexible and fast light vans are used [Lewis, 1999b].

Outsource transport activities to LSPs

It is claimed that third-party logistics service providers (LSPs) are capable of offering fast and cost-effective transport services at the same time [Fawcett, 1992; Logistics Europe, 1998a]. Some authors state that the emergence of JIT as a management philosophy has coincided with the growth of third-party LSPs specialising in consolidation services [Christopher, 1994; Daugherty and Spencer, 1994]. For example in the automotive and food industry, lead time reductions are achieved by making use of LSPs offering seamless and fast services [Kalsaas, 1996; Logistiek Actueel, 1998]. Usually this also implies a reduction in the number of carriers hired: the efficiency of JIT is said to require fewer carriers and the use of long-term contracts with carriers [Daugherty *et al.*, 1990]. One practical illustration of this tendency is provided by Dow Chemical Europe: it reduced its number of third-party carriers from 35 to 6 [Andriesse, 1996].

Use advanced route planning systems

Vehicle routing and scheduling (VRS) is the planning of the delivery and/or collection of goods using one or more vehicles within certain time constraints [Eibl *et al.*, 1994]. Modern route planning systems can further accelerate the transport process. Advanced dynamic vehicle allocation systems are equipped with routing software, digital maps, satellite communications and online information on traffic jams. Roberts Express, America's largest express carrier, uses such a system and is capable of delivering 96% of its shipments on-time across the USA, of which more than 50% are delivered within one day [Logistiek.nl, 1998a]. Other applications of routing systems found in the literature include for example Coca-Cola [Logistics Europe, 1999] and Mallinckrodt (producer of perishable medicines and winner of the Dutch National Logistics Prize 1996)[Andriesse and Wiegerinck, 1996].

A second set of order shipment time reductions consists of the *reduction in dispatch time*: compression of the time needed for loading and unloading activities. Effective materials handling can be realised by improving the dispatch area layout, efficient dock equipment and by using standardised transport units.

Improve dispatch area layout

Waiting times of trucks at dockyards can be reduced by improved layout of the dispatch area. The main objective of layout improvement efforts should be to reduce materials handling to a minimum: the best materials handling is no handling [Canen and Williamson, 1998]. If the number of dockyards is limited, trucks could be waiting for each other while (un)loading activities take place. Easy access of the docks is also a requirement for effective materials handling, for manoeuvring with trucks or trailers is usually time-consuming [Wijnberg, 1993]. Effective materials handling is further supported by improving document flows, because some of the waiting time for trucks is found to be caused by administrative delays [Nieuwsblad Transport, 1992; Wijnberg, 1993]. Oosterhout and Beije [1997] for example mention the Cargocard that is used to accelerate the administrative processes in the port of Rotterdam. This card contains all the required order information that is needed by the different processes within the port, and practically eliminates administrative delays.

Use efficient dock equipment

The forklift truck is the most common type of dock equipment [Coyle *et al.*, 1992], but more mechanised equipment is also available. Although manual loading and unloading can be perfectly effective in the case of small and heterogeneous orders, automated loading dock systems can save time in case of thicker product flows. One-shot vehicle loading is enabled by powered conveyor systems or slip chains [Redmond, 1997a]. Matsushita Electric uses such a system and can now load a trailer in just 15 minutes, while it used to take 2.5 hours before mechanical handling was implemented [Logistics Europe, 1997b]. The use of side-access trailers is another way of speeding up the loading/unloading process [Ng *et al.*, 1997]

Standardise transport units

Time can also be saved if all supply chain members use the same transport units (e.g. uniform pallet sizes). Re-packing of products between two pallet types is a non-value added and labour-intensive activity that can be prevented by unitising transport units across the supply chain. This form of supply chain integration is among others observed in the food and automotive industry [Logistiek.nl, 1998b; Nieuwsblad Transport, 1992].

Alternative 2: Compress inert processes

The inert processes discerned in the hypothetical supply chain include order transmittal, order processing, production, storage and order preparation. Figure 2-4 depicts time compression efforts in each of these processes.

Reduce order transmittal and order processing times

As Gibson [1995] puts forward, information technology (IT) may not be the only timesaver, but IT is an essential ingredient in time-based business processes and strategies. The traditional way of order transmittal and order processing is where batches of documents are passed from one supply chain member or from one workstation to the other [Sussams, 1995]. Online information is made available through IT applications such as electronic data interchange (EDI), web technology or electronic mail (e-mail); waiting times due to lengthy administrative processes are reduced to a minimum [Loughlin, 1998; Nieuwsblad Transport, 1998; Simms, 1997]. Additionally, the integration between EDI and Enterprise Resource Planning (ERP) systems is mentioned as a requirement for a continuous flow operation [Oosterhout and Beije, 1997].

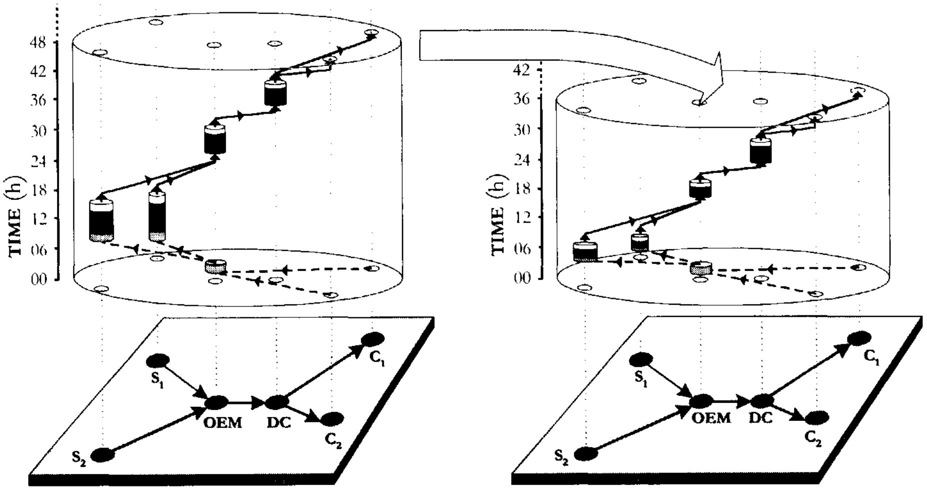


FIGURE 2-4 COMPRESSION OF INERT PROCESSES

EDI is a means of interfirm electronic communications, based on European Article Numbering (EAN) coding and a uniform syntax for messages (EAN Communications (EANCOM) standard), which leads to substantial reductions in order transmittal time [Calza and Passaro, 1997; Inkoop&Logistiek, 1997a]. EDI is said to be advantageous in business segments with high-volume transactions and a time-critical context [Bytheway, 1994]. Whereas incomplete standardisation of EDI calls for additional investments, web technology generally requires less assets [Loughlin, 1998]. The internet allows companies to be online with each other and enables the buyer to treat a supplier like a department of his own [Jedd, 1995]. Just two illustrations of these types of technology are formed by Ford and Heineken. Ford receives brakes of suppliers on a JIT-basis. The supplier has an online connection to the information systems of Ford [Jedd, 1994; Phillips, 1999]. Point-of-sale data are fed back to the brake supplier, initiating automatic orders. Likewise, Heineken had to reduce its order cycle time to one of its customers, Albert Heijn, from 72 to 24 hours. In addition to new storage techniques, EDI and a continuous order transmission/order entry process helped to accomplish this time-reduction target [Schipper, 1997].

Reduce production lead times

In the literature two main solutions for reducing production lead times are encountered: product modularity and reduction in changeover times. First, producing with the help of time-saving pre-fabricated modules is common in the construction and timber industry [Rand Europe and Coopers&Lybrand, 1998], but modular production is considered a general manufacturing strategy across almost all industry sectors [Jina *et al.*, 1997; NEA and Cranfield University, 1994]. Sheu and Wacker [1997] claim that modularity results in simplified planning and scheduling, which in turn leads to decreased manufacturing lead times. In the automotive industry vehicles are already designed with standardised platforms and interchangeable parts across models [Kalsaas, 1996]. In this context, computer-aided design (CAD) and computer-aided manufacturing (CAM) are supporting technologies that increase production speed and flexibility [Vastag *et al.*, 1994].

Second, reduction in waiting and changeover times is frequently mentioned in recent logistics journals. There are several ways of realising such time savings, such as group technology/cellular manufacturing and employee training. Group technology seeks to group machines so as to manufacture products with similar manufacturing characteristics at the same workstation [Balder, 1993; Voss, 1987]. The resulting product-oriented layout should result in a flow operation with minimum waiting times and materials handling. In addition to these more technical changes it is stressed that the major changes should be in the behaviour and attitudes of staff at all levels [Burnes and New, 1996]. Employee participation and intensive changeover training could result in significant setup time reductions, up to 50% [Balder, 1993]. Illustrations of these types of time-reductions are for example found in the textiles, clothing and leather industry [Rand Europe and Coopers&Lybrand] and in the telecommunications industry [Logistics Europe, 1998b].

Reduce storage lead times

One mode of storage lead time reduction that has gained considerable attention in recent years is crossdocking. Crossdocking practically amounts to an elimination of storage time, because warehouses are turned into switching yards rather than holding yards [Lalonde and Masters, 1994; Redmond, 1997b]: products barely enter the storage facility anymore, but are transhipped at the loading docks directly from one vehicle to the other. As Kinnear [1997] explains, the key to the process of crossdocking is transhipping, not holding stock. Due to the high requirements placed on co-ordination and carriers, who have to maintain tight time schedules, crossdocking is presented as easy to understand but hard to implement [Johnson, 1998].

Reduce order preparation times

Order preparation consists of order picking and packaging. Multiple systems for accelerating those processes are implemented in practice. Classifying stock to speed of throughput can already result in more efficient routing of forklifts [Bell, 1997; Jones *et al.*, 1997]. Additionally, automated palletising also represents considerable time savings in order picking, as manual pallet handling is both time- and cost-consuming [Bluijssen, 1993]. Renault France has for example transformed one of its three national warehouses into a highly mechanised European distribution centre [Allen, 1999]. Traditional mechanised systems include carousels and conveyors, while automatic storage and retrieval systems (AS/RS) and radio frequency (RF) are some of the latest innovations in this context. RF-identification is based on a chip or tag that is attached to each crate or pallet. Instead of repetitive bar code scanning, the chip contains identification data and sends or receives radio signals to and from a special reader. The main advantage of RF is that stock items do not have to be scanned over and over again, but are nevertheless traceable at any time. Unilever Italy has reduced warehouse lead times by using RF-systems [Logistics Europe, 1996].

Alternative 3: Choose for co-location

Within this alternative scenario, order cycle time reduction is achieved by a reduction in the physical distances between suppliers and the OEM, and between the OEM and his customers respectively. Mair [1992] argued that geographical proximity is not itself the fundamental issue in a JIT environment: physical closeness is less important than 'closeness in lead time'. Therefore, this alternative (see Figure 2-5) can also be considered a sub-group of the time-reduction alternative of order shipment time acceleration.

Theoretical locational options include concentration on nearby customers (ignoring the peripheral ones), the location of the production facility closer to the distribution centre, the location of the DC closer to customers and the location of the manufacturing plant closer to the customers. A research project by Buck Consultants [1999] showed that, on an international level, centralised and decentralised distribution structures co-exist. On a national level, distribution centralisation and manufacturing rationalisation seem to be dominant trends [NEA and Cranfield University, 1994]. Hence, longer mutual distances instead of shorter distances can be expected. However, opposite examples are also observed in the food industry where different retailers and their suppliers share the same distribution facilities.

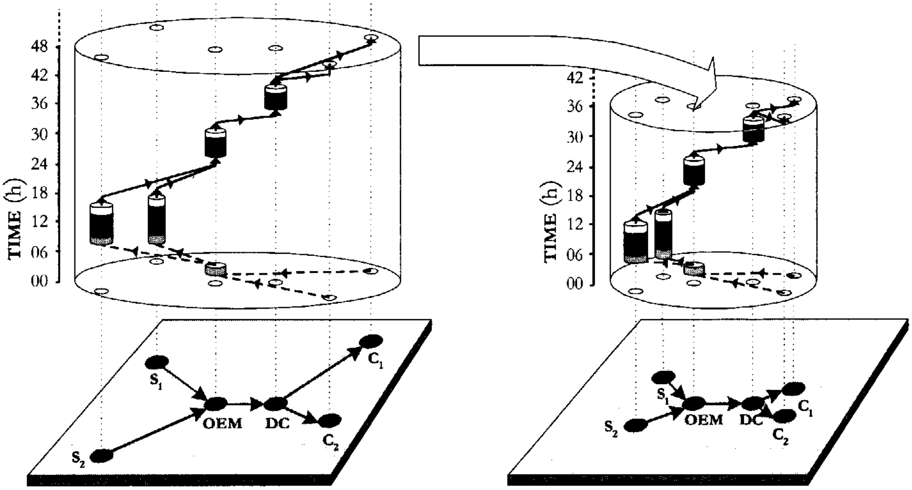


FIGURE 2-5 **CO-LOCATION OF SUPPLIERS**

Choose suppliers closer to OEM

One of the most encountered options in the literature includes the location of suppliers closer to the OEM. It is considered to be advantageous to deal with geographically proximate suppliers, or to encourage suppliers to locate near the manufacturing facility [Wafa *et al.*, 1996], because proximity facilitates just-in-time deliveries. Co-location or agglomeration effects are mainly encountered in the automotive and chemical industry [Rand Europe and Coopers&Lybrand, 1998; Van der Kaaij, 1996]: Toyota's affiliated suppliers are (on average) 30 miles away [Dyer, 1994], while SEAT persuaded 27 suppliers to co-locate in a pre-assembly industrial park located 2 kilometres from the assembly tracks [Logistics Europe, 1998c]. NedCar (The Netherlands) wants to establish the same, but is constrained by a lack of space surrounding the assembly site [Vossen, 1998].

Alternative 4: Eliminate links from the supply chain

The OEM could also decide to remove redundant or excessively time-consuming links from the supply chain, because it is argued that speeding up response times means simplifying the business process [Saunders, 1999]. This can be done by reducing the supplier base, by performing more pre-assembly and distribution activities in-house and by bypassing the distribution centre (disintermediation or direct distribution). One of these hypothetical options is shown in Figure 2-6.

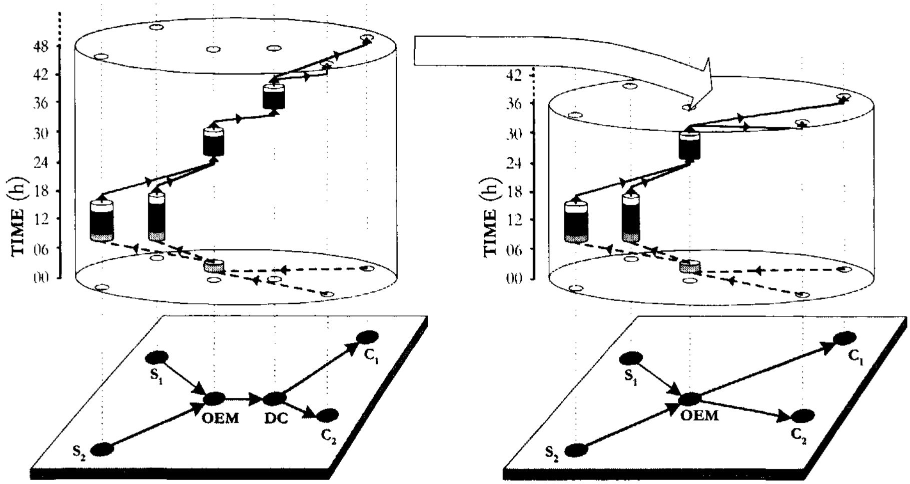


FIGURE 2-6 BYPASSING THE DISTRIBUTION CENTRE

Reduce supplier base

There is common agreement that JIT requires the utilisation of fewer suppliers and the use of long-term contracts with suppliers [Daugherty *et al.*, 1990; Fawcett, 1992]. Integrated suppliers are also a crucial element of the ECR philosophy [Inkoop&Logistiek, 1997b]. One advantage of partnerships with certified suppliers is assured quality, which reduces time-consuming return flows and the need for quality checks during order receipt [Voss, 1987].

The ultimate reduction in the supplier base would result in the OEM taking up all business activities by himself. Rover (UK) has recently returned to the model of producing more parts in-house [Logistiek.nl, 1999a]. This can however be regarded as an exception: there is a move away from a situation in which OEMs produce most of the components themselves [Lewis, 1999a].

Bypass distribution centre

Direct distribution and disintermediation is an option when delivery speed is a must. Direct delivery is applied in the distribution of fresh dairy products. If at all stored, dairy products are distributed using crossdocking techniques [Buck Consultants, 1996]. Another example of direct distribution is provided by Dell computers:

> *Dell sells directly to customers and thereby eliminates two months of delay in which a PC typically languishes in warehouses and on store shelves waiting to be sold* [Economist, 1996, p.79].

Disintermediation has attracted attention in the automotive industry because by far the longest part of the delivery process of a car is consumed by the outbound logistics stage, via an often complicated dealer and logistics network [Lewis, 1999c]. Renault has successfully removed intermediate stock and at the same time greatly improved response time to dealers [Allen, 1999]. The logistics concept of the SMART car is already based on a distribution network whereby distribution centres and dealers are completely bypassed [Intermediair, 1998]. Direct distribution is also expected to grow through the emergence of e-commerce [Logistiek.nl, 1999b]. UPS for example delivered 55% of all American internet orders in 1998, using its own direct network [Logistiek.nl, 1999c].

Alternative 5: Replace sequential by parallel processes

The last variant of time-reduction we will discuss, will in reality often be the starting point for an existing supply chain: a scenario where a swift reaction to customer orders is enabled by holding inventories of (semi-)finished goods. Inventory of (semi-)finished products could be held at the suppliers', the OEM's, or at the distribution centre (postponement). Examples of this alternative are represented by Figure 2-7: the two suppliers are operating a make-to-stock system in order to meet the required order cycle time of OEM.

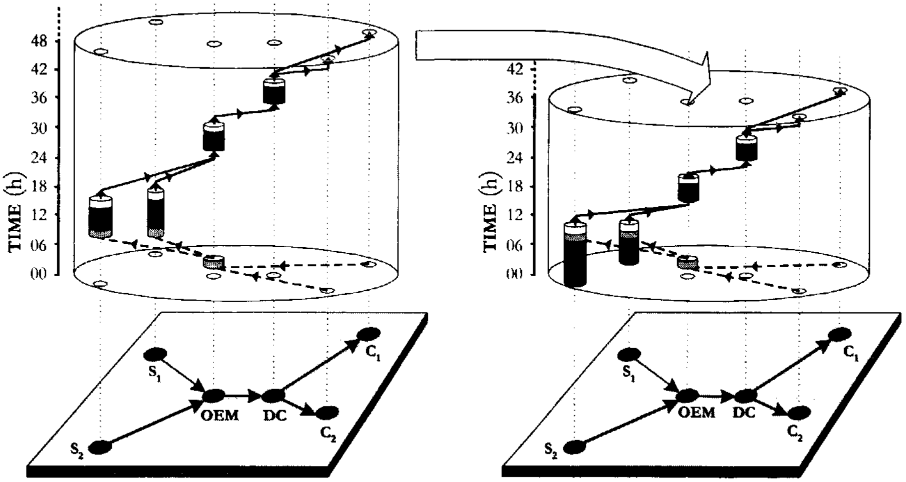


FIGURE 2-7 SUPPLIERS HOLDING INVENTORY

Hold inventory of (semi-)finished products at the OEM's or suppliers'

Although concepts such as ECR should in theory reduce inventory levels in the supply chain as a whole, practice sometimes seems to be slightly different. Toyota for instance holds just half a day of spare parts, but due to a fire at the factory of one of its suppliers, Toyota lost 3 days of production [Logistics Europe, 1997c]. Because of this vulnerability, it is claimed that Japanese companies have moved into sub-assembly manufacturing: holding inventory at the sub-assembly level, rather than at the raw material level [Jedd, 1995]. Others have also reacted on this Achilles heel of JIT production by raising inventory levels. DAF Trucks for example decided to increase the proportion of build-to-stock trucks, because order cycle times were becoming too lengthy [Logistiek.nl, 1997].

Hold inventory of (semi-)finished products at the distribution centre (postponement)

Postponement is the secondary processing of goods closer to the point-of-sale or later addition of regulatory or language-specific data [Hastings, 1997]. Postponement is already implemented in the pharmaceutical industry for last-minute packaging of standard bulk products [HIDC, 1996]. Typically postponed activities at distribution centres of LSPs are labelling, packaging, assembly finishing and customisation [New, 1999].

Alternatively, parallel production processes (instead of sequential ones), are a more responsive alternative to stock keeping, though probably harder to achieve. As Spanner *et al.* [1995] argue:

> *Most experts agree that the least effective way to be a time-based competitor is to merely accelerate existing processes and procedures. This is because conventional business processes are typically sequential. For time-based competition, however, parallel operations are required* [Spanner *et al.*, 1995, p.79].

Parallelism is achieved either by concurrent engineering of geographically separated production processes (e.g. synchronisation of production processes of OEM and suppliers) or by concurrent engineering of geographically co-located processes (e.g. preparation of the loading dock while production is taking place).

Concurrent engineering of geographically separated processes

Synchronised production between suppliers and OEM was already discussed in the context of ECR (see section 2.2). Synchronisation means that, as the OEM sells products, the suppliers are immediately triggered to replenish consumed amounts of materials. In fact, synchronised or parallel production can be thought of as a materials requirements planning (MRP) system with extremely short lead times.

Concurrent engineering of geographically co-located processes

Examples of concurrent engineering in the literature are found in the pharmaceutical industry [Andriesse and Wiegerinck, 1996], whereby transport is already organised while production is still taking place. In addition, parallel building phases are used in the construction industry [Gunasekaran and Love, 1998; Rand Europe and Coopers&Lybrand, 1998].

2.4 CONCLUSIONS

This chapter dealt with our third research question: what are the micro-impacts of time-based strategies on logistics choice behaviour? We explored this question by means of a literature study. We first defined time-based strategies and related concepts such as just-in-time, efficient consumer response and quick response logistics. Time-sensitivity and responsiveness were identified as crucial characteristics of time-based strategies that can be achieved by compressing time in both value-added and non-value added processes.

Section 2.3 consisted of an overview of time-reduction alternatives. These alternatives were deduced from a time-space prism of a hypothetical supply chain and were illustrated by practical applications found in the literature. Table 2-1 summarises the deduced alternatives of time-reduction.

These five alternatives are subdivided into practical methods of time-reduction. Acceleration of order shipments can for example be achieved by a reduction in transit time. This in turn can be accomplished by choosing faster modes of transportation, by outsourcing transportation and by using advanced route planning. As becomes clear from the overview given in this chapter, companies are faced with a broad set of choices when it comes to reducing time in their logistics processes.

Acceleration of transport processes is therefore just one among the many choices open to logistics managers, but according to some authors one of the more popular choices. As was argued in the previous chapter, the increasing use of faster modes of transportation (road and air transport) is partly attributed to the emergence of time-based strategies and associated JIT concepts [Chapuis *et al.*, 1993; Garreau *et al.*, 1991; Läpple, 1994; McKinnon, 1994]. Moreover, a tendency towards higher transport frequencies is observed in the literature, but others claim that an increase in the shipment frequency is being counteracted by increased consolidation efforts [Christopher, 1994; Daugherty and Spencer, 1994; McKinnon, 1994].

TABLE 2-1 TIME-REDUCTION ALTERNATIVES AND METHODS

Alternative	Methods
Accelerate order shipment	Choose faster modes of transportation Outsource transport activities to LSPs Use advanced route planning systems Improve dispatch area layout Use efficient dock equipment Standardise transport units
Compress inert processes	Reduce order transmittal and order processing time Reduce production lead time Reduce storage lead time Reduce order preparation time
Choose for co-location	Concentrate on nearby customers Locate manufacturing plant closer to DC Locate DC closer to customers Locate manufacturing plant closer to customers Choose suppliers closer to manufacturing plant
Eliminate links from the supply chain	Reduce supplier base Bypass distribution centre
Replace sequential by parallel processes	Hold inventory of (semi-)finished products at the manufacturing plant or the suppliers' Hold inventory of (semi-)finished goods at the DC Concurrent engineering of geographically separated processes Concurrent engineering of geographically co-located processes

Due to the sometimes contradictory outcomes of the literature study, our additional fieldwork is explicitly aimed at observing which impacts of implementation of time-based strategies actually do occur in the Dutch context. To this end, the next chapter consists of a report of case studies executed in one industry sector that also faces increasing time-sensitivity, the pharmaceutical industry. After identifying the economic sectors in which time-based strategies are most common (research question Q1), we will also go into the question of what specific causes of increasing time-sensitivity can be observed in the pharmaceutical industry (Q2).

3

Relevance and causes of time-sensitivity

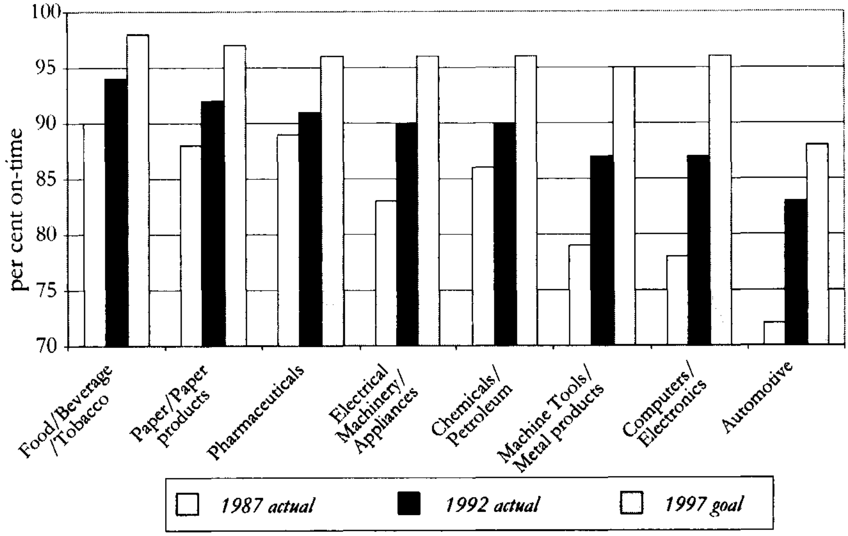
This chapter is aimed at providing an answer to research questions Q1, Q2 and an elaboration of Q3. The first research question concerns the *relevance* of time-based strategies for different business sectors (section 3.1). The second research question relates to the *causes* of the emergence of time-sensitivity in those sectors (section 3.2), while the third research question deals with the *impacts* that these strategies have on logistics decisions on the firm-level (section 3.3). In section 3.3, we will discuss the implications of time-based strategies for a specific case study industry: the pharmaceutical industry.

3.1 IDENTIFICATION OF TIME-BASED INDUSTRIES: LITERATURE REVIEW

A comprehensive study executed by AT Kearney [1993] reveals important logistics developments within different business industries, based on data of 1,000 industrial companies located in Europe. The report, which was updated in 1999, outlines trends in reliability and order cycle times.

In the previous chapter, we saw that the definition of time-sensitivity contains both elements of *reliability* and *speed*. These measures can therefore be used as an indication to determine the time-sensitivity of the different industry sectors. Figure 3-1 describes the evolution of the percentage of orders delivered on time. The industry sectors are ranked by the actual figures of 1992 (the black bar).

The business industries with the best reliability performances include the food/beverage/tobacco, paper products and pharmaceutical industry, with figures ranging between 91 and 94 per cent. Surprisingly, the computer and automotive industries' renowned 'lean' image is not reflected by relatively high levels of reliability. Apparently this image is mainly based on the high levels of delivery reliability of Japanese and American computer and car manufacturers, not equalled by their European counterparts. Another explanation will probably be that the delivery requirements in these sectors are so tight that it is hard to comply with them.

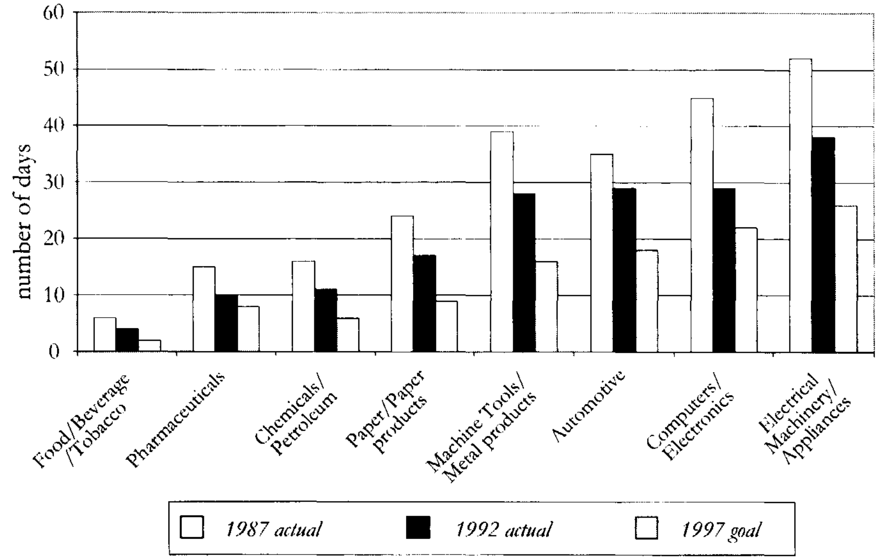


Source: AT Kearney [1993]

FIGURE 3-1 ORDER DELIVERY RELIABILITY (PER CENT ON TIME)

In general, every industry featured by and large the same ambition level: almost all business industries are aimed at achieving a reliability level of around 95 per cent for the year 1997. Unfortunately, the updated results [AT Kearney, 1999] do not provide sectoral figures. However, it became abundantly clear that the ambitious reliability targets had not been achieved by the year 1997. Across the board, it was concluded that very little actual improvement had been made. In 1997, reliability figures still averaged 88 per cent.

A second indication of the importance of time as a determinant of logistics decision making is the actual order cycle time. The average figures for each industry sector are depicted in Figure 3-2. Again, the food/beverage/tobacco and pharmaceutical industry appear in the top-3. The national character of these industries can partly explain this: as their distribution structures are mainly oriented towards domestic markets, order cycle times are also shorter. Conversely, the relatively long order cycle times of the automotive, computer and electrical machinery industry can to a certain degree be excused by their international nature. It should be noted however that these sectors reveal the largest dynamics in absolute terms.



Source: AT Kearney [1993]

FIGURE 3-2 ORDER CYCLE TIME (DAYS)

Whereas reliability targets for the year 1997 had not been achieved, the projected lead time reductions did materialise. The order cycle time had actually been reduced by 33 per cent between 1992 and 1997 [AT Kearney, 1999]. The seemingly limited progress with regard to reliability should therefore be put into perspective: faced with ever-shorter lead times, it is obviously harder to comply with reliability targets.

A manifest feature of Figure 3-2 is the overall trend of cycle time-reduction. Without an exception, all industries display a sharp reduction in the time consumed in the logistics supply chain. This observation is also confirmed by research findings of others. A survey of 600 European logistics service users demonstrated that the reduction in lead times is now viewed as the most important service level target [Logistics Europe, 1998a]. A comparable questionnaire among 134 Dutch industrial companies reached the same conclusion [Van Vliet, 1996]: these companies expected that customer demands such as order cycle time, flexibility and reliability would be the most important determinants of logistics decision making until the year 2001.

If one combines the top-3 rankings of both Figure 3-1 and Figure 3-2, one could conclude that the most time-sensitive sectors are:

- Food/Beverage/Tobacco.
- Pharmaceuticals.
- Paper/Paper products.
- Chemicals/Petroleum.

When we look at the sectors with the most dynamic changes (see Figure 3-1 and Figure 3-2), attention for the computers/electronics and the automotive industry would be justified as well.

Literature review

The presented statistics provide a useful but rough indication of the historic sectoral development of time-sensitivity. Therefore, we will briefly summarise the results of a literature review, which was executed in order to further examine the importance of time-sensitivity in each of the above business sectors.

Food/Beverage/Tobacco

The food and beverage industry is referred to as a leader in supply chain management and efficient consumer response in numerous publications [Kosters *et al.*, 1997; NEI *et al.*, 1995; Snijders, 1999]. In a logistics benchmark study within the Dutch semi-process industry, Kosters *et al.* [1997] conclude that food manufacturers outperform other manufacturers. This is explained by the increased implementation of ECR. Faber [1995] observes this emergence of ECR in the Dutch food industry as well.

Quick response (QR) pressures are also identified as the main drivers of logistics change in the British food sector [McKinnon and Woodburn, 1996; Logistics Europe, 1999]. According to Browne and Allen [1997] and Logistiek Actueel [1998], the emergence of ECR in the British and Dutch food industry is exemplified by an increasing need for speed in the supply chain of food products. Ploos van Amstel [1996] equally discerns a trend of continuous replenishment and tight time windows in the food industry, which can partly be explained by an explosion of the number of stock items (increase of product variations).

Pharmaceuticals

Logistics time-sensitivity is considered to be important in the pharmaceutical industry, owing to the exceptionally long research and development times and the relatively short time available for recovering these R&D efforts [Rand Europe and Coopers&Lybrand, 1998]. In addition to the shortening of the time-to-market, reductions in order cycle times could contribute to improved returns on investment [Simms, 1997]. Moreover, by being the first to introduce a new drug, one most likely takes possession of the largest market share. As Romanski and Patti [1995] put it:

> *Economic success in the pharmaceutical and medical supply segments of the health care industry depends on elapsed time. (...) By being first, a company can capture brand recognition and market share. (...) Robotics and material handling equipment rush orders through warehouses and into the hands of the consumers at record speed. The whole concept of time-based competition is alive and thriving in this industry* [Romanski and Patti, 1995].

Paper/Paper products

With respect to the role of time in the paper and paper products industry, few written sources of information were readily available. Lehtonen and Holmström [1998] mention two Scandinavian paper producers that implemented JIT logistics by increasing transport frequencies. Additionally, we interviewed the logistics manager of an international manufacturer of specialised paper products (Rexam Graphics), with a European sales office in the Netherlands. The interview took place in spring 1998. The interview concentrated on the company's logistics organisation and the reasons for the firm's increased use of air transport instead of sea carriers.

The reasons for acceleration in the logistics processes boil down to two factors. First, the *shortening of the product life cycle* of inkjet paper considerably contributed to an acceleration of logistics processes. Due to the continuing innovations in printing technology and accompanying paper requirements, the average shelf life of inkjet paper does not last longer than half a year. Second, the development of *structural next-day deliveries* to European customers had been initiated. Because of competitive forces, the company tried to differentiate itself from its competitors by offering faster logistics services. This interview therefore confirmed expectations that time plays an important role in the logistics decision making within the paper industry.

Chemicals/Petroleum

With regard to the importance of time-based strategies in the chemical industry, contradictory evidence is derived from the literature. NEA&Cranfield [1994] claim that order quantities are declining for both high-value specialty chemicals and bulk commodities, as customers demand a just-in-time ability from their chemical suppliers. The quest for inventory reductions can be seen as a cause for this trend. Logistiek.nl [1999a] and Logistics Europe [1998b] however report that chemical companies are rather lagging behind innovative logistics companies, as is exemplified by relatively low standards of delivery reliability. Kuipers [1999] differentiates between specialties and bulk commodities: while quick response logistics is *not* an issue for producers of base chemicals, it does play an essential role for producers of specialty chemicals (especially when they are part of automotive supply chains).

Computers/Electronics

The electronics industry can be sub-divided into business equipment (copiers, computers, fax, etc.) and consumer electronics (cellular phones, dishwashers, PCs, TVs, etc.). The European production of white goods is affected by a move towards more flexibility and reduced lead times [Lewis, 1998]. Additionally, it is claimed that speed and flexibility is everything in the PC manufacturing industry (see e.g. Dell's direct distribution concept) [Lewis, 1999b]. This is largely attributed to the short product life cycle of microelectronics:

> *Obsolescence is a big problem for computer manufacturers whose latest product rarely performs for more than six months* [Logistics Europe, 1997, p.38].

The business equipment industry equally witnesses efforts to reduce order cycle times [NEA&Cranfield, 1994]. Owing to fast successive product innovations no producer can afford to carry large amounts of inventory items, as these products quickly become outdated. This fact may be the cause for the wide acceptance of JIT-related concepts in the electronics industry [McKinnon, 1994; Voss, 1987]. Furthermore, competitive forces reinforce the need for flexibility and speed in logistics processes. As was revealed by case study research of KPMG [1998], IBM implemented ECR, because some of its competitors had been offering lead times of several days, whereas IBM used to provide its products within weeks.

Automotive

Voss [1987] and McKinnon [1994] claim that JIT has been most widely applied in the automotive industry. Toyota is probably the most famous example of a company that started to demand JIT delivery from its suppliers [Dyer, 1994; Stalk, 1988]. Notwithstanding the fact that time-sensitivity is an often cited phenomenon on the materials management side of the automotive supply chain, Lewis [1999c] notices that it takes hours to assemble a car, but weeks to deliver it. The speed that characterises the production process is not matched by an equally short delivery time. However, as is asserted on Logistiek.nl [1999b], the delivery time of cars has been reduced from months to weeks in recent years. That is, the order lead time has become an important weapon in the competition between car producers. Inventory control can be another motive for reducing order lead times: for example, NedCar is putting suppliers under pressure to reduce the time needed for the shipment of components, because it would be too expensive to carry more inventory than strictly necessary for the production process [Vossen, 1998].

The logistics of after-sales service (parts services) is also an automotive sub-market that is under increasing time pressure. Spare parts services are for example 'big business' for Europe's top truck manufacturers, and in the light of increasing competition each truck manufacturer is eager to provide the fastest possible service to his clients [Allen, 1999].

Apparel/Clothing
The apparel and clothing industry experiences increasing time pressure as well: especially with regard to the higher value segment and fashion garments, logistics decisions are increasingly taken in favour of acceleration [Lewis, 1999a]. The versatility of the fashion market causes producers' success to be dependent on short delivery times. The time in which a producer reacts to customer requirements is decisive in this industry [Rand Europe and Coopers&Lybrand, 1998]. An indication of the importance of time in the apparel and clothing industry is provided by the increasing use of express carriers for overseas shipments [TNO-INRO, 1996]. Furthermore, the 'leanness' of this industry sector is illustrated by the increasing redundancy of traditional clearance sales: because of improved logistics and application of information technology, there are barely any leftovers from last year anymore [NRC Handelsblad, 2000].

Other business industries
A number of industry sectors have not been discussed so far: the construction industry, the metal products industry and the steel industry. With respect to the distribution of *construction materials*, Rand Europe and Coopers&Lybrand [1998] identify the reduction in construction time as a strategic goal, while Wildschut and Wiggers [1993] explicitly claim that time is not a competitive factor at all. The latter authors assert that prices form the single most important factor in the current tender system.

As regards the industry of *metal products*, Rand Europe and Coopers&Lybrand [1998] conclude that a short time-to-market is crucial in today's business environment. However, further indications for this have not been observed in the literature. Case study research of our own in the steel industry showed that JIT principles are being implemented in the supply of iron ores [Van Geenhuizen *et al.*, 1996]. Iron ores destined for the Elsass-Lothringen region are shipped by inland waterway transport according to a tight schedule. Deep-sea carriers deliver iron ores from countries such as Brazil, Australia and Canada to the port of Rotterdam, and smaller inland barges subsequently take these materials to the steel plants in France every 20 hours. The German steel producers nowadays only hold one month of the mostly needed iron ores in stock. The inland barges are progressively being used as carriers of stock-in-transit [Van Geenhuizen *et al.*, 1996].

3.2 SOURCES OF HASTE

In the preceding section we have identified the business industries in which time-sensitivity appears as an important determinant of logistics decision making, based on literature data. The existing literature is however limited in scope, in that the underlying research projects are usually not centred on the same research questions as ours. Therefore, we decided to execute additional interviews with actual logistics decision-makers to obtain information tailored to our research needs.

Objective of interviews

First, we wanted to gain more insight into the question of what *caused* the emergence of deliberate time-sensitivity in the identified industry sectors (research question Q2). In other words, the interviews should provide an exploration of the so-called *sources of haste.* Second, we wanted to *evaluate* the results of the literature review: do real-life logistics decision-makers identify the same time-based business industries?

To achieve this dual purpose, we have interviewed chief executive managers of five large logistics service providers (LSPs) based in the Netherlands. The interviews were carried out during autumn 1998. The selected LSPs all distribute a broad range of products for an equally broad range of clients. Therefore these representatives can be considered experts in judging which business industries are increasingly facing time pressure. Due to the often intensive contacts with their clients, they are also considered being capable of answering the question of *why* these developments are taking place.

Interview protocol

Owing to the explorative character of the research questions, we decided to execute interviews with open questions. A research protocol with conversation themes in broad outlines was used as a guideline for the interviews. In order not to influence the respondents, we only provided a very brief description of our research goal. All interviews were tape-recorded and completely typed out afterwards.

The conversation themes included:

- What are the main groups of customers of your company (measured in sales volume)?
- What logistics activities does your firm perform for these customers?

- Did you experience increasing time-sensitivity in any of these activities in the last five years?
- If yes, which customer groups were involved and what caused the increasing time pressure within these customer groups?

Typification of respondents

Logistics service providers *DHL* and *TNT* are both positioned among the largest express carriers in the world, specialising in documents and packages usually not heavier than 50 to 70 kilograms. Both DHL and TNT work for all kinds of business sectors including the automotive, consumer electronics, pharmaceutical and clothing industry. These express activities are carried out via an extensive global road and air network.

Nedlloyd (now part of Danzas/Deutsche Post) is an internationally operating LSP with several product groups, ranging from parcels and less-than-truckload groupage (LTL) to integrated logistics. *De Rooy Logistics* is a transport holding company that stores and distributes finished products and spare parts for the automotive, consumer electronics and glass industry across Europe. *Vitesse Warehousing* is specialised in the management of distribution centres: Vitesse manages the European distribution centres for a range of clients. Vitesse uses contract parties for transportation activities, whereas the remaining companies execute these processes mostly by themselves.

DHL, TNT and Nedlloyd are companies that feature among Europe's top-30 of pan-European third-party logistics companies [Peters and Jockel, 1998], while TNT and Nedlloyd are also ranked in the top-10 of Europe's most admired companies in the contract logistics sector. This top-10 is based on the expert judgements of 150 logistics managers about the performance of their competitors [Cunningham, 1998].

Confirmation of identified industry sectors

The question of which business sectors experienced increasing time pressure in the last five years confirmed the results of the literature review. First, increasing time-sensitivity is a trend that is applicable to the majority of business sectors. Just like Figure 3-2 already showed, there is no industry sector where a deceleration trend can be observed. In other words, the respondents recognised logistics acceleration as a general trend. Second, when asked to indicate which business sectors had witnessed the most marked increase in time pressure, the respondents pointed to sectors as the automotive (including spare parts), consumer electronics (especially cellular phones and computers), food/food-retail and the pharmaceutical industry as front runners. The interviews therefore confirmed the findings of the literature review.

Revealing the sources of haste

Based on the analysis of the interviews we discern three sets of explaining factors for the emergence of logistics acceleration in this sub-section:

- Sources of haste stemming from the interaction between chain members.
- Sources of haste originating from the supply chain member himself.
- Technology-driven causes of increasing time-sensitivity.

Interaction between chain members

The first group of causes of increasing time-sensitivity is formed by the interaction between different chain members. The respondents described the emergence of higher customer demands as an interaction between offered and demanded service requirements. Such an iterative process is characterised by three principles: the impact of chain power, irreversibility of acceleration and mutual reinforcement of haste.

First, the impact of customer demands (the extent to which suppliers meet these demands) depends on the degree of *supply chain power* the customer has in relation to his supplier. This chain power is proportionally related to the relative importance of the customer for the supplier (measured in sales) and the number of alternative suppliers available to the customer. In turn, it depends on the chain power of the supplier if and to what extent he is capable of imposing higher service standards on his own suppliers.

Second, when *service standards* have evolved to a higher level, they are considered to be *irreversible*. As one respondent said: service levels almost *never* go down. Relevant service time levels are measured in terms of transit time, reliability and frequency of shipments. Customers adjust their own logistics operations to fast, reliable and frequent supply and soon become dependent on it. For example, if the frequency of delivery schedules is doubled (e.g. twice a day at 10:00 and at 17:00 hours), the customer will organise his operations in such a way that the incoming goods can be received on these points in time. Moreover, he may have adapted his production schedules based on these delivery times. Through this process of adaptation and habituation, once offered service levels become almost irreversible.

Third, *mutual reinforcement* occurs when a supplier offers faster, more frequent and more reliable service levels, and when customers subsequently actually demand these, and vice versa. An example of this induced demand is provided by the emergence of express carriers in the 1980s: whereas it used to be impossible to get a package from Amsterdam to New York within 24 hours, the advent of express carriers wakened latent demand for this type of services.

'Self-imposed' sources of haste

The second group of factors that are more directly connected to the individual chain member is sub-divided into revenue-driven and cost-driven factors:

- *Revenue-driven sources of haste*: possible competitive advantages of offering faster, more frequent and more reliable logistics services and the need to keep up with competing firms.
- *Cost-driven sources of haste*: increased inventory risks and the implementation of inventory reduction schemes cause increasing time-sensitivity.

The left part of Figure 3-3 describes the iterative and dynamic process of increasing customer demands and higher service levels. The right side of Figure 3-3 describes the encountered revenue-driven causes of logistics acceleration. This is done for a hypothetical supplier (S) and his customer, an original equipment manufacturer (OEM).

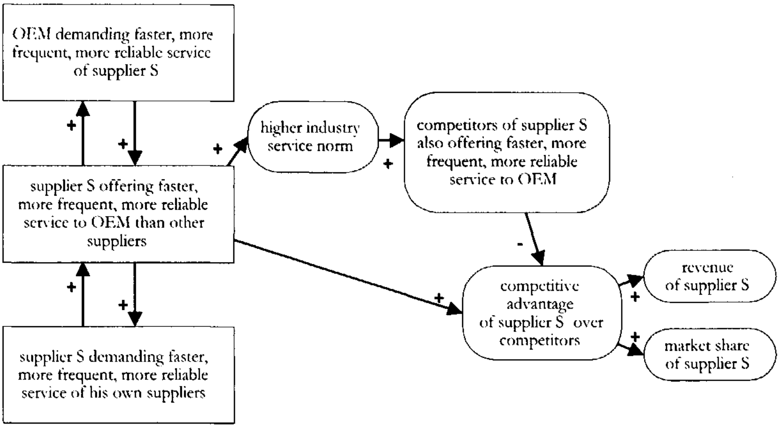


FIGURE 3-3 SOURCES OF HASTE: REVENUE ASPECTS

From the moment supplier S begins to offer better service levels, he creates a competitive advantage compared to other suppliers. This in turn is rewarded by an increase in market share and revenue. The evolution of a higher industry service norm however also activates competitors to develop the same or even better logistics performance levels, thereby reducing the competitive advantage of supplier S.

For example in the distribution of spare parts of trucks, it is found that the oligopolistic market structure of truck manufacturers makes each company highly responsive with respect to the established industry service norm. Lagging behind would endanger market share and revenue, as users of trucks increasingly base their buying decisions on the offered service levels. Speeding up the logistics chain can therefore also be a way of 'keeping up' with the competitors.

In addition to revenue-driven causes of haste, we also identified ***cost-driven logistics acceleration***. Figure 3-4 provides an analysis of the cost-side of increasing logistics haste.

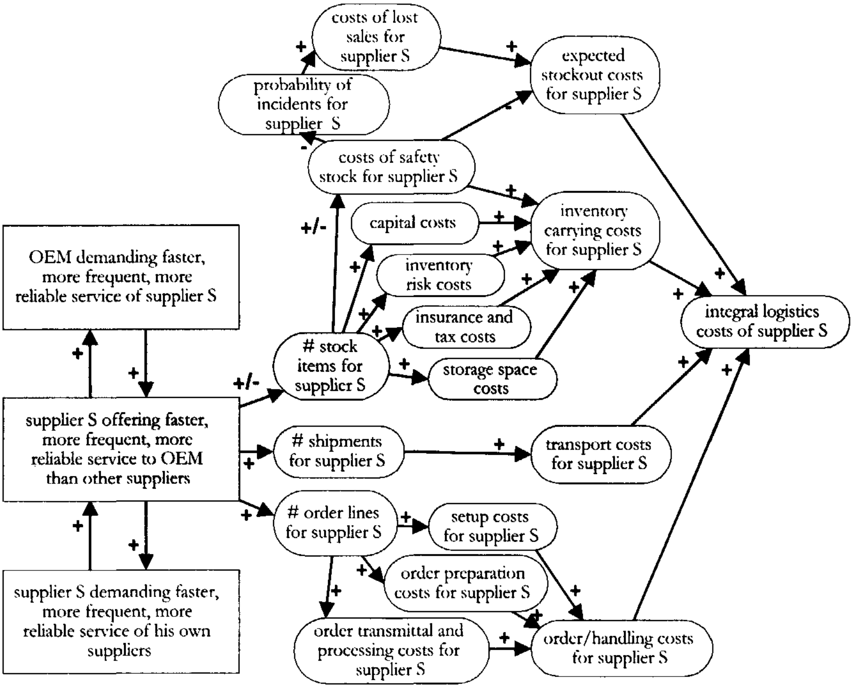


FIGURE 3-4 SOURCES OF HASTE: COST ASPECTS

Figure 3-4 shows the cost effects of supplier S offering better logistics service levels. In the end this service performance influences the integral logistics costs for supplier S. First, inventory levels are influenced by the service level offered. Not only does the number of stock items change for supplier S, but most probably also for his customer (OEM). If supplier S delivers faster, more frequently and more reliably it is likely that the OEM can reduce his number of stock items. However, for reasons of simplicity we have not included this interaction into Figure 3-4 (we will nevertheless take into account these aspects in later chapters). Additionally, it is clear that changes in the integral logistics costs for supplier S can make him adjust his logistics organisation. For example, if transport costs rose, supplier S could try to consolidate freight flows in order to compensate for the increased transport costs. These feedback mechanisms will be dealt with in the next chapter.

It depends on how supplier S organises his logistics operations if his higher service levels are realised either by an increased number of stock items (+) or also by a stock reduction (-). The latter can be accomplished by shifting some of the inventory to his own suppliers or by making his production process more flexible (e.g. with the help of actual market data of the OEM). Again this is conditional upon the chain power of supplier S over his own suppliers, and his customer OEM respectively.

In addition to the influence of higher service levels on inventory costs, they also bring about changes in the number of shipments (increased transport costs) and the number of order lines (increased setup costs, order preparation costs and order processing costs). The combined effects of stockout, inventory, transport and order costs determine the changes in the integral logistics costs of suppliers. In this model, increased transport and order costs can for example be traded-off against lower inventory carrying costs.

The cost-driven sources of haste mentioned by the respondents can now be placed against the background of Figure 3-4. First, many companies have experienced an increase in the *inventory risk costs*, because of the fast pace of product innovations. Owing to the continuous process of product renewal, manufacturers are reluctant to hold large amounts of stock items, because these can quickly become obsolete. This is particularly true for introductory and growth products typical of the computer, electronics, automotive, pharmaceuticals and specialty chemical industries [Daŝ and Handfield, 1997].

Second, the implementation of *inventory reduction schemes* can be considered a cause of logistics acceleration. In pursuit of increased profit margins, companies are always looking for ways cutting costs, while at the same time retaining high levels of service. One of the ways to achieve this is a reduction of inventory costs (being the sum of capital costs, inventory risk costs, costs of insurance and tax, and storage space costs). The trend of centralising stock locations can be seen in this light: with fewer stock locations, companies are confronted with lower safety stocks and overhead costs on average. If inventory centralisation coincides with higher transport costs (due to increased distances), this can still be legitimate on the firm-level: if inventory costs more than cover increased transport costs, the integral logistics costs still decrease.

Technology-driven sources of haste

The last group of causes for increasing time-sensitivity is formed by technology factors. The new opportunities of speedy transport and communications for example offer possibilities that are exploited to support further logistics acceleration (e.g. EDI, fast modes of transportation). The increased transparency of logistics chains, provided by the use of information and communication technology (ICT), further contributes to growing impatience. In the pre-internet age, orders used to vanish in the 'grey area' of order processing of the supplier. However, customers are nowadays increasingly on-line to see how their order is progressing. Consequently, customers expect to be handled instantaneously. Just like the rise of fax and e-mail have affected delivery requirements with regard to postal mail [Mieras, 1997], trends of e-commerce and home shopping will most likely impose higher standards on logistics services. It is claimed that people who are used to instant ordering and electronic payment also expect instant receipt of their purchases [Macleod, 1997].

Conclusions

Revenue-driven time-sensitivity is important in mature business sectors, as logistics performance has become an important competitive battleground (in addition to product's prices and physical qualities) in these sectors. This kind of revenue-driven time-sensitivity can for example be observed in the food sector. As Browne and Allen [1997] typify the food sector:

> *The food market is a mature market with a relatively static total market size. This means that individual firms tend to improve their performance at the expense of other companies' market share* [Browne and Allen, 1997, p.34].

According to the principle of 'service wins the order' (see previous chapter), improved logistics service is a competitive weapon to achieve increased revenue and market share.

The computer, electronics, automotive, pharmaceutical and specialty chemical industry are pointed to as sectors with introductory and growth products [Das and Handfield, 1997]. This latter group of business industries is more likely to be time-sensitive due to cost-driven factors. Because of the conceivable higher inventory risk costs (risk of obsolescence) of new products, cost aspects will in these sectors generally cause a relatively high degree of time-sensitivity.

The general applicability of the discussed sources of haste explains why the trend of time compression is so pervasive across all kinds of industry sectors. However, at this point we want to expand our knowledge of specific sources of haste within particular business sectors. Furthermore, we need to address research question Q3, namely: what are the micro-impacts of increasing logistics acceleration within specific business sectors? In order to provide answers to this question, we conducted an exploratory case study in one of the identified time-sensitive business sectors, the pharmaceutical industry.

3.3 EXPLORATORY CASE STUDY: DUTCH PHARMACEUTICAL INDUSTRY

In addition to the literature study of Chapter 2, we have made observations aimed at answering research questions Q1, Q2 and Q3 by means of a case study among companies in the Dutch pharmaceutical industry. This case study was carried out during spring 1997. The aim of the case study research was to describe and interpret changes in logistics choice behaviour in the pharmaceutical industry.

Why the pharmaceutical industry?

The pharmaceutical industry was selected because of the indications of time-sensitivity found in the literature (see section 3.1). The existing logistics literature suggested that time-sensitivity in the pharmaceutical industry could mainly be attributed to the increased costs of research and development (R&D), combined with the relatively short time available to recover those costs (*cost-driven time-sensitivity*). Additionally, being the first company to introduce a new drug to the market could pay off in a higher market share (*revenue-driven time-sensitivity*). These observed sources of logistics haste provided the motive for selecting the pharmaceutical industry as a case study industry sector.

Research protocol

The aim of the case study research was to observe *if*, *why* and *how* logistics time-based strategies are implemented in the Dutch pharmaceutical industry. The basis for the case study therefore consisted of forming a facts base on the actual logistics choice behaviour of pharmaceutical companies. Subsequent analysis should be aimed at induction: information gathered in the case study should support the construction of a descriptive conceptual model of logistics choice behaviour (see next chapter).

Given the goals of the case study, we chose to execute in-depth verbal interviews. These would be a sufficient means of exploring and observing logistics developments and changes in logistics choice behaviour within the pharmaceutical industry. We used a predefined research protocol, basically consisting of questions on the logistics organisation of the particular firm itself, its position and function in the total supply chain and the most marked changes that had taken place in both of these domains. Furthermore, we asked the respondents to articulate the motives and causes for the observed changes.

The interview was organised around the logistics decision areas of materials management, operations management and physical distribution, in order to get a picture as broad as possible. Every interview was tape-recorded and typed out afterwards. For the complete questionnaire we refer to Appendix A.

Respondents

We interviewed logistics managers of eight pharmaceutical companies with branches in the Netherlands: five manufacturing companies and three wholesalers. Due to reasons of confidentiality we will not provide the names of the manufacturing companies. Instead, these are characterised as follows:

- *Manufacturer A (MA)*: manufacturer of painkillers and cough mixtures.
- *Manufacturer B (MB)*: manufacturer of generics.
- *Manufacturer C (MC)*: manufacturer of plasters.
- *Manufacturer D (MD)*: manufacturer of homoeopathical products.
- *Manufacturer E (ME)*: manufacturer of pellets (raw material for drugs).

Because of the explorative character of the case study, we selected firms that would represent a cross-section of the pharmaceutical industry: we selected producers of both finished goods and semi-finished goods, as well as producers of prescription drugs and over-the-counter products. We did however not aim at statistical representativeness. On the contrary, we were mainly interested in the subset of companies that were experiencing increasing time-sensitivity. After all, applying this selection criterion would enable us to identify the impacts of increasing time-sensitivity on logistics choice behaviour.

The examples of the implementation of time-based strategies found in the literature usually involved larger companies. Due to their relative power in the supply chain, these companies are usually the front-runners in this respect. Therefore, we selected manufacturers that were employing more than 100 workers. Manufacturer A and E are branches of large multinational pharmaceutical firms that are among the top-50 of European and US pharmaceutical manufacturers (sales figures 1994) [HIDC, 1996]. These companies mainly rely on branded prescription drugs, but also produce over-the-counter products (OTCs). Manufacturer B manufactures a broad range of generic substitutes, while manufacturer C and D primarily produce OTCs. The three wholesalers are equivalent in the sense that they all serve the national market. The distribution channels they provide however diverge marginally.

Three national wholesalers (in order of sales volume) dominate the pharmaceutical wholesale market in the Netherlands: OPG, Brocacef and Interpharm. We have interviewed chief logistics managers of all three wholesale companies. Before we discuss the specific results of the interviews, we will provide a brief overview of the market situation of the Dutch pharmaceutical industry.

Sub-markets in the pharmaceutical industry

Pharmaceutical supply chains consist of many chain members: suppliers of semi-finished products and materials, drugs manufacturers, wholesalers, pharmacists, drugstores, hospitals and general practitioners (GPs). The manufacturing of pharmaceutical products is dominated by large international firms, and is increasingly concentrated in specialised production plants. These specialised factories manufacture for both local and global markets [IJPD&LM, 1994]. The distribution of drugs to the final customer is however primarily a national business. Simms [1997] observes that there is no pan-European wholesaling as yet, and that this is likely to continue for the foreseeable future. The vast majority of drugs are distributed through the networks of national wholesalers: a report of the HIDC [1996] estimates that 80 per cent of consumed drugs in Europe are sold via national wholesalers.

The drugs market can be divided in sub-markets for prescription drugs and OTCs. The latter are pharmaceutical products that are available to consumers without doctor's prescription (e.g. for sale in drugstores or in the supermarket). According to the HIDC [1996], over 80 per cent of European medicine sales however consist of prescription drugs. The prescription market is largely made up of branded medicines produced by large international conglomerates (so-called 'specialties'), which are protected by a patent. A smaller market share of the prescription drugs market is formed by 'generics'. These are chemically equivalent to specialties, but are usually cheaper.

Decreasing profit margins

In recent years, all of the mentioned parties in the pharmaceutical supply chain have been experiencing increased pressure on profit margins. This is caused by two factors: governmental health care policies and increased costs of R&D investments.

First, a clear contrast exists between public and private interests: *governmental policies* are aimed at reducing public expenditure on health care, while the pharmaceutical industry is concentrated on improving profit margins. Governmental economy measures have been taken since the early 1990s. One explicit goal of governmental policy is to reduce the quantity rebates that pharmacists receive from wholesalers and manufacturers. The health insurers however reimburse pharmacists the full list price. The Ministry of Public Health demanded pharmacists to reduce their yearly claims by five per cent and refrain from these commercial benefits [Volkskrant, 1997]. Moreover, the national government requires the use of cheaper generics, or effectively restricts choice through budgetary constraints [IJPD&LM, 1994]. A new price law (put in practice since June 1996) meant a further decrease in prices for pharmaceutical products.

Despite these measures however, it is claimed that the pharmaceutical industry still has 'sufficient' profit margins [Volkskrant, 1999a].

Second, *operational costs* for the pharmaceutical industry effectively increased. R&D costs are said to have increased by 500 per cent in the last 15 years [Simms, 1997]. Owing to lengthy testing and clinical trials procedures, it can take 10 to 12 years before a new drug can be brought to market [Romanski and Patti, 1995]. These huge investments have to be recovered within a progressively decreasing time frame. During the long development time, market opportunities and competitive threats can change dramatically [IJPD&LM, 1994]: better or competing products can quickly make a manufacturer's product obsolete. Moreover, patent protection usually already expires after ten years. After that, cheaper generic substitutes take away some of the original producer's market share and revenue.

Effects on the pharmaceutical supply chain

The combined cost pressures had profound effects on the way the pharmaceutical industry is organised. Jarrett [1998] claims that:

> (...) *health care logisticians now have the incentive to evaluate their supply chain management practices and seriously consider implementing the appropriate model of JIT* [Jarrett, 1998, p.750].

There are however also other adjustments that are made as a consequence of increasing cost-pressure. We observed five types of effects of decreasing profit margins (in random order): emergence of new distribution channels, rationalisation of production, vertical alliances, mergers and acquisitions, and logistics restructuring.

New distribution channels

Health insurers, wholesalers and pharmacists are all exploring the opportunities of new distribution channels in order to raise revenue. Due to the possible negative effects on public health, the sales of drugs through the internet is prohibited [Volkskrant, 1997]. Instead, health insurers have tried to set up mail order distribution in order to cut costs. However, these plans have failed up to now, because both wholesalers and pharmacists heavily resisted these initiatives [Nieuwsblad Transport, 1999]. Afraid of losing future co-operation of wholesalers, the manufacturers were reluctant to engage in mail order distribution. As one manufacturer said:

> *What's the point of gaining 20 new clients on the one side, while losing 500 existing customers on the other?*

Nevertheless, as a result of the mere threat of mail distribution, pharmacists are said to have accelerated their own delivery capabilities [Nieuwsblad Transport, 1999].

Likewise, wholesalers are experimenting with new distribution channels in the retail industry. For example, wholesaler Brocacef and retailer Schuitema are investigating the possibilities of drugs distribution via C1000 supermarkets. New legislative liberalisation of the drugs market has enabled this, but again comes across the resistance of conventional pharmacists [Volkskrant, 1999b]. Finally, in order to retain profit margins, some pharmacists have set up their own wholesale organisation. An example of this is Regifarm, an organisation that directly purchases drugs from manufacturers, without interference of traditional wholesalers.

All of these initiatives for the establishment of new distribution channels can be seen as a battle for chain power, *casu quo* profit margins. This has had consequences for mutual trust. As one respondent said:

> *The turbulence in the pharmaceutical industry is higher than ever before, and so is the degree of distrust between the chain members.*

Rationalisation of production

Manufacturers have been involved in a process of rationalisation. More and more firms implement a strategy of focused factories: the number of production plants is reduced to a minimum and the remaining production facilities specialise in a small range of products. Consequently, national production and distribution facilities are closed and concentrated in regional hubs on a European level. Bell [1997] for example describes the logistical strategy of Becton Dickinson, a US manufacturer of diagnostic products. This strategy involved the closure of all national distribution centres in Europe and the centralisation of its operation at one European production and distribution centre (EDC). This resulted in a reduction in inventory levels by 45%, inventory write-offs by 65% and non-availability by 75%. It is important to note that most of this restructuring is carried out under the condition that service levels remain unchanged (principle of irreversibility). Therefore, while inventory is concentrated in a smaller number of locations, accelerated transport over longer distances could be required.

Vertical alliances

Vertical alliances come into existence as the different wholesalers try to capture a higher degree of control over their logistics supply chain. However, the process of vertical integration is concentrated on the 'outgoing' part of the supply chain: for example, wholesaler OPG sold all of its production branches in recent years and concentrated on extending its chain power in the physical distribution process

[Financieele Dagblad, 1998]. The wholesalers OPG and Interpharm are deliberately acquiring or establishing alliances with pharmacists, to assure themselves of sales and to attain more direct point-of-sale data. With this information, inventory control can be improved. Brocacef has decided not to own pharmacies [Volkskrant, 1999c], but to hold on to the conventional sales contracts with pharmacies.

Horizontal integration

Mergers and acquisitions are examples of horizontal integration mainly encountered among the manufacturers. Producers increasingly try to reduce R&D expenditure, as well as production and marketing costs through scale enlargement [Stevenson, 1999]. Simms [1997] reported that between 1990 and 1995 there were no less than 246 mergers and acquisitions in the European pharmaceutical industry. Two mega-mergers have occurred just recently: on January 17th 2000 Glaxo Wellcome and SmithKline Beecham merged to become the world's largest manufacturer with a 7.3% market share [Economist, 2000a]. As a reaction, Pfizer bought Warner-Lambert on February 7th 2000 [Economist, 2000b]. This is now the world's second largest pharmaceutical manufacturing company. In order to take advantage of economies of scale, mergers and acquisitions are usually followed by a reorganisation of the production and logistics structure. The majority of mergers however are not successful:

> *It is startling to see that, with one exception, every big drug merger since 1970 has led to a subsequent loss in market share. Part of the reason for this may be that troubled firms have been the keenest to merge* [Economist, 2000a, p.65].

Nevertheless, it is expected that the process of mergers will continue in the next years [Booth, 1996].

Reorganisation of logistics structures

The reorganisation of logistics structures is also used as a means of reducing costs, while at the same time retaining or improving service levels. We have already observed the effect of production rationalisation and the emergence of EDCs among manufacturers, but national wholesalers are also involved in a process of reducing their numbers of regional distribution centres (RDCs). We will discuss this form of cost reduction, and the consequences it has on the time-sensitivity of pharmaceutical supply chains, in the following sub-sections.

Materials management of drugs: from manufacturer to wholesaler

In this sub-section we will discuss logistics changes due to increased time-sensitivity in the supply chain links from supplier to wholesaler (see Figure 3-5). In the next sub-section we will elaborate on these changes for the front end of the supply chain (from wholesaler to pharmacist/GP).

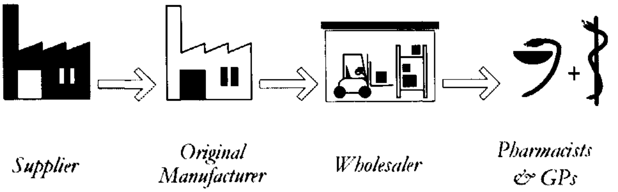


FIGURE 3-5 TYPICAL SUPPLY CHAIN OF MEDICINES

Time-sensitivity of manufacturers
Based on the analysis of the interviews we conclude that time-sensitivity for manufacturers is limited to the introduction of new drugs. Revenue-driven time-sensitivity could only be detected for this small proportion of products. As Simms [1997] already asserted:

> *A reduction in the time lost in the supply chain can have an enormous impact on the revenue generated by a product* [Simms, 1997, p.21].

Therefore, this time-sensitivity can be termed as revenue-driven time-sensitivity. The main advantage of being faster than his competitors is that this enables the manufacturer to capture a larger market share.

For the bulk of products however, time-sensitivity is only beginning to emerge. Cost-driven time-sensitivity is not observed as a major determinant of logistics choice behaviour on the materials management side of the supply chain. This can be explained as follows. When we look again at Figure 3-4, we see that cost-driven time-sensitivity occurs when there is a pressing need for inventory reductions, in order to reduce integral logistics costs. What would happen if a manufacturer started delivering faster, more frequently and more reliably to his wholesalers? It would not have a positive (nor negative) effect on his market share within the wholesalers' market. Because of their strong marketing position (e.g. sales representatives visiting GPs), producers of branded products are more or less guaranteed of their sales throughput. GPs prescribe these medicines 'anyway' and offering better service to wholesalers does not change anything in this respect. In fact, offering better logistics services to wholesalers would in most cases result in higher inventory levels for the manufacturer, for these are often not in a position to ask just-in-time deliveries of their suppliers themselves. The order penetration point, or inventory, would be shifted to the manufacturer.

In summary, manufacturers do not seem to have enough chain power with respect to their suppliers, and wholesalers lack the same chain power to control deliveries of the manufacturers. This leads to a 'lock-in' situation, where manufacturers have nothing to gain from more time-sensitivity. The results are correspondingly: one wholesaler had measured time performance of his suppliers and discovered that a mere 40 per cent of manufacturers delivered their products on the agreed day! This seems to be common in this part of the pharmaceutical supply chain: Simms [1997] observes that internal supply failures are all too frequent in the pharmaceutical supply chain. This results in excessive inventory levels.

Time-based deliveries only starting to emerge

Two interviewed manufacturers held inventory levels of two to six months (monthly sales divided by value of the inventory), while the interviewed wholesalers had duplicate inventory levels ranging between three and five weeks. Considering the fact that every manufacturer delivers his products to the wholesaler approximately twice a week, these inventory levels are clearly out of proportion. One wholesaler admitted that ten inventory days should actually be more than enough to guarantee his own delivery performance to the pharmacies and GPs.

In order to change matters in this respect, wholesalers and manufacturers should be aiming at closer integration between suppliers, manufacturers and wholesalers. As Stevenson [1999] claims:

> (...) *pharmaceutical companies should be examining their supply chains and striving for greater integration with their suppliers. To achieve greater integration, companies generally need to reduce their supplier base and effectively manage the changing relationships with the remaining suppliers. Measurement systems should be set up jointly with suppliers: you can't manage what you can't measure* [Stevenson, 1999, p.39].

The reduction in the supplier base is however not seen as an important trend, because the European directives on Good Manufacturing Practice (GMP) already mean that the number of suppliers is limited to a number of certified suppliers. Shifting between suppliers is therefore difficult.

However, things are beginning to change in the pharmaceutical industry. Two manufacturers claimed that they were actively looking for ways of achieving a more synchronised supply of semi-finished products from their suppliers. This synchronisation would at least reduce inventory levels of incoming goods. Moreover, we encountered an example of closer co-operation between a manufacturer and a wholesaler: Brocacef developed a closer relation with a manufacturer and successfully reduced its inventory levels. This was done by agreeing that the manufacturer would take the responsibility of sorting out products at the final customer level (crossdocking). Packages are delivered to the wholesaler at the end of the day and Brocacef can deliver these packages overnight to the pharmacies, without the need of repackaging. The increased costs of handling for the manufacturer were covered by the wholesaler. Through this project, both parties win: the manufacturer getting in contact with more precise and actual demand data, and the wholesaler reducing his inventories. This could be realised without negative implications for the service levels offered to the customers.

In conclusion, we observed that time-sensitivity is only an important determinant on specific parts of the materials management side of the supply chain. Typical of this part of the supply chain are producers with large amounts of inventory, and production schedules based on forecast-dependent Materials Requirement Planning (MRP) systems. This is clearly far from a just-in-time approach as described in the previous chapter. The impacts of increasing time-sensitivity in this part of the supply chain are therefore limited.

Time-reduction alternatives for pharmaceutical manufacturers

We summarise the main findings for each manufacturing company we visited in Table 3-1. Let us now review the means of time-reduction that are applied by the respective companies.

As we already observed in the above, manufacturers of pharmaceutical products for the greater part rely on high levels of inventory for achieving higher levels of service. This 'time-reduction' alternative therefore appears in all companies interviewed. The disconnection between actual sales (point-of-sale data) and production schedules is the root cause for this high reliance on stocks. Wholesalers do not order the products actually needed, but order what they think will be the actual orders (forecasts). This is because wholesalers do not have point-of-sale data at their disposal either, but in turn rely on the information that is provided by the pharmacists. This unavailability of actual demand figures across the pharmaceutical supply chain can sometimes lead to amplification effects. The result of these effects being that the supply chain is filled with products, although no patient has consumed one single extra tablet or capsule. The basic flaw of this system is obvious: patients will not consume more drugs if they are made cheaper to the pharmacist.

Another prevalent choice is the preference for outsourcing distribution activities to LSPs (reduce transit time). Often special contract couriers are used to ship the products from the manufacturer's distribution centre to the wholesaler's. Road transport is already used for the majority of shipments, and there is no scope for acceleration in that respect. The reason for contracting out distribution activities is that manufacturers would not be able to achieve the same level of service at the same costs if they executed these activities themselves.

TABLE 3-1 MAIN CHARACTERISTICS OF MANUFACTURING FIRMS

Company	Products	Methods of time-reduction
MA	*Specialties and OTCs:* Painkillers, cough mixtures, lotions etc.	Reduce transit time Reduce order transmittal and order processing time Hold inventory of (semi-) finished products at the manufacturing plant Hold inventory of finished products at the DC
MB	*Generics:* Broad range of medicines	Reduce transit time Reduce order transmittal and order processing time Reduce production lead time Hold inventory of semi-finished products at the manufacturing plant Hold inventory of finished products at the DC
MC	*OTCs:* Plasters, shampoos, etc.	Reduce transit time Reduce order transmittal and order processing time Bypass distribution centre/wholesalers Hold inventory of semi-finished products at the manufacturing plant Hold inventory of finished products at the DC
MD	*OTCs and specialties:* Homoeopathic products	Reduce transit time Reduce order transmittal and order processing time Reduce production lead time Reduce storage lead time Reduce order preparation time Bypass distribution wholesalers/ pharmacies Hold inventory of semi-finished products at the manufacturing plant Hold inventory of finished products at the DC
ME	*Semi-finished products:* Pellets	Reduce transit time Reduce order transmittal and order processing time Hold inventory of semi-finished products at the manufacturing plant

As most of the producers base their production schedules on sales forecasts and MRP-systems, the reduction in production times is only of limited importance:

most producers use a make-to-stock production philosophy and large production series are considered more efficient than smaller batches. The reduction in setup times is however an important target for some of the interviewed manufacturers. At least as important is the shortening of order transmittal and order processing times. This is done by the increased implementation of EDI and ERP systems.

As regards the other options of time-reduction, we saw that choosing for *co-location* is an option that has already been put into practice for many years: the vast majority of suppliers to original manufacturers are already national suppliers. On the other hand, manufacturers are not inclined to move to the vicinity of wholesalers as time pressure is not a primary issue and because other location factors are more pressing (e.g. investments in production facility). Next, the elimination of *links from the supply chain* is mentioned by the respondents, but has so far not been accomplished (see the discussion on mail order delivery). However, if this occurred, this would not be due to increasing time pressure, but to increasing costs and decreasing margins. As was mentioned before, much of the turbulence on the materials management side of the pharmaceutical supply chain is caused by increased pressures on costs, not specifically on time.

Physical distribution: drugs from wholesaler to pharmacist

The picture is completely different for the physical distribution of drugs from wholesaler to pharmacist. This part of the supply chain is characterised by a high degree of logistics speed, frequency and reliability. The pharmacists and GPs historically set high standards with regard to these service requirements. Especially when there is a customer waiting for a certain prescribed medication, instant delivery is needed.

Time-sensitivity for wholesalers

The average pharmacy is estimated to have 2,000 products in stock, covering average demand for approximately four weeks. GPs generally need a smaller assortment of products. The pharmacies can however not always provide the prescribed drugs to the patient waiting at the counter. For these occasions the RDCs of the wholesalers act as a backup. Such 'service shipments' are carried out twice a day to the average pharmacist. Often these shipments are performed within a guaranteed delivery time of two to three hours. Some pharmacists located in city centres (small storage space) even get their orders within half an hour. Reliability figures in this segment typically are around 98%.

These high-speed levels have evolved out of the oligopolistic market structure of wholesalers: providing better service pays off in higher market shares, so much of the strategy of wholesalers can be attributed to this revenue-driven time-sensitivity. The high delivery standards have resulted in a decentral pattern of

RDCs, in order to be able to comply with the short delivery times required (see Figure 3-6).

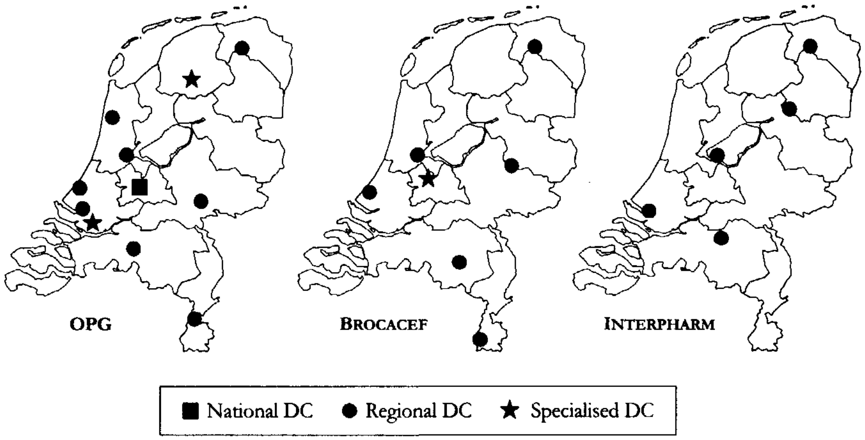


FIGURE 3-6 DISTRIBUTION STRUCTURES OF THREE DUTCH WHOLESALERS 1997

However, this pattern of RDCs has changed in recent years: due to the quest for inventory and overhead cost reductions, wholesalers have reduced the number of RDCs to a minimum (the minimum being dependent on current delivery requirements). Interpharm has for example recently reduced its number of warehouses from five to four. Brocacef had 11 RDCs in 1990, while this was reduced to six in 1997. In August 2000, OPG also announced plans to drastically reduce the number of regional DCs (at least two RDCs are closed), in order to cope with the intense competition among wholesalers.

Much of the rationalisation has been enabled by the impressive acceleration in both automated order processing and order preparation. Most pharmacies and GPs are connected to the wholesalers via an EDI-connection. Because these parties would lack the discipline to order drugs on the agreed time, wholesalers take the initiative to call the pharmacists and GPs at regular times (say at 10:30 AM every day). This call is the signal for the pharmacists and the GPs to place their orders. The wholesalers do not have the order entry capacity for a continuous flow of incoming orders: continuous ordering would disrupt picking activities and shipment preparation too much. In order to maintain a high level of service and to spread out orders more evenly over the day, more and more overnight deliveries are being observed: the pharmacist orders at the end of the working day, and the wholesaler delivers the order during the night. This obviously means an extension of working days for wholesalers.

GPs generally need a much smaller assortment of drugs. Therefore, shipment frequencies could (according to one wholesaler) in fact be reduced to once a week, while current levels are based on daily deliveries. However, as GPs are used to the current level of service, this cannot be turned back. This clearly illustrates the principle of irreversibility as introduced above. In summary, the motives for wholesalers to comply with the wishes of the pharmacists and GPs can be largely attributed to the competitive forces: failing to meet the requirements would mean a competitive disadvantage. The three national wholesalers have approximately the same assortment ranging between 17,000 and 25,000 products, while prices have been frozen by the price legislation. This means that logistics service is one of the only remaining areas of competition for wholesalers. The pharmacies have the chain power to ask two to four deliveries a day.

The wholesalers claim that due to the lack of chain power (not having actual point-of-sale figures at their disposal) no radical reductions in their own inventories are achievable. The future function of the wholesaler will not be one of holding inventory, but one of being the broker between manufacturer and pharmacist. This functional shift would mean that wholesalers' warehouses would be turned into switching yards, instead of holding yards. As one respondent said:

> *We should not invest in advanced storage systems, but in advanced order processing techniques.*

This future function is however largely dependent on the willingness of chain members to co-operate.

Time-reduction alternatives of pharmaceutical wholesalers

In conclusion, time-sensitivity is an important feature of the physical distribution of medicines. To achieve fast and reliable services, wholesalers use a broad set of time-reduction alternatives. The encountered measures of time-reduction for the wholesalers are:

- *Reduce transit time*: the wholesalers typically own a fleet of vans that perform regular shipments every day. Additionally courier services are hired occasionally. The wholesalers use own-account transport because of the perceived added value of a driver: the personal contact between driver and pharmacist is thought to contribute to competitive advantage. The fact that vans have already been used for years means that there is no scope for time-compression in this field. However, due to the increasing and persistent time requirements of pharmacists and GPs, the role of road transport is becoming more and more indispensable.
- *Reduce storage time*: crossdocking or pre-packaging is a trend with far-reaching consequences. Through the better co-ordination of orders between manufacturers and wholesalers, wholesalers are capable of reducing inventory levels, while at the same time guaranteeing current service levels.

- *Reduce order transmittal and order processing time*: almost all orders are handled by means of EDI, which combines speed with reliability.
- *Locate distribution centre closer to customers*: the current pattern of decentral RDCs illustrates that this form of co-location has already been implemented for many years.
- *Reduce order preparation time*: wholesalers have heavily invested in automated order entry and processing. Sometimes a paperless picking system is operated, which means that orders of pharmacists and GPs directly enter the picking locations. Additionally materials handling equipment, such as carousels, reduce time consumed in the picking process.

3.4 CASE STUDY CONCLUSIONS

In section 3.3, we described the findings of a case study executed in the pharmaceutical industry. This industry has witnessed considerable restructuring in recent years, owing to different pressures on costs. The five types of structural changes we have observed were: emergence of new distribution channels, rationalisation of production, vertical alliances, mergers and acquisitions, and logistics restructuring. In the remainder of section 3.3 we concentrated on the latter form of restructuring.

Materials management is usually slow and unreliable

Reorganisation of logistics structures induced by cost reductions is also connected with the increasing importance of time. We saw that the materials management part of the pharmaceutical supply chain is the least time-sensitive: revenue-driven time-sensitivity is only observed as far as the introduction of new drugs is concerned. For the greater part, however, existing medicines are distributed from manufacturer to wholesaler in anything but a just-in-time fashion. This is caused by incomplete supply chain integration between suppliers, original manufacturers, wholesalers and pharmacists. Manufacturers have little to gain by improving their service levels for shipments to wholesalers. This translates into high amounts of duplicate inventories along the supply chain. Only the outset of time-based deliveries is observed between manufacturers and wholesalers, as crossdocking becomes a technique to reduce time consumption, handling and inventory costs.

Other encountered time-reduction alternatives are the reduction in order transmittal and order processing time, holding inventory at different points and the reduction of the order shipment time. Often special contract couriers are used to ship the products from the manufacturer's distribution centre to the wholesaler's. Road transport is already used for the majority of shipments, and there is no scope for acceleration in that respect.

Physical distribution is usually fast and reliable

The physical distribution of drugs is completely different from materials management. Time is crucial for the shipment of drugs from wholesaler to pharmacist and GPs, as these sometimes need instant delivery of drugs. This is realised through a decentralised pattern of inventory depots of wholesalers. Deliveries within two to three hours are normal, due to the legislative regulations and the oligopolistic market structure. Wholesalers experience revenue-driven time-sensitivity as lagging behind the industry norm could result in decreasing market shares and revenues.

The reduction of time consumed in the pharmaceutical supply chain from wholesaler to pharmacist is mainly achieved through the application of information systems such as EDI and the decentral RDCs of wholesalers. The use of vans is increasingly indispensable because of the centralisation of stock locations.

4

Macro-impacts of time-based logistics

In the previous chapter, we explored the research questions Q1 (relevance), Q2 (causes) and Q3 (micro-impacts) by means of a literature review and by observations in the logistics services industry and the pharmaceutical industry. In this chapter, we will build on these observations by constructing a more general conceptual model of logistics choice behaviour. This model describes the interrelations between causes, micro- and macro-impacts of increasing logistics time-sensitivity. The conceptual model enables us to explore and deduce transport policy scenarios (research question Q5; see section 4.7). The deduction of transport policy scenarios is preceded by an analysis of macro-impacts of increasing implementation of time-based strategies (research question Q4).

4.1 POSITIONING AND CONCEPTUALISING LOGISTICS CHOICES

Not all causes of the rising demand for freight transport are open to the influence of governmental initiatives. Nevertheless, points of leverage for successful transport policy tactics can only be identified if the determinants of transport demand are understood. As Cooper [1991] maintains:

> *We must recognise that lorry operation is a consequence of logistics planning and until the objectives of logistics planning are understood, attempts to control the growth of lorry traffic in the interest of the environment are unlikely to succeed* [Cooper, 1991, p.99].

In order to understand the objectives and consequences of logistics choices, we need to explore the process of logistics choice behaviour and its determinants. The number of behavioural determinants is essentially infinite, which explains why choice behaviour is rarely understood or interpreted unambiguously [Oppedijk van Veen, 1985]. The multitude of business objectives and constraints that influence choice behaviour complicate the analysis of business decisions. Therefore, the analysis of the intricate process of logistics decision making under increasing time pressure, benefits from using a conceptual model that makes this process more tractable. The conceptual model that we use to achieve this consists of three building blocks (see Figure 4-1).

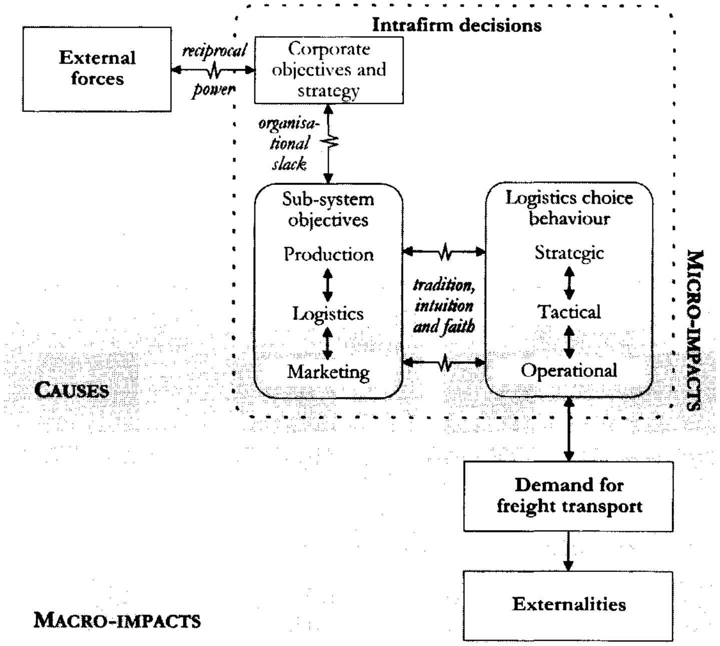


FIGURE 4-1 BUILDING BLOCKS OF THE CONCEPTUAL MODEL

First, examples of the *external forces* within which an individual firm operates are autonomous technological developments, market characteristics, public policies, customers' requirements, suppliers' capabilities and competitors' actions. Second, these external stimuli have impacts on so-called *intrafirm decisions*, such as the firm's corporate strategy or choices made within the logistics sub-system. Third, the output of the logistics sub-system has *macro-impacts*, in terms of changes in the demand for freight transport and eventually macro-impacts such as economic growth, congestion and emissions of CO_2. Knowledge of all these aspects will help us to systematically identify the conceivable points of leverage for freight transport policy tactics. In the next sections, we will elaborate each of the building blocks and their linkages. The aspects 'causes' and 'micro-impacts' have been discussed in the previous chapters. We will summarise and conceptualise the relations between these building blocks in sections 4.2 to 4.4. The links between 'micro and macro-impacts' will be examined in more detail in section 4.6.

4.2 EXTERNAL FORCES AFFECTING INTRAFIRM DECISIONS

Corporate objectives are typically defined in terms of revenue, market share or cost targets. An individual company however never formulates these objectives for their own sake. The basic premise of our conceptual model is that the external environment to a large extent shapes the formulation and implementation of a firm's objectives and strategies. External forces affecting corporate objectives include factors such as public policies, shareholders, market and product developments, or influences stemming from the supply chain partners of a particular firm.

The relationship between external forces and corporate objectives and strategy does not have a one-way direction. The translation of external factors into a corporate strategy is blurred by what we call *reciprocal power.* The actions and choices of an individual company are not entirely determined by external factors: the individual firm does have certain autonomy. This discretion of companies is defined by the level of power they can exert on their external environment. In the previous chapter we already found supply chain power to be dependent on the relative importance (e.g. measured in sales) of one particular firm in relation to another. This coincides with Robbins' observation that power or dependency emerges when one has resources that are either important, scarce or irreplaceable to the other [Robbins, 1992]. Stannack [1996] accordingly defines supply chain power as the capacity to optimise the behaviour of suppliers and subcontractors in accordance with desired performance objectives. In conclusion, through the existence of supply chain power, individual firms can also influence parts of the external environment.

4.3 INTRAFIRM DECISIONS AND THE LOGISTICS SUB-SYSTEM

The individual firm makes decisions on different levels and functional areas (or 'sub-systems'). Recognisable functional areas of a manufacturing company are the production, marketing and logistics sub-systems. The logistics decisions (including materials-, operations- and physical distribution management) are made within this intrafirm context. We will examine the logistics sub-system in more detail at the end of this section.

Corporate objectives and strategy affecting sub-unit objectives

A corporate strategy is seen as a choice of products, markets and required service levels [Copacino and Rosenfield, 1987; Magee *et al.*, 1985]. Stock *et al.* [1998] define a business strategy as the set of decisions that specify how a business company will achieve and maintain competitive advantage within its industry. These strategic choices are translated into more operational sub-system objectives and therefore affect marketing, manufacturing and logistics processes [Chow *et al.*, 1995]. This hierarchical way of thinking is also encountered in Lalonde and Masters [1994]:

> *The choice of a strategy leads to decisions of a more tactical or operational nature which will flesh out the strategic concept and guide the activity of the firm on a month-to-month and day-to-day basis* [Lalonde and Masters, 1994, p.35].

March [1988] disputes the feasibility of internal consistency of objectives within complex organisations. Not all activities within a company can be justified in terms of their immediate contribution to corporate objectives, owing to departmentalisation ('functional silos'), scarcities of time and energy and the occurrence of organisational slack or inertia. Due to this possible distortion, the connection between corporate objectives and sub-system objectives is not represented by a straight line in the conceptual model.

Production, marketing and logistics objectives affecting logistics choices

An important group of factors that set the requirements for logistics choice behaviour is made up of production and marketing objectives. Logistics is claimed to play an interface role between production and marketing [Emerson and Grimm, 1996; Morash *et al.*, 1997]. On the one hand, the requirements of the production department can be expressed as production cost reductions and efficiency gains (e.g. through large production series) or responsiveness (e.g. through small production series). These requirements obviously call for different logistics responses. On the other hand, logistics requirements stemming from the marketing department generally concentrate on achieving maximum customer satisfaction. This has implications for the required speed of delivery, degree of customisation etcetera [Wu and Dunn, 1995].

Again, the translation of marketing and production objectives into logistics objectives and choices is not straightforward. In practice, not all logistics choices will comply with the requirements evolving from the marketing or production department, or even from the logistics department itself. This is caused by behavioural mechanisms such as intuition (people may do things without fully understanding why), tradition and faith (people do things because that is the way they are used to be done) [March, 1988].

Logistics sub-system

In Chapter 2, we have identified the relevant logistics choices that are influenced by the implementation of time-based strategies (see Table 2-1). These logistics decisions can be labelled as *structural* decision elements, pertaining to tangible freight or information flows. In addition to these structural logistics decisions, logistics *controlling* decisions can also be discerned (such as human resource policies, quality systems, organisation and performance measurement, cost accounting). As the problem statement of this dissertation is primarily concentrated on structural decision elements, the remaining of this chapter is mainly centred on these types of decisions.

The logistics choices that are influenced by the implementation of time-based strategies can be categorised into different decision levels. Therefore, we will propose a categorisation of logistics choices at the end of this section. First, however, we will discuss different existing classifications of logistics choices that were encountered in the literature.

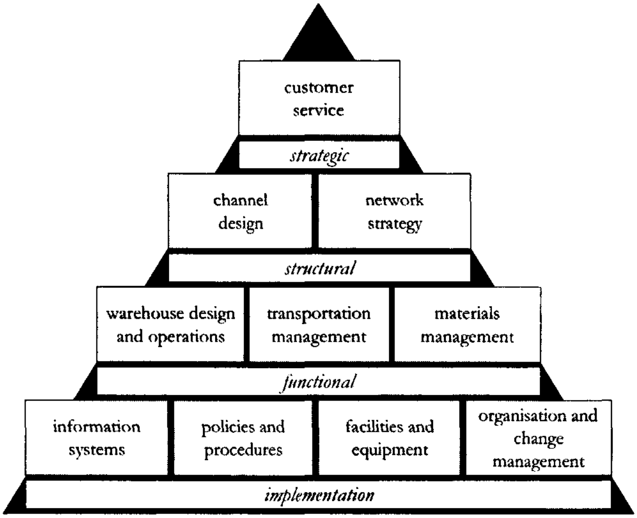
Hierarchical conceptual models of logistics choice behaviour

The common way of depicting logistics choice behaviour is to position logistics choices within a hierarchical model. The tenet of many of the existing models is that lower-level logistics decisions are conditional upon higher-level decisions.

Copacino and Rosenfield [1987] divide logistics system design choices into four hierarchies or stages:

- *Long-term distribution and production patterns*: plant and warehouse choices (number of facilities, size and location), transit mode selection, product assignments to production facilities.
- *Deployment of inventories within a network*: locating and controlling inventory within a logistics network.
- *Aggregate planning for the intermediate term*: manufacturing and distribution plans for a yearly, seasonal, or semi-annual time horizon.
- *Plant operations*: manufacturing and distribution plans including workforce planning, routing and scheduling of workers and delivery vehicles, and the day-by-day selection of transport modes for specific deliveries.

Christopher [1994] presents an alternative hierarchical model. He attributes a decisive role to customer service requirements (see Figure 4-2). In his vision, customer service requirements set the standard for lower-level logistics decisions. For instance, the choice of *warehouse design and operations* pertains to the question as to what extent layout and materials handling equipment will facilitate customer service objectives. At the implementation level of decision-making, choices such as *information systems* and *policies and procedures* should equally be consistent with higher-level choices.



Source: Christopher [1994]

FIGURE 4-2 CHRISTOPHER'S HIERARCHICAL MODEL

Ruijgrok's SPITS-model [TNO-INRO *et al.*, 1994] takes a broader view: in addition to customer service characteristics, this model displays the influences of environmental factors (e.g. technology, infrastructure), product/market and company characteristics on the logistics organisation. Perl and Sirisoponsilp [1988] as well as Van Goor *et al.* [1996] make a distinction between strategic, tactical and operational logistics decisions. This categorisation is made on the basis of the investment requirements, the time horizon and the frequency of decisions involved:

- *Strategic logistics decisions* concern major capital commitments and a long time horizon (typically several years), including the locational choices within a distribution network, or more basic make-versus-buy decisions.
- *Tactical logistics decisions* are made on an annual, semi-annual or monthly basis. Tactical logistics decisions entail choices such as the mode of transportation, type of materials handling equipment or layout of warehouses.
- *Operational logistics decisions* relate to the day-to-day operations and usually involve low capital investment. Examples include the order control policy (frequency, replenishment time, backorder procedures), order picking (order picking procedures, warehouse routing) and route planning (scheduling, assignment of vehicles).

As the differences between the encountered models show, it remains disputable to what level of decision-making a particular choice should be allocated: for example, Van Goor *et al.* [1996] assign facility location to the tactical level, while Perl and

Sirisoponsilp [1988] typify this as a strategic choice. The exact position of each decision element in the hierarchy therefore remains a question of relativity.

Perl and Sirisoponsilp [1988] and Jayaraman [1998] emphasise the interaction between the different decision elements and decision levels. Decisions on locations of facilities, transport and inventory management together form what is called the *integrated distribution network decision* of a company [Jayaraman, 1998]. Cooper [1994] puts it slightly differently by calling these combined decisions the *logistics concept* of an organisation. Instead of facility location, transportation and inventory, Fawcett and Fawcett [1995] choose three other dimensions of logistics choice behaviour for their conceptual model:

- *Purchasing and materials management*: management of the acquisition of inbound materials for use in the transformation process.
- *Operations management*: planning and control of the transformation process; converting inputs into finished goods via assembly, testing and packaging.
- *Physical distribution*: management of outbound transportation, inventory and warehousing, documentation and order processing of finished goods to provide customer service at competitive costs.

Taxonomy of micro-impacts

These broader categories enable us to classify and allocate all of the logistics choices that were generated by the analysis of time-space prisms (see Chapter 2). Figure 4-3 contains both structural and controlling logistics decisions along two dimensions: from strategic to operational and from materials management to physical distribution decisions.

The logistics decision elements themselves are printed in bold characters. We have also included the direction of each decision, in case the company involved would implement a time-based strategy. It should be noted that this taxonomy essentially pertains to manufacturing companies (OEMs), but similar classifications can be made for other supply chain members. The position of each decision element in this taxonomy should not be viewed as an absolute fact, but rather as an indication of its relative position. Interaction exists between the different levels of logistics decision making: operational experiences should continuously be fed back into the strategic decision making process, and vice versa. These interactions will be dealt with in the next section at full length.

	MATERIALS MANAGEMENT	OPERATIONS MANAGEMENT	PHYSICAL DISTRIBUTION
STRATEGIC	**Make-versus-buy** use time-sensitivity and responsiveness as key criteria **Supplier location** choose for co-located suppliers	**Facility location** locate plant close to customers **Production layout** product-oriented layout using group technology cells	**Make-versus-buy** use time-sensitivity and responsiveness as key criteria, outsource transport to attain consolidation economies **Finished goods warehouse location** locate close to customers or use direct distribution
TACTICAL	**Supplier selection** reduce supplier base, supplier certification for integrated suppliers **Materials warehouse layout** improve dispatch layout, use crossdocking techniques **Materials handling equipment** selection based on efficiency, standardise transport units	**Product design** aim at product modularity and handling ease **Business process engineering** aim at reduction of lead times and work-in-process, concurrent engineering with materials management and physical distribution activities **Production concept** pull scheduling/synchronised production	**Third-party LSP selection** reduce LSP base, long-term contracts with LSPs **(Semi-)finished goods warehouse layout** design flow-through warehouse, improve dispatch area layout, use crossdocking techniques **Materials handling equipment** selection based on efficiency, standardise transport units **Mode of transportation/vehicle type** choose fast and reliable mode of transportation
OPERATIONAL	**Supplier performance measurement** use time-sensitive measures **Ordering policy** continuous replenishment **Inventory management** hold inventory of materials at suppliers' or locate suppliers' personnel on-site to manage inventories **Information systems** use bar coding, EDI linkages or web technology with suppliers for automated ordering and tracking and tracing, integrate information applications for logistics processes (ERP)	**Production control and performance measurement** based on time-sensitivity and responsiveness and reliable operations **Work assignment** simplify work tasks, employee decision making on factory floor, train to reduce changeover time, cross-training and annualised hours **Information systems** use computer-aided design and manufacturing systems, track materials flow using bar code technology or radio frequency	**LSP performance measurement** use time-sensitive measures **Inventory management** hold inventory of (semi)finished goods at manufacturing plant or DC (postponement) **Order picking procedures** classify stock to speed of throughput **Route planning/vehicle scheduling/timing** use advanced route planning and scheduling systems, shift to night distribution **Information systems** use bar coding, EDI linkages or web technology with LSPs for automated order entry and shipment planning, integrate information applications for logistics processes (ERP)

FIGURE 4-3 TAXONOMY OF LOGISTICS DECISIONS

4.4 ELABORATION CONCEPTUAL MODEL: CAUSES AND MICRO-IMPACTS

On the basis of the literature study, the interviews with LSPs and the case study in the pharmaceutical industry, we will now discern perceived links between causes and micro-impacts of increasing logistics time-sensitivity. Before we discuss this elaboration of the conceptual model we will make some restrictions. First, we will only discuss the logistics decision elements that are affected by *increasing implementation of time-based logistics strategies*, as just these were identified in the taxonomy of logistics choices. Second, we will only discuss the *structural* logistics decision elements from this taxonomy, because we are primarily interested in logistics decisions that have a direct physical component. Third, we merely selected those logistics decision elements that have impacts on the firm's *external transport* requirements (resulting in changes of vehicle-kilometres).

The logistics decision elements that meet these restrictions are listed below. We have operationalised each of the logistics choices into a measurable unit. Furthermore, the sign (+) or (-) denotes whether the particular decision element increases or decreases as a consequence of the implementation of time-based logistics strategies. Some decision elements can both lead to an increase as well as a decrease (see Chapter 2):

- *Make-versus-buy materials*: per cent products contracted out (+ or -).
- *Supplier location*: distance between suppliers and production facility (-).
- *Supplier selection*: number of suppliers in supply chain (-).
- *Production concept*: per cent of products made according to just-in-time principle (+).
- *Inventory management*: inventory level of finished goods and materials (+ or -).
- *Production facility location*: distance between production facility of OEM and DCs (-).
- *Mode of transportation*: per cent by road transport (+).
- *LSP selection*: number of DCs in supply chain (-).
- *DC location*: distance between DCs and customers (-).
- *Make-versus-buy distribution*: per cent of transport activities contracted out (+).
- *Timing*: per cent night distribution (+).
- *Route planning*: level of consolidation (+ or -).
- *Vehicle scheduling*: frequency of delivery (+).

Figure 4-4 connects these logistics decisions elements (or micro-impacts) with the cost- and revenue-driven sources of haste (or causes) that were identified in the previous chapter. It should be stressed again that these relationships are hypotheses based on the discussed case study and literature review. The actual testing of relationships will take place in Chapter 7.

The upper part of Figure 4-4 describes the dynamics within a hypothetical supply chain. Increased time-sensitivity starts with a customer who demands faster, more frequent and more reliable logistics services (at the right side, factor C10), because this would enhance his market share, revenue and/or cost objectives. The OEM would be less inclined to conform to these customer requirements, if his market share/revenue were rising anyway (i.e. without having to offer better service) or if his integral logistics costs were increasing as a consequence of providing better service.

If the OEM complied with the customer requirements, both his own and his customer's market share and revenue might improve. The impact for the OEM's integral logistics costs is unclear: it depends on the level of supply chain power the OEM can exert over its own suppliers. If the OEM succeeded in providing his customer with better logistics services, without having to bear the burden of increased logistics costs himself, the OEM would be able to benefit from increased time-sensitivity as well. The OEM could do this by shifting some of the extra inventory needed to the supplier, or by negotiating that the supplier is not compensated for conceivable additional transport costs.

The main message from this section is that logistics choices cannot be viewed in isolation. This evolves from the fact that logistics activities do not possess an intrinsic value, but are executed on the basis of corporate objectives that are positioned outside the logistics sub-system (e.g. market share objectives). The conceptual model (see Figure 4-1) shows that we are ultimately interested in the question which macro-impacts are caused by which choices in the logistics sub-system. In the next section we will therefore explore the connection between the logistics sub-system and its macro-impacts.

4.5 MACRO-IMPACTS OF LOGISTICS CHOICE BEHAVIOUR

It goes without saying that transport activities are of strategic importance to the functioning of a modern society. Transport and logistics activities (also within manufacturing industries) account for approximately 11 per cent of the Dutch labour force [NEI *et al.*, 1995]. In the governmental document *Transport in Balans* [Ministry of Transport, 1996] it is also claimed that no prosperity is possible without efficient freight transport. Freight transport can therefore be considered as a basic good.

Nevertheless, there is a dark side to these positive externalities of freight transport operations. The combination of different literature sources yields the following list of negative externalities [Bouman *et al.*, 1990; Cooper, 1991; Greene and Wegener, 1997; Koopman, 1995; Van der Krogt and Verhage, 1996; Ministry of Transport, 1997a; Rand, 1996]:

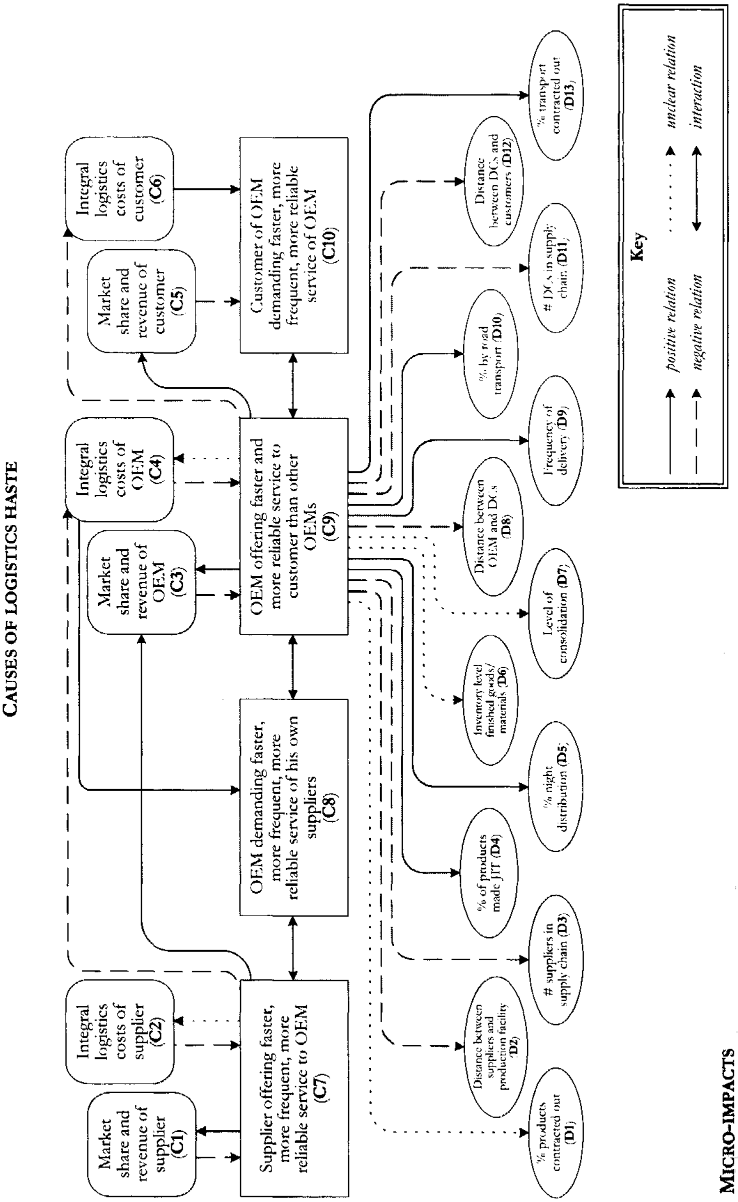
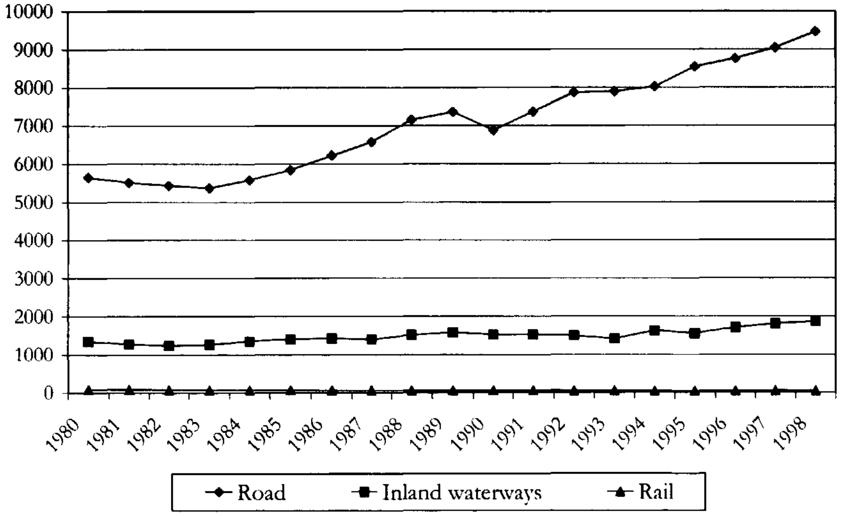


FIGURE 4-4 CONCEPTUAL MODEL: CAUSES AND MICRO-IMPACTS

- *Emissions*: air and water pollution caused by exhausts.
- *Disruption*: noise from engines and tyres, vibration, partition of landscape and wildlife habitats, visual intrusion by infrastructures and vehicles.
- *Depletion of energy resources*: vehicle operation contributes to the depletion of fossil fuels.
- *Congestion*: adding an extra vehicle reduces traffic speeds if infrastructure capacity is limited.
- *Maintenance costs*: infrastructure use leads to wear and tear of the infrastructure.
- *Safety concerns*: road accidents cause deaths, injuries and property damage.

One of the most challenging problems is the reduction of emissions (mainly CO_2) [Ministry of Transport, 1997b]. Emissions of CO_2 contribute to the greenhouse effect, NO_x and SO_2 lead to acidification, while C_xH_y cause smell. Both NO_x and SO_2 have actually been reduced since the late 1980s, but CO_2 emissions are still increasing. Figure 4-5 shows the ongoing trend of rising CO_2 emissions of freight transport by road, as compared to the exhausts of rail and inland waterways (in the Netherlands). This trend is strongly influenced by the rise of vehicle-kilometres by road [NEI, 1999].



Source: AVV [2000]

FIGURE 4-5 **CO_2 EMISSIONS BY FREIGHT TRANSPORT IN THE NETHERLANDS, 1980-1998 (MLN KG)**

CO_2 emissions have risen despite the use of cleaner engines and reduced fuel consumption of lorries and vans. Between 1986 and 1997, an increase in vehicle-kilometres (up 30 per cent) was responsible for the greater part of the 45 per cent rise in CO_2 emissions [AVV, 2000]. Additional contributing factors for CO_2 emissions are provided by Van der Krogt and Verhage [1996]:

- *Speed*: extreme speeds are relatively inefficient with respect to fuel consumption.
- *Vehicle type*: calculations of Van den Brink and Van Wee [1997] show that a small van produces many more negative exhausts than a truck: 6.4 times higher CO_2 emissions, 2.7 times higher NO_x, and 5.9 times higher SO_2 emissions.

Freight transport policy objectives

Governmental policy initiatives have to balance both positive and negative externalities of freight transport activities. Figure 4-6 summarises the dual objective of the Dutch freight transport policy initiatives, which was deduced from several governmental reports: *The Second Transport Structure Plan* (SVV-II) [Ministry of Transport, 1989], *Transport in Balans* (TiB) [Ministry of Transport, 1996] and the *Five-Year Programme Infrastructure and Transport* (MIT) [Ministry of Transport, 1998].

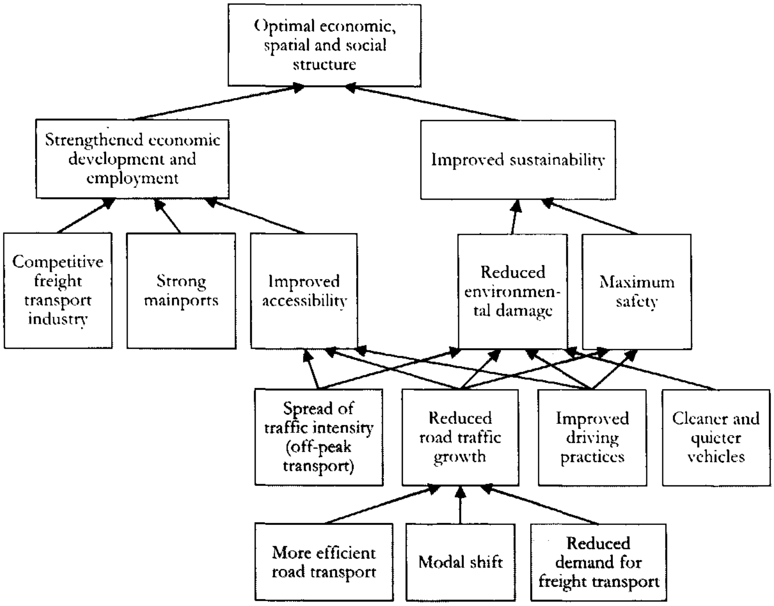


FIGURE 4-6 FREIGHT TRANSPORT POLICY OBJECTIVES

The prime objective of (freight) transport policy is to create a so-called optimal economic, spatial and social structure. This broad objective is split into two parts.

When we look at the negative externalities, improved sustainability of freight transport is the relevant sub-objective. The aspects of sustainability that were discussed in the mentioned governmental reports are: improved accessibility (i.e. reduced congestion), reduced environmental damage (i.e. reduced emissions, disruption and depletion) and maximum safety. These sustainability objectives can be achieved by a shift to off-peak operations, reduced road traffic growth, improved driving practices and cleaner/quieter vehicles. A reduction in the growth of road transport can in turn be obtained by more efficient road transport, a modal shift to rail and waterway transport, and a reduction in the demand for freight transport. The grey boxes show the aspects that are particularly relevant to our problem statement: these are factors that are influenced by changes in logistics choice behaviour.

Vehicle-kilometres figures linked to logistics choices

Freight transport tactics are only effective if the mentioned negative externalities are reduced. As we have seen, the problem of CO_2 is a very persistent problem. The development of CO_2 is closely related to the trend in vehicle-kilometres by road. We will therefore use vehicle-kilometre figures as a proxy variable for the development of negative externalities. The Ministry of Transport [1996] has formulated vehicle-kilometre reduction targets for the same reason.

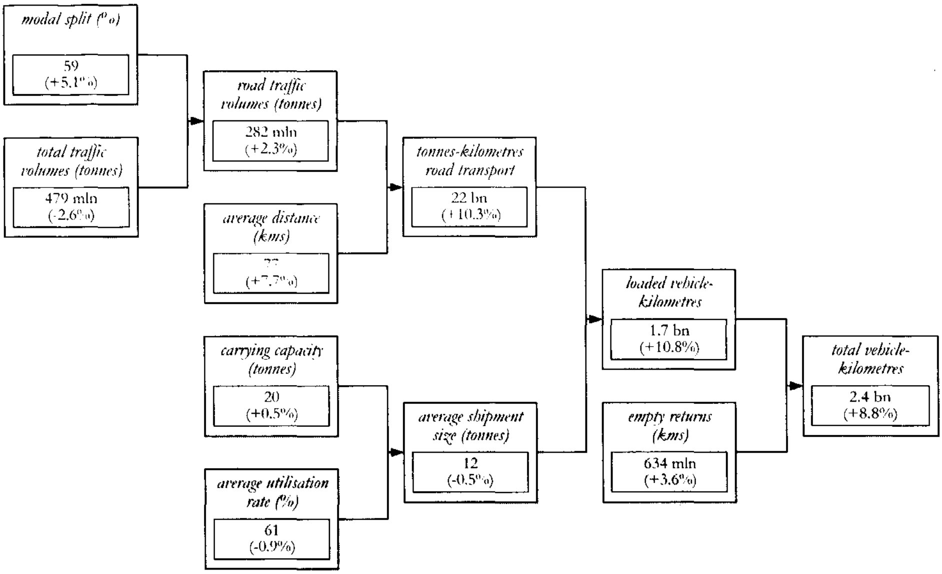
In its most conservative scenario, AVV [1998] projects a growth of total freight vehicle-kilometres by road of 41 per cent between 1986 and 2003. However, this figure alone has no explanatory value: we want to explore the factors that are behind these growth figures.

Decompositional model of macro-impacts

Vehicle-kilometre figures can be decomposed into a number of underlying factors. The total number of vehicle-kilometres realised within a certain period of time is dependent on:

- Modal split (per cent of total freight volumes transported by road).
- Total traffic volumes (tonnes, all modes).
- Road traffic volumes (tonnes).
- Average distance (kilometres).
- Tonnes-kilometres by road transport (tonnes-kilometres).
- Carrying capacity per vehicle (tonnes).
- Average utilisation rate (per cent).
- Average shipment size (tonnes).
- Loaded vehicle-kilometres (kilometres).
- Empty returns (kilometres).

These factors can be displayed in a decompositional model that specifies their mutual relationships. The result is an explanatory scheme with total vehicle-kilometres portrayed as an output variable (see Figure 4-7).



Source: calculations based on (unpublished) CBS data

FIGURE 4-7 **GROWTH OF THIRD-PARTY DOMESTIC FREIGHT TRANSPORT BY ROAD IN THE NETHERLANDS, 1994-1996**

The data for this figure were acquired from the Central Bureau for Statistics. Not all of the required data are published in the regular CBS publications, but were obtained on request. Owing to limited data availability, Figure 4-7 is filled with data of domestic third-party freight transport volumes in the Netherlands (i.e. own-account transport by industrial companies is excluded). Consistent and complete figures are only available for the years between 1994 and 1996. Elaborate statistical analyses are therefore impossible, but the data illustrate how the figure of total vehicle-kilometres can be decomposed into several underlying factors. The above decompositional model for example shows that an increase in tonnes-kilometres could be compensated by improved utilisation rates (resulting in constant vehicle-kilometre figures).

4.6 ELABORATION CONCEPTUAL MODEL: MICRO- AND MACRO-IMPACTS

In order to link the discussed micro- and macro-impacts of time-sensitivity, we have observed statements in the literature that connect the selected logistics decision elements (see also Figure 4-3) with the underlying factors from the decompositional model. These (mostly qualitative) remarks informed us about the existence and direction of relations between these two groups of factors. The literature sources that formed the basis of this conceptual model were: B&A [1997], Bertens and Langenberg [1995], Browne [1997], Ter Brugge and Mandos [1992], Buck Consultants [1999], Bukold *et al.* [1993], Chapuis *et al.* [1993], Cooper [1991], Cooper [1994], Van der Kaaij [1996], Ministry of Transport [1996], Ministry of Transport [1997a], NEI *et al.* [1995], NEI [1999], O'Neal [1989], Raad voor Verkeer en Waterstaat [1998], Raad voor Verkeer en Waterstaat [1999], TNO-INRO [1999] and Wu and Dunn [1995].

The results of the analysis are shown in Figure 4-8. As becomes clear from this causal diagram, logistics decision making is a complex matter. The relations between logistics choices made within an individual company (the upper part of Figure 4-8) have repercussions on the macro-level (the lower part of Figure 4-8). We see that logistics choices themselves interact, and that they also have effects on factors that are connected to vehicle-kilometres.

The purpose of this causal diagram is to enable us to analyse logistics changes and their macro-impacts, and additionally to generate ideas for freight transport policy tactics. The conceivable impacts of proposed policy tactics can be explored by means of the relations between the factors in the model. The policy analysis aspect will be elaborated in the next section. In the remaining of this section, we will confine ourselves to highlighting some of the interactions and impacts.

The solid arrows reflect positive relationships, the broken lines mirror negative relationships, while the dotted lines concern relationships for which divergent conclusions are drawn in the literature (the relation is either positive or negative, or depends on the specific circumstances). For example, the outsourcing of transport activities (D13 at the right top of Figure 4-8) is thought to be positively related to the level of consolidation (middle). Third-party LSPs are generally capable of combining shipments of different shippers, which results in better levels of consolidation. A negative relationship for instance exists between the level of inventory and the frequency of deliveries: if inventory levels rose, frequency of delivery could be reduced. The relativity of the strategic or operational position of each decision element is demonstrated by this causal diagram. For example, one could label the decision element *distance between suppliers and production facility* 'more strategic' with regard to for example *frequency of delivery*, but 'more operational' compared to the *number of suppliers in the supply chain.*

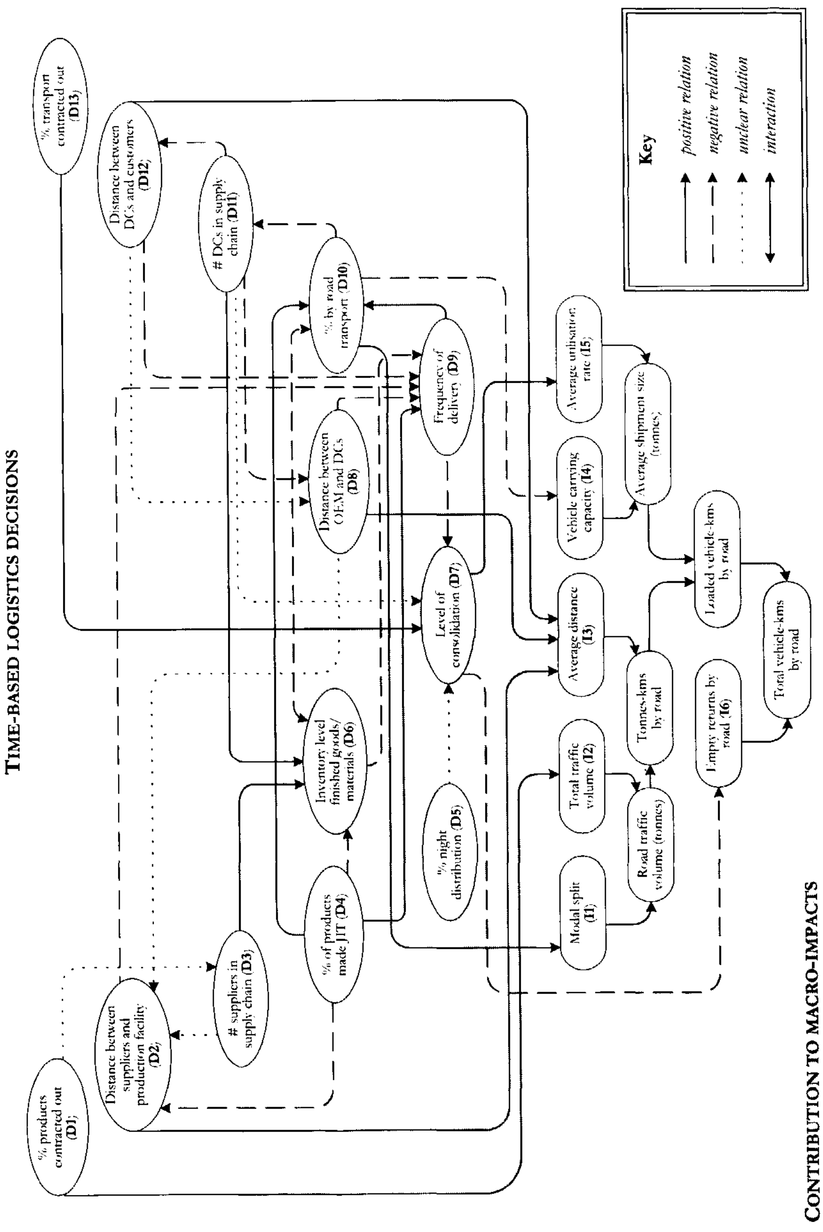


FIGURE 4-8 **CONCEPTUAL MODEL: MICRO- AND MACRO-IMPACTS**

As regards the contribution to macro-impacts, we can see that six decomposition factors are connected to logistics choice behaviour: empty returns (kilometres), modal split (per cent by road), total traffic volume (tonnes), average distance (kilometres), vehicle-carrying capacity (tonnes) and average utilisation rate (per cent of carrying capacity). The remaining variables in the decomposition model are dependent variables, and therefore not actually relevant to the transport policy maker.

As was already discussed in the first chapter, the *choice for faster modes of transportation* and *increased shipment frequencies* are two of the most frequently cited impacts of time-based strategies. These two factors appear important in Figure 4-8 as well, but they are also displayed together with their determining factors. The need for faster transport is for example enhanced by reduced inventory levels and an increased proportion of products manufactured just-in-time. Some of the other crucial factors appear to be the level of consolidation and frequency of delivery. Many logistics decisions affect these two variables (e.g. the percentage of transport contracted out, the distance of suppliers to the production facility, inventory levels). The locational choices (suppliers, production plant and DCs) obviously have impacts on the average distance.

The causal relationships that are depicted in both Figure 4-4 and Figure 4-8 are also summarised in a table in Appendix B. We will discuss specific conceptual relations in the next section, when we explore the different policy alternatives that can be deduced from and analysed with these causal diagrams.

4.7 POLICY SCENARIOS

In order to formulate the policy implications of the previous analyses of impacts of time-based logistics strategies, we wanted to explore the ideas and opinions of actual freight transport policy-makers. In this section, the results of a workshop with these policy-makers will be discussed. Furthermore, the ideas for policy tactics that were put forward during the workshop will be analysed by means of the conceptual framework, and later combined into policy scenarios.

Policy tactics based on expert workshop

In March 1998, we organised a workshop within the framework of our research project. Thirteen policy-makers of different ministries (Department of Transport, Department of Economic Affairs and Department of Spatial Planning), as well as of provincial authorities and representatives of interest groups within the field of freight transport, were invited to an expert meeting. A list of the participants' names and employers is provided in Appendix C.

The goal of the expert meeting was twofold:

- Validate the hypothesis whether increased time-sensitivity of logistics chains is ultimately causing extra road vehicle-kilometres.
- Generate a list of possible governmental and/or business company actions in order to reduce negative externalities of increased vehicle-kilometres, caused by the acceleration of logistics activities.

To facilitate this expert meeting a group support system (GSS) was used. This GSS is designed to make group meetings more productive and more efficient. Information and communication technology is applied to structure and store the information that is exchanged among the members (i.e. policy-makers) of a meeting [Van den Herik, 1998]. Because of the brainstorm- and validation character of the meeting, the use of the GSS was expected to be more effective compared to traditional meetings.

Support for hypothesis

During the first part of the session, the participants were asked to express their opinions with regard to the following hypothesis: *increased time pressure in logistics supply chains has caused extra road traffic growth in the last decades.* For the greater part, the participants supported this hypothesis. Several arguments were mentioned that underpin the proposition.

To give an example, it was claimed that logistics acceleration results from increased specialisation and outsourcing of non-core activities. Whereas some activities were previously carried out in-house, new external materials flows are generated. The time and availability requirements posed upon these flows are often relatively high, as they are still considered an integral part of the production system. Without extensive control systems, this can easily lead to ever-smaller drop sizes, low utilisation rates and subsequently increased vehicle-kilometres. Another cause for acceleration is claimed to be the increased flexibility of production and marketing: due to the extended differentiation of products, inventory control has become a necessity, along with increased speed in production and distribution. The underlying trigger of these developments is said to be formed by customer requirements: reinforced by increased prosperity, customers want specific products and do not like having to wait for them. As a side effect of this higher-level trend, logistics systems emerge that comply with these requirements.

Generated ideas for policy tactics

Numerous suggestions for policy actions, to be initiated by government and/or industry, were put forward during the brainstorming part of the session. Given the broad support for the hypothesis that logistics acceleration contributes to the growth of vehicle-kilometre figures, we asked the participants to formulate ideas for policy initiatives. We set two requirements before the policy-makers started writing down their ideas:

- The proposed policy initiatives should take into account the trend of logistics acceleration and the impacts it has on logistics choice behaviour.
- The policy initiatives should contribute to a reduction in vehicle-kilometres by road.

For the remaining, the participants were asked to formulate their ideas without paying too much attention to feasibility and conceivable practical problems, in order not to miss out on ideas that might be effective, but (currently) hard to implement. Additionally, participants could anonymously add comments to others' ideas and explain their own suggestions.

The merit of the session was that participants did not consider the outlined transport problem in isolation, but also paid attention to the causes of the problem, which are often outside the logistics sub-system. Points of leverage for possible tactics are therefore not only found at the level of transport decisions, but are rather defined for the entire spectrum from causes to macro-impacts, as identified in our conceptual framework.

Appendix D provides the complete list of ideas for policy tactics that were generated during the session, together with a short explanation. Apart from the overlap between ideas, this list of crude ideas appears rather heterogeneous, while not all ideas are well defined either. In the following, we will therefore screen the ideas and combine them into different policy scenarios.

Screening of ideas for policy tactics

In Figure 4-6 we identified the relevant sub-objectives of governmental freight transport policy (see the grey boxes). This implies that four groups of relevant policy tactics can be discerned:

- *Spread*: a given quantity of traffic volume is transported during an extended period of time (i.e. off-peak transport, night distribution).
- *Modal shift*: a given quantity of traffic volume is transported by another mode of transportation (i.e. shift to rail or inland waterway transport).
- *Efficiency*: a given quantity of traffic volume is transported more efficiently (i.e. improved utilisation rates, combination of part-shipments).
- *Reduced demand*: eliminating part of the traffic volume (e.g. through co-location, producing more products in-house).

We have added the label of one of these groups to each idea in Appendix D. First, idea (01), impose higher charges on road transport, is for example aimed at enhancing spread, modal shift and efficiency. Second, idea (02), extend time windows, is a spread measure that attempts to achieve a shift of transport activities to off-peak hours, thereby reducing congestion and environmental damage. Third, ideas (03) to (11) are modal shift measures intended to reduce the share of traffic flows completed by road. Fourth, ideas (10) to (22) refer to tactics that would improve the efficiency of road transport practices. Fifth, idea (23) pertains to the group of reduced demand tactics; that is, spatial measures that could contribute to the prevention of transport flows. We will analyse each of the mentioned groups of tactics by means of the causal diagrams presented in the previous sections.

Formulation of policy scenarios

The causal diagrams (summarised in Appendix B) can be used to systematically evaluate the effects of the policy tactics that were generated during the expert workshop. With the help of the conceptual relations in Appendix B, policy scenarios are constructed. These scenarios reveal some of the conceivable dynamics caused by the implementation of the proposed policy tactics.

With respect to the scenario construction, two restrictions are made. First, it should be noted again that the scenarios are based on conceptual relationships, which will have to be verified in later research efforts. Second, this section deals with policy *analysis* and not so much with policy *management*. This means that the goal of this chapter is to explore and analyse the conceivable effectiveness of policy initiatives, under the assumption that certain points of leverage do exist, and that they can be influenced by governmental actions or by the joint actions of government and business industry.

We will illustrate the construction of a policy scenario by means of an example. Let us suppose that governmental policies could enhance the proportion of freight transport activities contracted out to third-party LSPs. This corresponds with logistics decision D13 in Appendix B. When we look at the row D13, we can see that this decision only has positive impacts on logistics decision D7 (*level of consolidation*). When we look in turn at the row D7, one can identify the impacts of this decision: a positive impact on I5 (*average utilisation rate*), a negative impact on I6 (*empty returns by road*), and a negative impact on D9 (*frequency of delivery*). This procedure can be repeated continuously, but we have limited the analysis to a maximum of four iterations. This is done because the conceptual relations should not be viewed deterministically (that is, with probability 1), but rather probabilistically. The probability of each policy impact therefore becomes smaller as the number of iterations increases.

We have displayed the results of this procedure for the different policy tactics in Appendix E. The advantages of depicting conceivable impacts of policy tactics in this fashion are:

- Assumptions about the direction of conceptual relations have to be made explicitly. These assumptions to a large degree determine the outcomes of the scenario, but these can therefore be easily traced back to the underlying assumptions. Different scenarios can be constructed for different assumptions.
- Unclear conceptual relations are immediately identified, and research efforts can be directed towards these 'missing links' in order to complete the causal diagrams and to improve the *ex ante* evaluation of policy impacts.

We will discuss each policy scenario in the following sub-sections.

Policy scenario 1: Impose higher charges on road transport

Short [1995] claims that the only way to get rid of 'marginal travel' is to increase its price. Geurs and Van Wee [1997] observe that higher fuel prices principally affect demand for freight transport, but that fuel costs usually only represent a small percentage of the total transport costs. The effects of infrastructure- or kilometre-charges on vehicle-kilometres are however unknown [Geurs and Van Wee, 1997]. Blauwens [1998] claims that road pricing (a flexible charge dependent on time and location) is superior to all other taxes on car use.

Policy tactic (01), *impose higher charges on road transport*, as suggested by the participants of the expert workshop, aims to affect several factors that are identified in the causal diagrams:

- D5 (*% night distribution*) might rise because time-dependent charges might lead to a shift in transport operations to cheaper hours.
- D7 (*level of consolidation*) could increase because firms might be stimulated to improve utilisation rates in order to reduce the extra costs per product transported.
- D10 (*% by road transport*) could diminish as some companies might consider using another mode of transportation, and thereby avoid paying the extra charges.

When we look at the consequences in terms of changed logistics decisions and macro-impacts (see Appendix E, Policy scenario 1), one can see that most of the desired impacts are actually achieved. Under the assumption that increased night distribution leads to increased consolidation (see next policy scenario), one can discern that a shift to off-peak distribution eventually could lead to improved utilisation rates, reduction of empty returns, modal split by road and increased average vehicle carrying capacity. The same conclusion can be drawn with regard to the effects of increased levels of consolidation. The reduction in the share of road transport (decreasing D10) results in a reduced modal share by road, increased vehicle carrying capacity, reduced empty returns and increased utilisation rates. However, after the policy tactics have taken effect, in the long run also undesired side effects could appear. This is reflected by the impacts that are depicted within the boxes.

Policy scenario 2: Extend time windows and promote 24-hour economy

It is claimed by NEI *et al.* [1995] that tightened time windows in inner cities and driving times regulations negatively influence consolidation possibilities for shippers. Owing to the time-constraints, opportunities for gaining consolidated shipments are effectively reduced. Time policies could therefore be formulated in order to moderate this effect. Ettema and Timmermans [1996] regard time policies as a valuable addition to traditional transport policies (albeit in the context of passenger transport), in order to limit mobility growth and enlarge the transport options open to the decision-maker. Dijst [1995] defines a 'time policy' (also in the context of personal mobility) as a set of tactics aimed at mitigating constraints on time budgets. Recently, an experiment with extended time windows has been executed in the city of Haarlem.

TNO-INRO [1996] sums up the advantages of extended time windows, and an increased proportion of night distribution. First, energy consumption and emissions could be reduced by a reduction in vehicle-kilometres (e.g. through an increased number of stops during night hours, optimal routes without congestion delays). Second, emissions could be reduced, because less energy is wasted by braking and accelerating. However, on balance, the impacts of night distribution on vehicle-kilometres are unknown [TNO-INRO, 1996].

Policy tactic (02), extend time windows, is transformed into policy scenario 2 in Appendix E. The obvious point of leverage for this scenario is D5 (*per cent night distribution*). An increase in this logistics decision is assumed to have a first-order impact on the level of consolidation (D7) and a second-order impact on I5 (increased *utilisation rates*) and I6 (reduced *empty returns*). No visible undesired side-effects can be observed for this policy scenario.

Policy scenario 3: Promote modal shift

Establishing a modal shift involves making intermodal alternatives more attractive compared to road transport. This can be achieved either through adjustments to the intermodal alternatives (e.g. improving transhipment time) or by limiting investments that support further growth of road transport (e.g. by letting congestion get worse). Modal shift policies have however proven to advance with difficulty. NEA and NEI [1990] for example question the feasibility of modal shift policies.

Nevertheless, modal shift policies are among the main points in the freight transport policy of the Ministry of Transport [Ministry of Transport, 1996; Ministry of Transport, 1997a]. The policy project 'Modal Shift' was executed under the supervision of the Ministry of Transport, in co-operation with the Dutch shippers association EVO. This project encompassed a series of quick scans among 100 large and medium-sized enterprises, representing approximately

15 per cent of the total Dutch vehicle-kilometres by road. Within 80 per cent of the examined companies, at least one freight flow could equally be transported by shortsea shipping, rail or inland waterway [EVO, 1999], but it still remains to be seen how many of these flows are actually shifted to other modes.

A direct modal shift policy could start from two different points of leverage in the conceptual framework:

- D10 (*per cent road transport*): a direct reduction in the modal share of road transport (e.g. through service improvement of inland waterway transport/rail).
- C10 (*customer demanding better service from OEM*): as the time requirements of the final customer often cause the need for fast, relatively cheap and reliable transport modes such as road transport, modal shift policies could also begin with this determining factor. This policy scenario therefore assumes that C10 can in one way or another be influenced.

The impacts of a direct reduction of D10 (*per cent road transport*) were already discussed within policy scenario 1. The impacts of reducing C10 are displayed in Appendix E. First, the first-order effect of a reduction of the customer requirements is the relaxation of service levels provided by the OEM (C9). Although it was claimed in the previous chapter that service levels almost never go down, we will assume that this *is* the case for the hypothetical OEM. This would have a series of conceivable impacts on the firm level, ranging from an increase in the number of suppliers (D3) to an increased level of consolidation (D7). This eventually brings about changes such as a decrease in modal split by road, increased vehicle carrying capacity and increased utilisation rates.

A number of counter-intuitive or unlikely impacts however also arise from this scenario. The most unlikely relations are denoted with a dotted line. Based on the results of the case study in the pharmaceutical industry, we hypothesised that D2 (*distance between suppliers and production facility*) will decrease as a consequence of the implementation of time-based strategies by the OEM, while D5 (*per cent night distribution*) and D6 (*inventory level*) increase. When we project this line of thought on policy scenario 3 however, this would for example result in increased distances between suppliers and production facility (D2), higher average distances (I3) and lower frequencies (D9). Likewise, a reduction of D6 (*level of inventory*) should, according to the conceptual relations, cause an increase in frequencies (D9) and the modal share of road transport (D10). These impacts are partly undesired, but also unlikely. The irreversibility of service levels (see previous chapter) and the inertia of logistics decision making can explain these 'unlikely' relations: factors such as the level of inventory (D6) or the percentage of transport contracted out (D13) may be affected by *increasing* customer requirements, but this does not imply that the reverse is also true. If customer requirements were relaxed, the OEM could equally decide not to change the logistics organisation at all, and thereby causing no changes in the factors of the conceptual model.

Policy scenario 4: Promote efficiency

The Dutch 'Transactie'-programme was set up by the Ministry of Transport to make industrial logistics decision-makers more aware of the inefficiencies in the supply chain, for example caused by insufficient co-operation between supply chain partners and resulting in low utilisation rates. Browne and Cooper [1989] mention three ways of promoting co-operation between firms: education and communication, simulations of previously hidden information, and calculating the benefits of increased co-operation. Exactly this was done in Transactie-programme. Additionally, AVV [1997] and Christensen [1996] attribute an important role to the use of information and communication technology (ICT): better information provision could lead to improved utilisation rates. NERA [1998] however claims that some of these improvements might be offset by the longer average distances that might occur as a consequence of the increased use of ICT.

The points of leverage involved in this policy scenario are principally C10 (reducing *customer requirements*), D6 (increasing the *level of inventory*), D7 (increasing the *level of consolidation*) and D13 (increasing the *percentage of distribution activities contracted out*). C10 and D7 have been elaborated previously. Therefore this analysis is confined to D6 and D13.

Influencing both of these factors largely produces the desired effects on the macro-impacts. For example, increasing the level of inventory (D6) would result in a decreased frequency (D9) and share of road transport (D10). In the end, this contributes to reduced modal share of road transport (I1), reduced distances (I3), increased vehicle carrying capacity (I4), increased utilisation rates (I5) and reduced empty returns (I6). Frequencies (D9) would only rise as a fourth-order effect.

Policy scenario 5: Spatial adjustments

The Raad voor Verkeer en Waterstaat [1998], Holzapfel [1995] and Bleijenberg [1998] assert that one of the main causes for the increase in vehicle-kilometres lies in the increased spatial range of logistics activities. For this reason, the mentioned authors suggest that spatial policies might be fundamental to the reduction in freight transport demand. The Ministry of Transport [1996] also identifies spatial policies as an important problem solution. Holzapfel [1995] for example asserts that regional co-operation can avoid the transport of goods. Bleijenberg [1998] proposes measures such as the consolidation of part-shipments via regional hubs, the resistance against further internationalisation and centralisation of inventory and production locations or the promotion of local sourcing rather than global sourcing. This latter option reminds us of the early protectionist governmental efforts to stimulate national consumption (e.g. 'Buy British', 'Koopt Nederlandsche waar', 'Ja zu Austria').

The points of leverage of this policy scenario are obviously D2 (*distance between suppliers and production facility*), D8 (*distance between OEM and DCs*) and D12 (*distance between DCs and customers*). Whereas the first-order effects of this scenario would contribute to a decrease in the average distance (I3) a number of other impacts would be counterproductive or unclear. First, it remains unclear which impact a reduction of D8 (*distance between OEM and DCs*) has on D2 (*distance between suppliers and production facility*). This completely depends on the actual configuration of the supply chain under examination and cannot be generalised for 'an average supply chain' as yet. Second, the assumption that decreased distances lead to higher frequencies (D9) produces a rebound effect: as distances are diminished, firms tend to increase the frequency of shipments. On balance, the contribution of spatial policies might therefore be neutralised.

4.8 CONCLUSIONS

In this chapter, we hypothesised and summarised the conceptual relations between causes, micro-impacts and macro-impacts of increasing logistics time-sensitivity. This was based on literature as well as on our own empirical fieldwork (as described in the previous chapter). We have used these relations to make further hypotheses about the impacts of policy scenarios that were originally generated during an expert meeting of policy-makers. The policy scenarios that have been discussed in this chapter provided insights into the first- and higher-order effects that policy measures might have.

The presented policy scenarios however require further refinement. This elaboration should be aimed at three points:

- The hypothesised causality between the conceptual factors: are the conceived causal relationships actually observed in practice?
- Overlooked relationships: relationships that have been overlooked in this chapter might be observed through acquiring new empirical data.
- Conceivable asymmetry in conceptual relations: some of the proposed policy scenarios might appear less effective if part of the conceptual relations were asymmetric.

In addition, the policy scenarios and the underlying hypotheses should be tested empirically. The practical responses to transport policy initiatives by the target group of the policy tactics needs to be investigated in order to provide a first behavioural test of these tactics.

In the next chapter, we will examine the methods and techniques that can be used to reveal these aspects of refinement. We will provide an overview of the methods and techniques that have been implemented in the literature for comparable research problems and finally choose a set of research methods that comply with our research objectives. We will construct an operationalised research protocol that will be applied in further empirical research.

5

Developing the case study protocol

The research approach used throughout this dissertation follows the lines of the empirical cycle (see Chapter 1). Starting with an analysis of conceivable time-reduction alternatives in Chapter 2, we conducted a case study in the pharmaceutical industry to explore the causes and impacts of time-based logistics decision-making (Chapter 3). This led to the induction of a conceptual model in which the logistics sub-system is placed within a larger context. Subsequently, we deduced a series of new hypotheses, in the form of conceptual policy scenarios (Chapter 4). In this chapter, we will present and underpin the case study methodology that we use for the external validation of both the conceptual model and the deduced policy scenarios. The analysis units and the methods of data collection are described in this chapter. Analysis results will be presented in Chapter 6 and 7.

First, we will clarify the purposes of the methodology developed (see section 5.1). These purposes imply that we will continue to incorporate a systems view in our research methodology. Section 5.2 provides a brief overview of approaches used in existing logistics research studies, respectively the survey methodology and the multiple case study methodology. Section 5.3 describes the choices we make to operationalise the case study approach adopted in this dissertation. The various data collection techniques used will be discussed in this section. As freight transport issues have not been studied as extensively as passenger transport, we will also draw parallels between freight and passenger transport, to see what methodological lessons can be learnt from adjacent fields of research.

5.1 PURPOSES OF THE METHODOLOGY AND SYSTEMS VIEW

At the end of the previous chapter, we concluded that the presented conceptual model needs further refinement. At the same time, the policy scenarios that were deduced from the conceptual framework need to be tested empirically. Therefore, the methodology that is to be developed should satisfy a dual goal.

First, it should enable us to gain a better understanding of logistics choice behaviour under increasing time-sensitivity and thereby *refine the conceptual model* presented in the previous chapter. The methodology should enable us to describe, interpret and explain recent and current changes in logistics systems. It should be investigated whether actual logistics decision-making processes replicate the hypothesised relations, and if not, what deviations from the theory can be discerned. The expected micro-impacts of increasing time-sensitivity, as well as the repercussions on the macro-level, should be verified empirically. Furthermore, the causality (internal validity) and conceivable asymmetry of the hypothetical relations need to be recorded.

Second, the methodology should facilitate *a preliminary test of the policy scenarios*, i.e. explore the future reactions of actual logistics decision-makers with regard to the proposed policy initiatives and determine the degrees of freedom at their disposal. Policy initiatives often do not work in the intended direction, because of the inventive behaviour of individuals that are confronted with policy constraints [Jones *et al.*, 1983, Salomon and Mokhtarian, 1997]. As a consequence, policy initiatives could end up being un- or even counter-productive. Therefore, an exploration of the choice options available to logistics decision-makers would provide a first 'behavioural' test of the proposed policy scenarios. Likewise, it is claimed that choice inertia may play a role, because certain thresholds need to be crossed before routine behaviour is changed [Fischer, 1993]. Acquired information on behavioural responses and possible threshold effects can be used for a further refinement of the conceptual model.

Before we discuss the specific methodological choices with regard to these purposes, we will recapitulate the basic systems view that we have departed from in this dissertation. This is done by a brief overview of the experiences with the systems approach in the field of passenger transport studies.

Drawing parallels between passenger and freight transport: the activity-based approach
The activity-based approach that is encountered in passenger transport studies [see for example Jones *et al.*, 1983], explicitly incorporates a systems view. The derived character of transport activities is strongly reflected by this approach: the demand for travel almost always emerges from other activities that require travel (e.g. one travels to the cinema to watch a movie). In addition to the derived

character of travel, the activity-based approach assumes that travel decisions usually cannot be taken in isolation, but are constrained by exogenous constraints of various types [Ben-Akiva *et al.* 1996; Jones *et al.*, 1983]:

- *Socio-economic characteristics* of the individual: travel demand is affected by variables such as income, stage in life-cycle, household structure, etcetera (e.g. if you are an unmarried young man you are more likely to travel to the cinema than a married father of four little children).
- *Spatial opportunities*: certain activities can only be executed at certain places (e.g. when there is no cinema in your neighbourhood, you may need to travel to another city).
- *Temporal opportunities*: certain activities can only be executed at certain times (e.g. since the cinema is closed until 19:00 hours, you will not be able to go to the movies during daytime).
- *Available transport options*: the demand for travel is also influenced by the level of transport services offered between activity locations (e.g. if the cinema is not accessible by public transport, you might not be able to get there after all).

These exogenous constraints or opportunities can also be translated in terms of logistics choice behaviour. Just like a father of a household has to adjust some of his travel decisions to the demands of other household members, a logistics manager cannot take transport decisions individually either. He or she is part of a 'household' made up of the production and marketing departments of the company, and a broader 'social network' of suppliers and customers. Each of these set their own requirements on the logistics manager. Likewise, the spatial and temporal opportunities and the available transport options could even be more relevant in the context of logistics decision-making. The logistics manager is constrained by the existing spatial structure of distribution centres, production facilities and locations of suppliers and customers, as well as by the temporal constraints stemming from limited opening hours of customers' facilities, time windows in inner cities, etcetera.

In this systems view, logistics decision-making and its derived demand for transport is seen as a tip of the iceberg. The massive iceberg that is below sea level represents the activity patterns that require and generate transport activities (e.g. being able to manufacture products, selling and delivering the products on time) and all of the other mentioned constraints. An important implication is that, when policy initiatives try to influence the 'observable' part of the iceberg, the success of these policy initiatives will probably be affected by the 'unobservable' part of the iceberg as well. In order to keep track of this 'unobservable' part of the decision-making process, we need to hold on to a holistic systems view. To conclude the metaphor, the methodology that is to be developed and operationalised in this chapter needs to be 'waterproof', in order to allow us to take a look under the sea level as well.

5.2 SURVEY VERSUS CASE STUDY RESEARCH

In the logistics literature, two broad approaches to exploring and testing theoretical models stand out: the *survey* and the *multiple case study* methodology. In this section, we will briefly discuss the strengths and weaknesses of these methodologies, together with examples of applications in logistics research studies.

Survey methodology

Bruinsma and Zwanenburg [1992] claim that the survey methodology is aimed at generalising, suitable for testing highly structured problems and models. The problem statement should already be operationalised in hypotheses about relations between measurable variables. Surveys are usually applied when the researcher is already capable of structuring the problem at hand [Bruinsma and Zwanenburg, 1992]. Using multi-item scale techniques (e.g. Likert scales), one measures the different dependent and independent variables, and afterwards tests the existence of significant relations (e.g. through multiple regression analysis). For this reason, this approach is also called 'statistical modelling' [Futures Group, 1994a]. Surveys are often executed in the form of large-scale postal questionnaires. Statistical representativeness is important, as the final goal of the survey is to generalise findings.

Applications of the survey methodology in logistics research

Some applications of the survey methodology in logistics research are summarised in Table 5-1. All of the mentioned studies used postal self-administered questionnaires to test predefined hypotheses. In the example studies, the independent and dependent variables are mostly measured by means of five-point up to ten-point Likert scales. A survey can however also be used to measure and compare absolute values (e.g. average transit time). The common analysis techniques employed are regression analysis and Chi-square analysis. With the help of *t*-tests or *F*-tests, the significance of the hypothesised relations is examined. The survey method therefore basically is a quantitative approach that can be used for the testing of hypotheses that are based on an already elaborated theoretical framework. To get representative results, response rates are important, but as the examples in Table 5-1 show, response rates may actually vary strongly.

TABLE 5-1 EXAMPLES OF SURVEY METHODOLOGY IN LOGISTICS RESEARCH

Source	Goal of research	Response rate	Method of analysis
Spencer *et al.* [1994]	Examine trends in the usage of third-party logistics (among others)	7% (n=164)	Simple descriptive statistics
Vonderembse *et al.* [1995]	Test differences between JIT and non-JIT users with regard to various variables (e.g. shipment sizes, lead time)	13% (n=268)	Chi-square analyses
Muilerman [1994] and Muilerman [1996]	Examine relations between the importance of locational factors of third-party logistics firms and various background variables (e.g. size of firm, market segment)	61% (n=672)	Chi-square and regression analysis
Wafa *et al.* [1996]	Test propositions of relationship between geographical distance, extent of supplier certification etc. and degree of JIT success	19% (n=130)	Correlation analysis and stepwise regression
Van Hoek [1998]	Test relations between the application of postponement (dependent variable) and ICT, variability of demand, degree of modularity etc.	15% (n=80)	Multiple regression analysis
Ellram *et al.* [1999]	Examine current logistics practices and trends in US retailing channels	9% (n=92)	Simple descriptive statistics
Jayaram *et al.* [1999]	Test relations between time-based performance and overall business performance as well as the relations between 13 time-based action programs and time-based performance	39% (n=57)	Multiple regression analysis
Larson and Kulchitsky [1999]	Test relations between logistics improvement programs and actual business performance and logistics people	57% (n=410)	Multiple regression analysis
Tan *et al.* [1999]	Test whether quality management, supply base management and customer relations practices can impact corporate performance	21% (n=313)	Multiple regression analysis

Advantages and disadvantages of surveys

The simple but powerful analysis techniques that can be used for its analysis (e.g. regression analysis) form the main advantage of the survey methodology. Provided that a representative response is obtained, these analytical techniques allow the researcher to accept or reject predefined hypotheses about conceived causal relations between a range of dependent and independent variables.

However, the survey methodology does have some drawbacks. Chow *et al.* [1994] conclude on the basis of an extensive review of logistics research studies:

> *The predominance of the mail survey as a data collection method in the logistics studies reviewed raises some concern in light of its inherent limitations* [Chow *et al.*, 1994, p.22].

First, computed regressions and significance of relations never prove the existence of causality between the independent and dependent variables. A statistically significant relationship is a condition for causality between x and y, but not a sufficient requirement: such an analysis should always be preceded by the formulation of a theory that identifies causal relationships. In a causal relationship, the dependent variable y is not allowed to precede independent variable x in time, and no intervening variable z may cause the correlation between x and y. For a closer examination of these types of issues, and the exploration of a theory, the survey methodology may be less appropriate. Second, Chow *et al.* [1994] criticise the so-called 'rate-your-own-company' studies. The reliability or even validity of research methods that completely rely on judgements of managers about their own company's performance can be questioned. Chow *et al.* [1994] recommend that these studies be supplemented with data from other types of respondents, such as customers. Third, in a survey it is not clear whether all respondents interpreted the questions in the same way. However, a well thought-out survey design will of course prevent many of these biases. Fourth, usually many similar questions need to be asked in order to measure the variables under study. In the survey of Tan *et al.* [1999] for example, respondents had to rate up to 70 items. The researcher can neither control possible fatigue effects or the conditions under which the survey is completed. Finally, it is claimed that postal surveys could face response problems [Zwart, 1993], but as the figures in Table 5-1 show, response rates may actually strongly vary.

Case study methodology

Eisenhardt [1995] defines a case study as a history of a past or current phenomenon. Case studies are executed using multiple sources of evidence, such as in-depth interviews, archives, documents and direct observation. Both qualitative and quantitative data sources can be used in a case study. Using different data collection methods enables the triangulation of data, which improves the validity of results. Ellram [1996] considers multiple case study research as a suitable means for theory building (e.g. discerning types of respondents), explaining 'best practice', and providing understanding in the field of logistics research. Additionally, both Yin [1989] and Eisenhardt [1995] discuss the opportunities of testing theory through the use of case studies.

Applications of the case study methodology in logistics research

Case study research is also popular in logistics research. Table 5-2 summarises several applications of the case study methodology in this field. It is revealed that most of the reviewed studies use the case study to *explore* various issues. However, Hörte and Ylinenpää [1997] and Lehtonen and Holmström [1998] used multiple case studies to *test* a series of hypotheses. The number of case studies is usually limited, while the data collection techniques generally concentrate on personal interviews, complemented by documents, archival records and observations from site visits.

Advantages and disadvantages of case studies

Case studies are suitable for obtaining in-depth descriptions, interpretations and explanations of real-life phenomena. Empirical patterns can be discerned and compared with a theoretical framework. The often-used face-to-face approach enhances validity of results, because the researcher is able to control the circumstances under which the data are gathered. The interviewer for example has the opportunity to ask follow-up questions in case of unclear answers. The researcher can verify the existence of hypothesised relations, but can additionally obtain answers to the 'why' of these relations, which facilitates the interpretation and explanation of results. Furthermore, if results are accurately recorded, so-called 'causal chains' can be discovered in the answers of the respondents [Akkermans and Bertrand, 1997].

A number of disadvantages are however also connected to the case study research methodology. First, the face-to-face approach could equally be a danger, as several kinds of biases could slip into the data collection process as a consequence of the personal interaction between the researcher and respondent (e.g. control-effect, biased-viewpoint effect). These biases can be controlled to some extent by tape-recording interviews and by producing literal interview transcripts, allowing the verification of raw data. Second, there are no standard analysis techniques for case study data. Therefore, the analysis of case study data is demanding. This disadvantage also implies that the analysis procedures need to be explicated as clearly as possible, in order to enable the verification of conclusions by others.

TABLE 5-2 EXAMPLES OF CASE STUDIES IN LOGISTICS RESEARCH

Source	Goal of research	No. of cases	Data collection and method of analysis
Eibl *et al.* [1994]	Explore the requirements and benefits of a computerised vehicle routing and scheduling system	1	Action research and retrospective analysis
Rao and Young [1994]	Explore attitudes of shippers and service providers within global companies towards outsourcing of logistics functions	44	Interviews, classification of key factors
Daugherty and Pittman [1995]	Provide better understanding of how successful time-based strategies are achieved	10	Interviews, identification of key issues
Loomba [1996]	Explore the interfunctional linkages between physical distribution and after-sales service	2	Interviews, formulating hypotheses
Hörte and Ylinenpää [1997]	Test hypotheses about the gap between customers' and suppliers' perception of order-winning criteria	4	Open-ended interview questions re-coded by researchers
Norrman [1997]	Describe and explore if and how time-based distribution affects companies' organisational structure	4	Interviews, explanation building by typifying cases
Lehtonen and Holmström [1998]	Testing the effects of alternative locations of the order penetration points in the paper industry	4	Interviews and formal simulation of alternative scenarios
Rohr and Corrêa [1998]	Explore the extent of implementation of time-based competition and identify the main time-reduction actions	7	Documents, semi-structured interviews, identification of key issues
Voordijk [1999]	Explore the obstacles to and opportunities for the implementation of integrated logistics in the building industry	19	Partly open-ended interviews, identification of key issues

Third, case studies often result in 'soft' theoretical generalisations, and not in 'hard' statistical test results. However, if the goal of the study is to build or refine a theoretical framework, theoretical generalisations may be just what the researcher is looking for. Fourth, the revealing of causal chains solely based on retrospective case studies is limited, in that cause and effect may be inseparable in the reasoning of the respondents [Eisenhardt, 1995]. The ideal exploration of causal relations, through a longitudinal study, is however not always feasible.

Evaluation

As we have seen, no methodology is perfect. Given the purposes of the methodology (see section 5.1), however, we prefer multiple case studies to a survey: our primary purpose is to refine the conceptual model, which requires an in-depth understanding of the logistics decision-making process under increasing time-sensitivity. The case study methodology meets the objective of being able to describe, interpret and explain recent and current logistics system behaviour, and moreover record causality and conceivable asymmetry of conceptual relations. The systems view can also be incorporated within a case study, because this methodology allows the researcher (and the respondents!) to keep track of the 'big picture' and continue to see the object of study in perspective. A survey would be a more appropriate approach, if we were more certain about the character and causality of the relations in the conceptual model. In light of the status of our conceptual model, we attached more importance to theoretical refinement and generalisation than to statistical generalisation. An argument for using multiple case studies is that each case adds various supplementary aspects of the phenomenon under study, which results in a more complete and richer theoretical framework, and moreover enhances external validity of the conceptual model. Statistical testing would be something for later research efforts.

5.3 OPERATIONALISATION OF CASE STUDY PROTOCOL

In this section, we will operationalise the specific elements that we use within the case study protocol. In addition, we will define the level of analysis and the criteria for case selection.

Level of analysis

As became clear from the previous, we have adopted a disaggregate approach, concentrating on micro-level analysis of individual case studies. We thereby focus on the unit within which the relevant logistics decisions are actually made. As depicted in Figure 4-1, this unit is identified as a company's logistics function, that operates within the context of internal (i.e. marketing and production requirements) and external opportunities and constraints (e.g. customer requirements and suppliers' capabilities). The logistics function can either be concentrated within a logistics department or spread over different departments. As the external forces often largely affect the logistics decision-making process of an individual firm, it is important to include supply chain factors in the case study protocol as well. This is in line with the systems approach discussed in section 5.1.

In summary, we concentrate on the logistics function within companies that are expected to represent a larger (and growing) population of time-sensitive companies: after all, the changes in logistics choice behaviour due to increasing time-sensitivity are subject of this dissertation.

Case selection criteria

Our research goal is to analyse the relevance, causes and micro-impacts of time-based strategies, and their macro-impacts on the demand for freight transport (see Chapter 1). Thus we need to select companies for our case studies that meet the following criteria:

- First, the companies should (have) face(d) increasing time-sensitivity in the context of their logistics decision-making process. The features of time-based strategies, as discussed in section 2.2, are used as a guideline for case selection. Time-sensitive companies will be more easily identified in economic sectors that were typified as the most 'time-based sectors' in Chapter 3.
- Second, cases should display enough variation in background variables that could be important for explaining differences in results (e.g. product and market characteristics).
- Third, as the implications of time-based strategies for resulting freight flows are also crucial to our analysis, it would be preferable to include only those companies that generate a substantial amount of freight flows.

Applying these selection criteria implies that, in further analyses, we will only be able to generalise for this subset of companies. That is, we cannot extend our conclusions to companies that are characterised as 'non-time-based competitors'. However, in the perspective of our research goal, these conclusions are not required. The above criteria also mean that random sampling would be inappropriate. Rather, we will need to use *judgemental sampling* [Zwart, 1993]: case study firms will be chosen on the basis of their relevance with regard to the research goal and the above mentioned criteria.

The case study protocol will be discussed in the subsequent sub-sections. Based on the analysis of pros and cons, and the appropriateness of the specific methods and techniques discussed in the above, we selected several measurement techniques in our case study protocol. For the refinement of the conceptual model and the discernment of causal chains, we use *direct questions* of both quantitative and qualitative nature, as well as a fully quantitative approach, the *conjoint analysis*. The latter approach is used to quantify the degree of time-sensitivity of the case study companies: if we speak of time-sensitive companies, we want to be able to measure just how time-sensitive they actually are. The conjoint analysis approach is a suitable methodology to perform this kind of quantification. Finally, we use *stated-adaptation* techniques for a preliminary behavioural test of the policy scenarios presented in the previous chapter.

Direct questions on the logistics organisation

Examples of other case studies

The operationalisation of direct questions of course depends on the specific problem statement of the study. The basic setup of an interview is however generally the same: starting with 'easy' identification questions and gradually becoming more specific (*funnel*-technique). In other case studies [e.g. Hoekstra and Romme, 1987; Mennega *et al.*, 1993; NEHEM, 1993] the first part of the interview is used to describe the basic logistics structure, consisting of a physical 'map' of the logistics supply chain. Coyle *et al.* [1992] also point out that logistics systems analysis could be carried out through the analysis of the logistics channel, which is defined as the network of intermediaries engaged in transfer, storage, handling and communication of freight flows.

The goal of the first part of the interview is to obtain descriptive data on what actually happened in recent history to the logistics decision-making process, owing to increased time-sensitivity. Because memory-biases could occur when the respondent is asked something that happened too long ago [Zwart, 1993], the time horizon in our questions does not exceed three years. We use direct questions to measure the relevant variables identified in the conceptual model.

Operationalisation of direct questions

The setup of our case study protocol was also based on the *funnel*-technique: we started with identification questions, and later concentrated on specific issues (refer to Appendix F for the full protocol). The first questions are meant to describe the basics of the logistics organisation under study. Both the respondent and the interviewer can use this company profile as a point of reference in the remaining of the interview. The descriptive part allows the respondent to tell about the things that he is knowledgeable about, which could improve his or her co-operative attitude with regard to more difficult or hypothetical tasks later in the interview.

After the introductory questions, the respondent is asked to concentrate on the product group that is in his or her opinion most 'typical' for the whole logistics organisation. This helps the respondent (and again the interviewer) focus on the main issues, without being carried away by interesting but irrelevant details.

Answers to direct questions can potentially be distorted if it is to be expected that respondents are neither able nor willing to provide truthful answers [Korteweg and Van Weesep, 1983]. However, most of the questions included are not commercially confidential. Moreover, the questions only relate to the 'typical' product. Therefore, the respondents might not feel that confidential information is required.

Some product characteristics are discussed, which could later be used as explaining background variables. Subsequently, we inquire after the variables mentioned in the conceptual model (see 'Logistics Organisation' in Appendix F; note that the bold figures between brackets reflect the relevant variables in the conceptual model). For example, we ask what the average level of inventory of the typical product is, and whether this level has changed during the last three years. The central question involves the most important changes in the mentioned aspects of the logistics organisation, which are brought about by the implementation of time-based management concepts. This question deals with the causality between increasing time-sensitivity and logistics choice behaviour.

The next part of the case study protocol, the conjoint analysis, requires more explanation than the above direct questions. In the following, we will first discuss the theoretical backgrounds of this approach. Second, we will summarise experiences of others with conjoint analysis in the field of logistics research. Third, we will discuss the operational choices we have made for the purpose of our case study protocol.

Conjoint analysis to measure time-sensitivity

If we want to determine the time-sensitivity of (a group of) individual companies, we could try to ask directly how time-sensitive they consider themselves to be, compared to other important logistics factors. However, several biases could occur, if respondents were asked to directly explicate the relative value they attach to attributes and the way they combine them into an overall judgement [Futures Group, 1994b]. Validity issues would rise in such a direct approach: the researcher cannot be sure whether the respondent also incorporates additional variables in his evaluation. For example, if a logistics manager were asked to give points to a transport service that is twice as fast as the current one used, the logistics manager might introduce a 'hidden' variable in his evaluation. In evaluating the alternative, the logistics manager might include costs, since in his or her experience, faster alternatives are often more expensive. In these cases, the quantification of time-sensitivity is biased by the introduction of an undesired second variable.

So-called decompositional multi-attribute models form one class of quantitative multivariate models that are capable of estimating the respondent's sensitivity for certain characteristics independently (e.g. time-sensitivity of a logistics organisation). In this approach, hypothetical choice alternatives ('profiles') are defined by a varying combination of choice characteristics ('attributes'). Each alternative is presented as a package of attributes. The respondent is asked to evaluate the hypothetical profiles by, for example, giving a low mark to the least attractive alternative and awarding higher marks to better alternatives. The rating, which is the dependent variable, is then decomposed by relating the measured attributes to the dependent variable [Hair *et al.*, 1998]. The decompositional approach is also called conjoint analysis.

Results of conjoint analyses can be used to determine and quantify the relative importance of attributes that are of interest to the researcher. Fowkes *et al.* [1989] claim not to know of alternative methods that yield the same quantitative valuations. Furthermore, estimated preferences can be used to identify certain segments within the sample of respondents. One could search for homogeneous sub-groups with similar preferences and interpret inter-group differences by an analysis of background variables [Oppewal and Timmermans, 1992].

Conjoint analysis requires an elaborate preparation by the researcher. Before the stated-preference data can be collected, several issues and assumptions need to be decided upon. These issues and assumptions are made during five preparatory steps [Molin, 1999; Zwart, 1993]:

- Selection of salient attributes.
- Determination of relevant attribute levels.
- Selection of experimental design and composition rule.
- Choice of measurement task.
- Choice of estimation method.

Selection of salient attributes

The attributes that are to be incorporated in the conjoint experiment can be identified on the basis of the experiences of similar research projects or by using techniques such as rating procedures or focus group interviews [Molin, 1999]. It is recommended to limit the number of attributes and thereby keep the experiment simple [Hensher, 1994]. Including too many attributes could lead to fatigue effects and moreover cause the respondent to use simplification strategies during the evaluation process. These would result in exaggerated differences in importance between the most and least important factors [De Ortúzar and Willumsen, 1994]. Inclusion of all the important attributes is essential if one wants to develop models that can predict travel behaviour. However, this requirement is less stringent if the researcher is merely interested in the mutual trade-offs between attributes [De Ortúzar and Willumsen, 1994]. The variables that are excluded should be considered fixed within the experiment, and can be treated as contextual effects. Under all circumstances, the presented attributes should be both non-redundant and meaningful to the respondent.

Determination of relevant attribute levels

It is advisable to limit the number of attribute levels, as too many levels would cause the construction of too many profiles. On the other hand, non-linearity cannot be investigated when only two attribute levels are evaluated. Therefore, incorporating at least three levels enables the researcher to analyse possible non-linear effects. Furthermore, it would be recommendable to take the same number of levels for each attribute. Wittink *et al.* [1992] discussed the so-called *number-of-attribute-levels* effect in conjoint analyses. This effect entails the tendency of respondents to pay more attention to attributes with more levels than other attributes. This consequently results in increased (i.e. biased) importance of those attributes that are in the majority.

Another requirement is that the attribute levels presented should reflect a reasonable range of values in the opinion of the respondents. Threshold effects may occur if the respondent feels that some attribute level is well below the minimum acceptable level. Complete trade-offs of alternatives and attributes, which are required under the model assumptions, are not made in those cases. Hensher [1994] therefore advises that researchers be cautious about choosing attribute levels which are outside the range of current experience and believability.

Selection of experimental design and composition rule

A crucial choice that has to be made by the researcher deals with the assumptions about the respondent's evaluation process. It is often assumed that respondents simply add their value per attribute level, which is also called 'part-worth utility', to reach an overall judgement of the alternative. Timmermans [1982] defines this composition rule (also 'combination rule') as the rule used in combining attributes to produce a judgement of relative value or utility for a product or service. This assumption implies the following general linear model:

$$V_j=\beta_0+\sum_k \beta_k X_{kj} + \varepsilon_j$$

where V_j is the overall utility for a particular profile j, the β_k are the main effects of attributes k on the dependent variable (overall utility), X_{kj} represent the independent variables (coded attribute levels), and ϵ_j is an error component. The experimental design behind this model is called a main-effects or linear design.

A main effect is the contribution of an attribute level to the overall judgement, regardless of other attribute levels within the profile. This design does not allow for the estimation of interaction effects. A (positive or negative) interaction effect means that certain combinations of attribute levels result in lower or higher overall judgements than the sum of the main effects would suggest. Moreover, the main-effects model assumes that respondents compensate between attributes: one 'bad' attribute level can be compensated by another 'good' attribute level. Non-compensatory models can be approximated by including a multiplicative combination rule. Let us illustrate the above by means of a simple example.

Suppose a car driver wants to buy a new car. Let us assume that he or she is interested in two characteristics: the size of the car and its average fuel consumption. All of the alternative cars offered to the driver only differ with regard to these two aspects, while all other attributes are presumed equal. In evaluating the alternatives, the car driver could use both compensatory and non-compensatory combination rules. In the latter case, he or she would formulate crucial conditions with respect to his or her future car: the driver for instance requires that the car be large enough to bring his or her five children to school. If the car were small but on the other hand fuel-efficient, he or she would not consider the alternative, since the 'wrong' size causes the rejection of the whole alternative. If the driver used a compensatory composition rule, he or she would possibly accept a smaller car if it were extremely fuel-efficient.

The exact meaning of interaction between attributes can also be illustrated with this example. Suppose that this particular car driver expressed the following part-worth utilities: a large car gets +2 points (e.g. on a ten-point scale) and a very fuel-efficient car would be valued with +1 point compared to the average rating given to all alternatives. If we assumed that no interaction existed between size and fuel-efficiency, a large and a very fuel-efficient car would deserve +3 points in the eyes of the car driver. If, however, interaction did exist, this 'ideal' combination of attributes could for instance obtain +5 points in the evaluation process by the car driver.

The main-effects model is probably the most commonly used 'fractional factorial design'. In such a design, not all but only a subset of possible combinations of attribute levels are presented to the respondent. These subsets are determined on the basis of standard statistical designs. Fractional factorial designs are mainly used to reduce the number of profiles, while still maintaining orthogonality. Orthogonal designs enable the researcher to measure the effect of changing each attribute level on the overall judgement (the part-worth utilities) efficiently, and to separate this effect from the effects of changing other attribute levels [Hair *et al.*, 1998], because the attributes are varied independently from each other. The price of reducing the number of profiles is that the researcher cannot estimate possible interaction effects among the attributes. However, the majority of previous conjoint analysis applications in transportation studies are variations of the main-effects design [Hensher, 1994], due to its ease of estimation and because it possesses a reasonable explanatory value. Louviere [1988] states that main-effects models usually explain 80 per cent or more of the variability in behavioural responses.

Choice of measurement task

The measurement task of a conjoint analysis can take three forms: ranking, rating or choosing. Ranking can be seen as a complete pair-wise comparison of all the profiles presented. Rating involves giving numerical marks to the profiles on a certain scale. Ranking and rating are called *stated-preference* tasks, while *stated-choice* tasks are comprised of choosing between two or more alternatives. According to Hensher [1994], rating tasks are the richest response metric, but also the most demanding on a respondent. Louviere [1988] however claims that ranking is more elaborate. Stated-preference analysis is considered to be especially suitable for determining the relative importance of different attributes [Kroes, 1988]. Another advantage of ratings is that these data enable the estimation of disaggregate models (i.e. models for each respondent) together with aggregate models (i.e. models per (sub)group), provided that the given ratings can be considered to be of interval measurement level. Hensher [1994] expresses some doubts in this respect, but Louviere [1988] claims that it seems acceptable to assume that rating data do satisfy interval measurement properties.

Choice of estimation method

If ratings are used, and if it can be assumed that the ratings are measured on the interval level, ordinary least squares (OLS) regression is a suitable parameter estimation method. Before estimation takes place, however, it is common practice to code the attribute levels in an analysis design. There are different ways of coding (e.g. dummy, orthogonal or effect coding) but the codings themselves do not influence the estimation of the part-worth utilities. If effect coding is used, the estimated β_k are interpreted as the part-worth utilities, defined as the deviations from the constant term, the β_0 (which signifies the average rating) [Molin, 1999].

After the models have been estimated, for continuous attributes, part-worth utilities of intermediate attribute levels can be derived by interpolation. In this fashion, utility values for non-observed continuous attribute levels can be deduced. Furthermore, different segments within the sample of respondents could be identified in case of large variance in preferences. Clusters of respondents could be discerned on the basis of other background characteristics of the respondents. For each cluster, a new model could be estimated.

Having discussed the basic preparatory steps of conjoint analysis, we will summarise the main advantages and disadvantages of this approach to decision modelling.

Advantages and disadvantages of conjoint analysis

Conjoint analysis provides a powerful approach to modelling trade-offs made by respondents in various decision contexts. Compared to directly asking respondents whether they consider themselves sensitive or insensitive to certain attributes, the preferences that are deduced within a conjoint analysis experiment can be expected to provide a more realistic picture of the actual decision-making process. The main disadvantage of directly asking respondents is connected with the validity issues discussed at the beginning of this sub-section. In reality, a decision-maker usually has to find a balance between positive and negative characteristics of different alternatives, because one generally does not get 'something for nothing'. Contrary to direct asking, conjoint analysis is especially suitable for modelling these kinds of trade-offs, because all relevant attributes are incorporated in the same experiment.

Probably the most fundamental doubts that one can have about conjoint analysis refer to the external validity of stated-preferences: how do they relate to the actual preferences of the respondents? After all, stated-preferences are 'only' expressed in a hypothetical setting. However, this equally goes (or even more so) for any methodology other than the analysis of revealed preferences. Nevertheless, discrete modelling experiences show that stated-preferences perform well when predicting real-life choices [Louviere, 1988]. Other questionable issues with regard to conjoint analysis are connected to the assumptions underlying the decision-making process (especially the combination rule) and several possible biases that could creep into the exercise.

The assumed additive combination rule does not hold once the respondent feels that particular attributes do not meet minimum requirements. It is therefore imperative that the attributes, which are incorporated in the experimental design, reflect an acceptable range of attribute levels. A thorough preparation and setup of the conjoint experiment can prevent many of the possible biases. If for instance non-commitment biases occurred (i.e. if the respondent provides unconstrained and unreliable answers because the subject of the study does not appeal to him or her), it means that the researcher has to redo his homework to make the experiment more realistic. Furthermore, realism in the experiment could be preserved by focusing on specific, rather than general, behaviour and by keeping the exercise simple. This would prevent the occurrence of unconstrained response biases [De Ortúzar and Willumsen, 1994].

Applications of conjoint analysis in logistics research

To show the practical use of conjoint analysis, several examples of conjoint analysis applications in the field of logistics are summarised in Table 5-3. As can be seen, conjoint analysis can be used for various purposes: obtain monetary values of time, estimate the market potential of new or improved modes of transportation, explore the opportunities for modal shift, and the like. The majority of the studies listed concentrate on freight transport decisions. Table 5-3 also reveals that conjoint analysis can be used for a varying number of respondents: from a small sample of ten [NEA, 1994] to large populations of almost 500 respondents [Swait *et al.*, 1994]. The latter research project was the only study reviewed that used postal questionnaires for data collection, while all of the other studies involved personal interviews.

The attributes that were used to build profiles varied with the different goals of the studies. However, the factors transport cost, transit time and reliability seem to form common denominators within almost every conjoint analysis experiment within the context of logistics research. Apparently, these attributes are the most important and salient attributes with regard to logistics choices. The remaining attributes are always chosen in line with the specific research goals.

Operationalisation of conjoint analysis

On the basis of the previous studies, and on the basis of our earlier empirical work, we selected the attributes transport costs, transit time, reliability and frequency of shipments as the most relevant attributes to our analysis. The operationalisation of the attribute levels can only be done after the actual case selection has been executed, as we found that it is crucial that the presented levels are within the range of current experience. Considering this, the selection of attribute levels will be carried out after a preliminary inquiry into the specific characteristics of the research population. Therefore, we will select the attribute levels in the next chapter. The specific experimental designs, as well as the actual showcards or visual aids that are used in the data collection phase, will also be dealt with in that chapter.

As was shown in the above, rating-based conjoint analysis is most appropriate for determining the sensitivity of respondents for certain aspects of the logistics organisation. Therefore, we use a rating task to measure the basic trade-offs the case study companies make in their strategic logistics decisions. The specific strategic decision we aim at is represented by factor C9 (*OEM offering faster, more frequent, more reliable service to his customer*) in the conceptual model, as presented in the previous chapter. This decision is hypothesised to have impacts on lower-level logistics choices such as the level of consolidation and inventory levels.

In order to operationalise the mentioned strategic question, we need to make sure that the experiment is meaningful to the respondent and preferably as close as possible to his or her daily experience. A series of abstract, strategic choice alternatives could cause the already mentioned non-commitment bias in the answers of the respondents. Therefore, we chose to translate this *direct* strategic question into a more *indirect* operational question.

TABLE 5-3 EXAMPLES OF CONJOINT ANALYSIS IN LOGISTICS RESEARCH

Source	Goal of research	Task	Cases	Attributes
Fowkes and Tweddle [1988]	Examine the values placed by freight consignors on various aspects of service of trunk-haul freight movement	Rating	6	Transport costs, transit time, reliability, frequency, number of lifts in transit
Fowkes *et al.* [1989]	Obtain values of the rate reduction necessary to compensate for longer transit times, poorer reliability and the use of intermodal systems	Ranking/ Rating	50	Transport costs, transit time, reliability, use of intermodal systems
NEA and NEI [1990]	Explore opportunities for modal shift and the conditions required	Rating	35	Transport costs, transit time, reliability, probability of damage
HCG [1992]	Obtain monetary values of time gains and losses within setting of domestic Dutch freight transport	Choice	119	Transport costs, transit time, reliability, probability of damage, frequency of delivery
Vieira [1992]	Provide carriers with shippers' sensitivities to changes in different dimensions of service when making mode choice decisions	Choice	158	Transport costs, transit time, reliability, loss and damage, usability of equipment, payment terms, responsiveness to inquiries
NEA [1994]	Estimate market potential of faster, more frequent, more reliable inland waterway systems	Choice	10	Transport costs, transit time, reliability, frequency, flexibility, door-to-door service
Swait *et al.* [1994]	Model freight shippers' choice of carriers using both revealed and stated-preference data	Choice	495	Company name, transport costs, transit time, reliability, pickup, shipment tracing, coverage, refund policy, payment terms
NEI *et al.* [1995]	Deduce the preferences for certain physical distribution structures in the Dutch food industry	Rating (?)	17	Transport costs, reliability, number of DCs, frequency, per cent stock out, time of day for shipment
Bus and Verweij [1997]	Examine the feasibility of a high-speed underground transport system	Rating (?)	25	Transport costs, transit time, reliability

The respondent is asked to imagine himself or herself in a situation in which he or she should choose a logistics service provider (LSP) for a shipment of the typical product to the customer. The respondent is requested to value different abstract-mode profiles that represent a series of different LSPs. Each profile carries different characteristics, including different transport cost, transit time, reliability and frequency of shipments. This indirect way of interviewing the respondent has the advantage that the respondent will be less inclined to introduce a bias into the exercise. If he or she were asked to evaluate profiles that reflected the logistics manager's own performance levels, the respondent could become suspicious and might tend to exaggerate his evaluations. If the profiles display the conditions according to which a third party should perform, a more objective evaluation can be expected. The conditions that the respondents require from their LSPs are therefore used as a proxy for how they believe they should deliver to their customers.

In order to further increase realism in the experiment, we place the stated-preference experiment against the background of the 'typical product', as identified by the respondent in the first part of the interview. This should guarantee that the respondent evaluates the profiles with the actual and usual constraints in the back of his mind.

Futuring methods

The second purpose of the methodology developed in this chapter (see section 5.1) is that it should facilitate a preliminary test of the policy scenarios. Based on the methodology we should be able to explore the future reactions of actual logistics decision-makers with regard to the proposed policy initiatives and determine the degrees of freedom at their disposal. A systematic exploration of how the 'target population' is going to react to proposed policy measures is usually lacking, although such a behavioural test would provide the policy-maker with important information about conceivable unanticipated side effects [Michon, 1989]. The set of policy reactions is often much larger than policy-makers assume, which could undermine the effectiveness of policy measures. Salomon and Mokhtarian [1997] claim (yet in the context of passenger transport policy) that few studies have focused on the range of possible adaptation strategies.

Rausch [1994] defines 'futuring' as the exploration of what *could* happen (i.e. identifying scenarios), while forecasting goes one step further: forecasting is aimed at estimating what will *most probably* happen. The previously discussed conjoint analysis techniques are not appropriate for testing complex responses to policy initiatives, because people react on different dimensions in their activity pattern [Ettema, 1996]. Some techniques that can be used for futuring are summarised in this sub-section.

Formal simulation

Bienstock [1996] reasons that logistics systems lend themselves to investigation using simulation methodology, because these systems:

- Involve networks of 'fixed facilities and connecting linkages'.
- Are characterised by complex and stochastic interrelationships among system components.
- Generate data that are relatively quantifiable.

Formal simulation, i.e. resulting in quantified models, is for example used in the SMILE-model [Tavasszy *et al.*, 1998] and a study by Buck Consultants [1999]. In the latter study two policy scenarios and two market scenarios were developed. The goal of the different scenarios was to determine the effects on the number of vehicle-kilometres and the total transport costs in the logistics chain. Several simplifications had to be made in the setup of the simulation. For example, a virtual network of two retailers and five regional distribution centres was assumed. Lead times and transport costs were also modelled. Not included into the model were for example the possibilities of rail transport.

Despite the place these simulation models have deserved in the field of logistics research, we however do not prefer to translate our conceptual model into a formal simulation model at this point. The reasons for this are basically the same as for not choosing the survey methodology (see section 5.2). In this phase of the research project, we are first and foremost aimed at refining and analysing the hypothesised relations that build the conceptual model. We want to explore the conceivable reactions of the target population to selected policy scenarios. A simulation model requires assumptions about underlying choices, while we insufficiently know what the actual choice options are. In our research, we are primarily interested in obtaining information about these expected choices. Just like statistical testing of the conceptual model, formal simulation would therefore be something for later research efforts.

Stated-adaptation technique

Techniques that are summarised as stated-adaptation methods can also be positioned under the heading 'simulation and gaming'. These approaches may carry characteristics that fit better to our research purposes:

> *Simulation gaming can help bring a rich and varied range of possible specific changes that may occur in an existing or imaginary scenario and explore what repercussions might result.* (...) *In a simulation, the consequences of any relevant idea, no matter how absurd, can be explored* [Rausch, 1994, p.10].

Scenarios are policy analysis tools used in this approach. Scenarios are defined as plausible narrative descriptions of the future that focus their attention on causal processes and decision points [Futures Group, 1994c]. Faivre d'Arcier *et al.* [1998] provide a picture of how they used scenarios in what they call *stated-adaptation surveys* (SA). They developed this technique in the context of passenger travel studies. Stated-adaptation is an interactive technique that allows respondents to show their attitudes and behaviour in hypothetical situations. The SA-technique uses game simulations during in-depth interviews (i.e. for small groups of respondents) in order to determine how individuals would react to policy incentives. During the first part of the interview actual travel data are collected (cf. the direct questions regarding the logistics organisation of a typical product flow). During the second part, these data are used as a point of reference for a simulation game [Faivre d'Arcier *et al.*, 1998]. Subsequently, several scenarios are applied to the actual travel data and activity pattern. This has the advantage that despite the hypothetical character of the questions, constraints in the decision-making process are incorporated as well [Faivre d'Arcier *et al.*, 1998].

The stated-adaptations expressed by the respondents can be made more realistic if the interviewer ascertains that they are feasible, by reflecting on the facts base regarding the actual travel behaviour and activity pattern of the respondent. The respondent's answers must be plausible and compatible with these constraints [Faivre d'Arcier *et al.*, 1998].

Advantages and disadvantages of stated-adaptation technique

The advantages of the stated-adaptation technique are that the interviewer can immediately react to non-responses or wildly implausible responses [Faivre d'Arcier *et al.*, 1998], when the respondent ignores his or her usual constraints. The researcher can then point out to the respondent that such an answer is not allowed in the game, by rephrasing the question as 'what would you do, if it were not allowed to say what you just said?'.

However, there are some serious disadvantages connected to the stated-adaptation technique. Directly asking a respondent what he or she would do under several policy scenarios can be expected to contain several biases. A non-commitment bias occurs if the scenario does not appeal to the respondent, while policy-response biases are introduced into the exercise if the respondent guesses what the underlying goal of the study is, and tries to influence the results of the study [Kroes, 1988].

Non-commitment biases can be controlled by constantly relating the scenarios to actual behaviour. Therefore, just as with the stated-preference exercise, we place the policy scenarios against the background of a shipment for the typical product. When the constraints of actual choice behaviour are incorporated, the results can be expected to be much more reliable than those of a completely unstructured 'what if' survey [Jones *et al.*, 1983].

Policy-response biases are probably the hardest to combat. However, not all scenarios presented are 'apocalyptic' scenarios. Furthermore, the interviewer can play a role in minimising this effect by stressing his status of an independent researcher and by asking questions such as 'why don't you already apply this adaptation to your current logistics organisation?'. But, fair's fair, policy response biases can probably not be eliminated completely from the experiment. This means that we need to be aware of this bias when analysing the results of a stated-adaptation experiment: the stated-adaptation results should therefore be used cautiously.

Applications of stated-adaptation technique in logistics research

Behavioural tests have not been executed in the field of logistics research and policy-making very often. To our knowledge, only Korver and Mulders [1991] and McKinnon and Woodburn [1996] used 'what if' scenarios in the context of logistics policy analysis research. In the former research project, 15 logistics managers of manufacturing and transport companies across different sectors were confronted with a scenario of dramatic congestion delays. McKinnon and Woodburn [1996] examined likely reactions of 88 logistics managers in the British food and drink sector to a sharp increase in the cost of road transport. The managers could answer spontaneously and reveal their adaptation strategies. Responses varied from direct transport changes (e.g. change time of day, change of route, investing in more/larger vehicles, consider alternative modes) to indirect impacts (e.g. pass on cost increases to customers, change level of inventory, change production process, centralise or decentralise inventory, change location of production site).

Operationalisation of stated-adaptation method

The policy scenarios that were deduced in the previous chapter were translated into meaningful scenarios for the respondent (see Appendix F). As we did not want to overload the respondent, we decided to drop the spatial policy scenario, because this scenario was expected to produce the most undesired side effects. This results in four policy scenarios tested by the answers of the respondents.

Respondents are free to show any proposed adaptation, both in the transport decisions and in any other logistically relevant decision area. The stated-adaptation technique is meant to generate a response set that is as broad as possible. The only thing the interviewer requires is that the responses should be plausible within the constraints of current decision-making (i.e. relate the response to a shipment of the typical product). Forcing the respondent to provide answers within pre-defined structures could lead to the over-estimation of the policies' effectiveness.

6

Measuring time-sensitivity in the food industry and parts service industry

In this chapter, we will discuss the results of two case studies. Using the case study protocol developed in the previous chapter, we will present the outcomes of fieldwork in the Dutch *food/beverage/tobacco industry* (further referred to as 'the food industry') and the *parts service industry*. This chapter thereby concentrates on the results of the conjoint analysis experiment. By means of this technique, we will quantify and compare the time-sensitivity of companies within the case study sectors. The remaining case study findings (the refinement of the conceptual model and the transport policy implications) will be discussed in the next chapter.

Before the conjoint analysis results are presented, we will shed light on the selection criteria for the case study industry sectors (section 6.1). Furthermore, we will clarify the selection procedure that was applied to identify the individual case study companies (section 6.2). Subsequently, sections 6.3 and 6.4 provide an introduction into the basic logistics characteristics of the parts services and the food industry.

6.1 SELECTION CRITERIA FOR CASE STUDY SECTORS

The criteria for selecting case study companies have been presented in the previous chapter: increasing time-sensitivity should be a relevant trend, sufficient variation in background variables should be available, and the case study sectors should generate substantial freight transport volume. We will elaborate each of these criteria below.

Increasing time-sensitivity

The business sectors that face increasing time-sensitivity have already been identified in Chapter 3. This identification was based on a literature review and a series of interviews with representatives of logistics service providers. These research activities yielded the following 'short list' of time-sensitive business sectors: pharmaceuticals, consumer electronics, automotive (including spare parts services) and food industry.

We have already performed an exploratory case study in the *pharmaceutical industry* (see Chapter 3). The information added by a repeated case study was considered to be relatively small. A case study of another time-sensitive sector was assumed to provide a more effective contribution to the refinement of the conceptual model. More pragmatic considerations led us to the decision not to select the *consumer electronics industry*: experiences of our own (in a research project in association with KPMG [1998]) had shown that the degree of co-operation among the relatively small number of electronics manufacturers could be problematic due to 'survey-fatigue' in this sector. The *automotive industry* also provides a small population of manufacturers to be approached, since only a very limited number of car and truck manufacturers are located the Netherlands.

The remaining two business sectors are the *food* and *parts services industry*. From the interview series among LSPs (see Chapter 3) we observed that part services form a class of time-sensitive companies *pur sang*. This time-sensitivity is not only confined to parts services in the automotive industry, but also applies to other kinds of after-sales repair and maintenance services. Finally, the time-sensitivity of the food industry is documented in many publications on the emergence of ECR in the Dutch food industry.

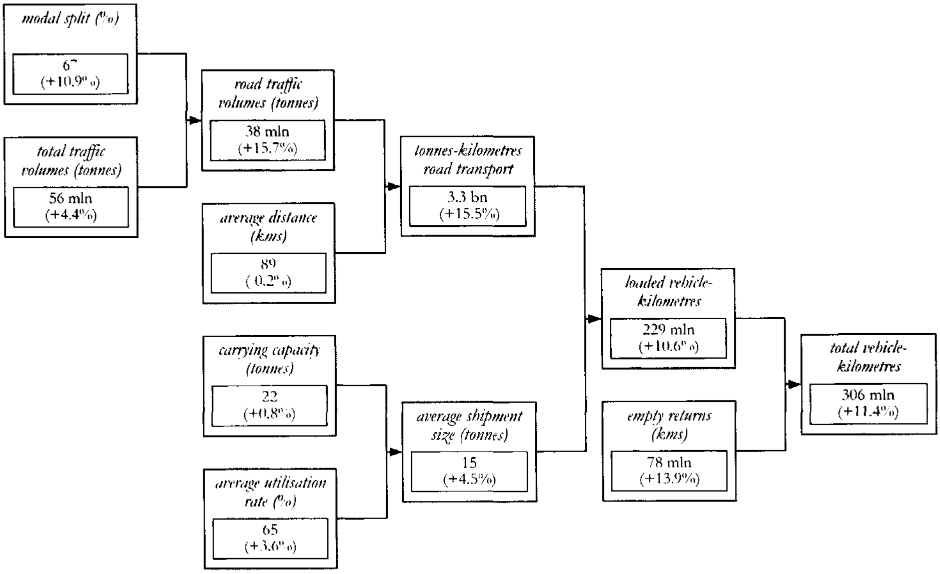
Sufficient variation in background variables

The use of two case study sectors guarantees variation in background variables such as market demands and product characteristics. These variables can be exploited to find explanations for observed differences in logistics choice behaviour. The conjoint analysis results within the food industry acquire additional meaning when they can be contrasted with results from an equal experiment in the parts service industry. Furthermore, policy responses of service companies, as inquired during the stated-adaptation exercise can be viewed as policy responses under the highest degree of time-sensitivity. Thus, results from the parts service industry can be used to evaluate findings of the food industry: the former consisting of companies that have time-sensitivity 'in their genes', the latter representing companies that have learned to be time-sensitive in recent years.

Substantial freight transport volume

Parts services can hardly be traced back in freight transport statistics, because these services partly form a specific class of passenger transport. It is estimated that around seven per cent of all business trips are made for the purpose of after-sales repair and maintenance [Van der Hoorn, 1999]. The freight transport of individual parts is not recorded in detailed statistics. Therefore, the quoted seven per cent only account for the last part of the logistics chain of a typical repair and maintenance trip: the mechanic who is travelling to the location of the defect.

Detailed freight transport statistics for the food industry are available only for the years 1994 to 1996, because statistical definitions used by the CBS changed after this period. Some crucial statistics are not published in the regular CBS publications, but were obtained from the CBS on request. Figure 6-1 provides the same model that was used for decomposing total industry statistics in Chapter 4. Figure 6-1 contains growth figures of third-party freight transport by road between 1994 and 1996 (between brackets), and absolute data for the year 1996.



Source: calculations based on (unpublished) CBS data

FIGURE 6-1 DOMESTIC FREIGHT TRANSPORT BY THIRD-PARTY ROAD CARRIERS IN THE NETHERLANDS, 1994-1996: FOOD SECTOR

The food industry differs from the all-industry average with respect to several points. These deviations include the food industry's relatively high modal split by road (67 versus 59 per cent), the higher average distance (89 versus 77 kilometres) and the slightly better average utilisation rate (65 versus 61 per cent). As compared to the total industrial freight movements presented in Chapter 4, the food industry accounted for 13 per cent of the total domestic freight vehicle-kilometres in 1996, which is ranked among the largest sectoral shares.

6.2 SELECTION OF INDIVIDUAL CASE STUDY COMPANIES

The identification of specific case study companies in the food industry started with a web-search and an exploration of professional journals. Two journals, the *Levensmiddelenkrant* and *Food Personality*, published rankings of food manufacturers within several categories. Every year, the *Levensmiddelenkrant* [1999] grants the 'Golden Partner' award to those manufacturers that are most appreciated by purchasing and category managers of all retail chains. The awarded companies excel in their logistics performance. Likewise, the journal *Food Personality* [1999] identified the so-called 'Captains of the Category', on the basis of judgements of 340 supermarket managers. In the opinion of these managers, the 'captains' are the front-runners with regard to the implementation of ECR. We selected the case study companies on the basis of these two different rankings. Because these companies were listed as front-runners as regards the implementation of ECR, they can be considered to be among the most time-sensitive. Furthermore, we selected companies-in-transition based on leads found in individual articles. The case study companies in the Dutch food industry totalled 33 manufacturers. Additionally, we interviewed a representative of the retailer that introduced ECR to the Netherlands, Albert Heijn.

Contacting food managers

Individual logistics managers of the selected companies were sent a letter, in which we made a request for an interview. In this letter, we also indicated that we would contact the logistics manager by phone within two weeks (see Appendix G). During the phone conversation we referred to the information gained from the literature, and this appeared to be a successful way of communicating. We believe that this approach aroused the managers' interest. Approximately 75 per cent of the selected companies agreed to participate, while the remaining managers either did not have time available or were afraid of giving away commercially confidential information.

In the food industry, we interviewed manufacturers of just about everything you can eat or drink (see Table 6-1). During spring 1999, the 33 food manufacturers were visited. These companies usually were the market leaders within the 14 categories studied. Due to reasons of confidentiality, we will not provide the names of individual companies. Per category we interviewed logistics managers of at least two different companies (numbers between brackets).

TABLE 6-1 DIVERSITY OF CASE STUDY COMPANIES

Food manufacturers (n=33)	Service organisations (n=15)
Beer (3)	Air-conditioning and climate control systems
Biscuits (2)	Automatic postal systems
Bread substitutes/breakfast products (2)	Automatic doors
Canned vegetables and fruit (3)	Bar coding and scanning instruments
Cheese (2)	Cellular phones and digital receivers
Fresh fish, mussels and oysters (2)	Computer operating systems
Long-life dairy products (2)	Electronic point-of-sale systems
Meat products (2)	Industrial pumps
Potato products (2)	Jet vans and heat exchangers
Ready-to-eat meals (3)	Laboratory/medical measurement instruments
Salads (2)	Oil tank gauging instruments
Soft drinks (3)	Professional coffee machines
Sweets/candy products (3)	Professional printers and copiers
Tobacco products (2)	Soft drink vending machines
	Traffic lights systems

Contacting service managers

Within the service industry, we visited 15 firms producing all kinds of products that may require after-sales repair and maintenance (see Table 6-1). The approach in contacting service managers was different due to the kind co-operation of the Dutch Association for Service Management (NVSM). The NVSM had carried out a questionnaire among its members during spring 1999. This questionnaire identified the companies that had experienced severe problems with road congestion in their logistics operations. Twenty companies had indicated that they were prepared to take part in a follow-up interview. These service managers were contacted directly, and all of the 15 managers that were reached before the cut-off date were visited during July and August 1999.

Execution of the interviews

We recorded most of the interviews on tape, and typed out the literal text immediately afterwards on a laptop computer, while impressions were still fresh. Afterwards, the respondents were sent a summary report.

Just as in the food industry, an average interview in the parts service industry took about one hour and 15 minutes (ranging between 45 minutes and 2.5 hours), at times followed by a factory tour. Some interview questions could in some instances not be discussed due to a lack of time, or because the question was not relevant to the respondent. While the direct questions could generally be posed (or asked by phone afterwards), the conjoint analysis and the stated-adaptation experiments could not always be carried out. Ultimately, we collected the following numbers of case study data:

- *Conjoint analysis experiment*: 27 out of 33 (food industry) and 10 out of 15 (parts service industry).
- *Stated-adaptation experiment*: 20 out of 33 (food industry) and 14 out of 15 (parts service industry).

The relatively limited number of food cases where the stated-adaptation experiment could be executed need not be problematic, since Faivre-d'Arcier *et al.* [1998] quote a number of 20 interviews, after which the value-added of each extra case decreases. The main goal of the stated-adaptation experiment was to obtain a broad set of policy responses that is used in the food industry, and for this goal, the number of 20 proved to be sufficient. With regard to the policy responses, incremental learning decreased, as in later interviews we were observing answers seen before.

It should be clear from the above that the sampling strategy we used was not random, but what is called ***judgemental*** or ***theoretical sampling***. The case study companies were deliberately selected because they could contribute to the refinement of our conceptual model; i.e. they would support us in determining the impacts of increasing implementation of time-based strategies. Consequently, results are not representative of the whole food industry, but only of the subset of food manufacturers that engage in time-based business strategies. This subset of companies however forms the larger part of the food industry, since some retailers increasingly demand continuous and reliable logistics services from their suppliers. Moreover, as we shall see, the retailers' demands progressively spill over to the suppliers of the suppliers, causing the wider applicability of time-based concepts in the whole food industry. As will be confirmed by the case study results, the current front-runners with respect to ECR can be expected to continue to shape the logistics landscape of the food industry.

In the next two sections, we will briefly introduce the parts services and food industry, by summarising major business trends and by clarifying the specific causes of time-sensitivity of these two industry sectors.

6.3 INTRODUCING THE PARTS SERVICE INDUSTRY

The parts service 'industry' is not a traditional economic sector, but rather a colourful mixture of firms originating from all kinds of different business sectors. The parts service industry pertains to all firms that provide after-sales repair and maintenance services for industrial systems as well as for consumer products [Fortuin and Martin, 1999]. Whereas after-sales services can range from warranty arrangements, to financial leasing contracts and user training, we will confine the analysis to the service activities that lead to physical transportation of spare parts: repair and maintenance services. Davis and Manrodt [1994] use the term 'service logistics' to describe the management of these service activities.

Revenue-driven sources of haste

Time-sensitivity has appeared in service logistics because of cost- and revenue-driven factors. Loomba [1996] and DeToni *et al.* [1994] assert that after-sales customer service is increasingly becoming *the* order-winning criterion for many firms. Furthermore, it is claimed that responsive and fast after-sales services are profit centres in themselves: they provide the 'icing on the cake' or may even be the 'cake' itself, as in the case of for instance truck dealers.

In a personal interview with a product manager of DAF Trucks, it became clear that DAF's strategy had gradually evolved towards the provision of *total care*-products, meaning that trucks are no longer sold solely by themselves, but rather as complete packages. These packages include after-sales repair contracts, additional technical support, financial arrangements, etcetera. This trend is confirmed by one of the LSPs mentioned in Chapter 3. Large truck manufacturers such as Renault, Mercedes and Iveco are all heading for service contracts which are, to date, only common to the copiers sector. Research within the lift truck industry revealed that 'full-service' contracts have become more popular in this sector as well [Stad, 2000]. In summary, service organisations seek their competitive advantage in offering better and faster services than their competitors, because faster services are believed to generate larger revenues.

Cost-driven sources of haste

Revenue-driven time-sensitivity is closely connected with a form of cost-driven time-sensitivity: full-service contracts are also becoming more popular as a consequence of the huge downtime costs of processes that are dependent on repair activities (e.g. production processes). Most of the mentioned service contracts move towards the principle of *guaranteed functioning*, because customers expect to have the disposal of a functioning product at all times. The downtime costs usually by far exceed the costs of a spare part being delivered by an express carrier. Groot-Beumer [2000] claims that an average failing production process costs 50.000 EUR or more a day. However, as we observed within some service organisations, increasing downtime costs are also a matter of choice by the customers: production plans are deliberately adjusted to maximum capacities (i.e. rely on perfectly functioning primary processes or control systems). The equally deliberate removal of buffer stocks led to situations in which each small disruption instantly results in lost sales, or at best, delayed deliveries. According to the service managers interviewed, this has caused growing impatience and intolerance among customers. This is reflected by the emergence of penalty clauses in service contracts, in case service activities are delayed.

In addition to cost-driven time-sensitivity of customers, cost factors also play a role for the service organisation itself. An intrinsic problem of spare parts is to determine an appropriate inventory policy. Demand for spare parts is often highly unpredictable (as demand data are scarce) and parts are usually relatively expensive [Fortuin and Martin, 1999; Groot-Beumer, 2000]. In other words, inventory costs for spare parts, especially for slow-moving parts, are of concern to any service manager. Standardisation/sharing of common parts and contracting out spare part inventory can contribute to a reduction of inventory costs, but these tactics are not always feasible. Owing to the high costs involved with keeping parts in stock, it is usually not acceptable to compensate uncertainty in demand by increasing stock levels. One of the remaining options is to accelerate the incoming and outgoing delivery process of spare parts. Fortuin and Martin [1999] assert that any uncertainty with respect to the demand process has to be compensated by the flexibility of the delivery process.

All of this has caused the rise of overnight spare parts deliveries throughout Europe, and even speedier services on the national level. An example of the latter is formed by Van Roosmalen [2000] who describes the service performance of a manufacturer of hydraulic tubes: in case of defective tubes, the manufacturer guarantees that a mechanic and the required spare parts will arrive on the spot within one hour. Another typical example of speed is provided by an automatic door manufacturer from our own case study: 85 per cent of the response times are within eight hours, while 30 per cent of defects are repaired within two hours.

Increasingly, the speed and flexibility required are achieved through outsourcing the delivery process to specialised LSPs. The director of the Worldwide Logistics Group, the spare parts business unit of UPS, claims that specialised LSPs are often faster and cheaper than own-account services. Economies of scale and scope are responsible for this [Lijftogt, 2000]. Examples of companies that contracted out the world-wide delivery and warehousing of spare parts are Volkswagen, Compaq (both to TNT) and Philips consumer electronics (DHL).

DHL for example controls 60 different European spare part centres, from which spare parts should be delivered within 2 to 4 hours [Lijftogt, 2000].

In summary, the delivery of service parts can be very time-critical. First, it is claimed that responsive services provide a solid basis for competitiveness (revenue-driven time-sensitivity). Second, speed and reliability of delivery times are of vital importance because of the huge downtime and inventory costs involved (cost-driven time-sensitivity). These dual sources of haste explain the high degree of logistics sophistication within the parts services industry. Logistics performance levels such as one-hour services are unparalleled by most other business sectors. For these reasons, we will use parts services as a *benchmark case study*: a case study that is used as a point of reference reflecting logistics developments under the most extreme circumstances.

6.4 INTRODUCING THE FOOD INDUSTRY

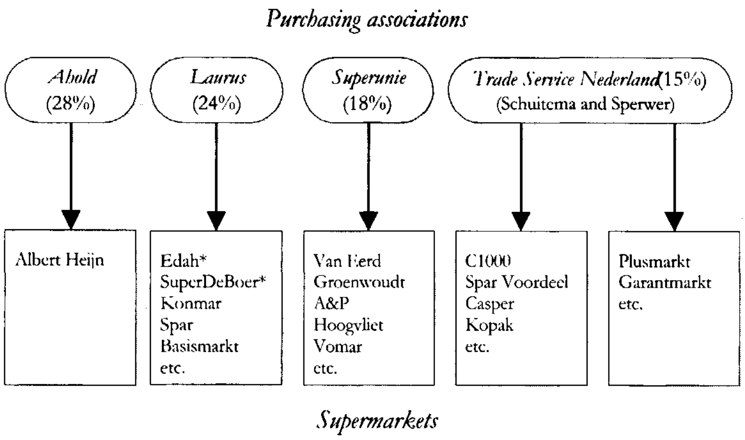
The Dutch food market is a mature but highly competitive market that is dominated by a small number of large retailers. Individual retailers tend to improve their performance at the expense of other retailers' market shares and profitability. This is because the saturated market for food products leaves no room for autonomous growth [Browne and Allen, 1997; NEA, 1996]. The only 'way out' of this dilemma is to search for international expansion or alternative domestic distribution channels (e.g. shops at petrol or railway stations, e-commerce) [Dikstaal, 1999; Logistiek.nl, 1998a]. However, whereas the retail outlets at petrol stations have generally not been profitable [Distrifood, 1999], web-based sales are still in their infancy. E-commerce can moreover be considered as a substitute for conventional distribution channels, rather than a generator of additional growth. That is why retailers have, up to now, mainly relied on improving the performance of their traditional distribution channels, in order to retain competitive power. To accomplish this, retailers and manufacturers have resorted to two basic strategies: cost leadership and differentiation. As we shall clarify below, time-sensitivity is a by-product of both of these strategies.

Cost leadership

One way of reducing costs is by becoming larger in order to cash in on economies of scale. It is not surprising that the traditional mom-and-pop shops are endangered species nowadays, since the sales figures of almost every small supermarket (shops smaller than 400m^2) are declining [Kregting and Joppen, 1999]. In addition to this 'natural' selection process, large retail chains are growing even larger by a seemingly unrelenting process of mergers and take-overs. This concentration trend is usually followed by a drastic rationalisation of the distribution structure [Buck, 1999], which eventually results in lower distribution costs (lower inventory levels and bulk shipments to regional DCs) [Browne and Allen, 1997]. For example, Laurus (one of the large Dutch retailing conglomerates) announced that it will close 10 of its 15 distribution centres in the next two years [Nieuwsblad Transport, 2000] along with the transformation of Edah and Super-De Boer into Konmar supermarkets, in order to reduce costs.

Mergers and take-overs

By the end of the 1990s, there were four large Dutch purchasing associations that jointly controlled between 80 and 90 per cent of all retail sales (see Figure 6-2): Ahold, Laurus, Superunie and TSN. The remaining market share is made up by independent stores and discount chains such as Aldi [Buck, 1999; Retailplanner, 1999]. This high degree of concentration has come into existence in the last few years: for example, in 1998 De Boer-Unigro merged with Vendex Food to form the conglomerate *Laurus*. *TSN* (owned by Schuitema) is the combined buyers' association for Schuitema and Sperwer, serving supermarkets such as C1000 and the Plusmarkt. Recently, *Schuitema* en *Sperwer* unfolded their plans to merge [Logistiek.nl, 2000]. The extent to which the Dutch retailing business is concentrated is further illustrated by the fact that *Ahold*, the holding company of Albert Heijn, is the main shareholder of Schuitema.



* will be changed into Konmar [Nieuwsblad Transport, 2000].

Source: Retailplanner [1999]

FIGURE 6-2 THE CONCENTRATED DUTCH RETAIL SECTOR IN 1999 (% MARKET SHARE)

The concentration among the retailers has also changed the balance of power between retailers and manufacturers. NEA [1996] observes a struggle for control over the supply chain between manufacturers and large retailers, resulting in a victory for the retailers: there has been a shift from a supplier-controlled to a retailer-controlled distribution network [Browne and Allen, 1997]. Instead of relying on direct store deliveries by manufacturers, retailers have set up their own network of regional DCs (RDCs) through which they channel their supplies to the individual stores [Fernie, 1992; NEA, 1996]. The secondary distribution from the RDCs to the stores is usually completely controlled by the retailers. Likewise, retailers have extended their power to govern the primary distribution of food products from manufacturer to national or regional retailer's DCs.

Cost-driven sources of haste

This shift of negotiating power had major implications for the logistics organisation of the primary and secondary distribution processes. The setup of a network of composite RDCs enabled retailers to provide stores with daily deliveries: different product groups are channelled through the same DC and delivered on the same (multi-compartment) vehicle [NEA, 1996]. Moreover, lead times were progressively reduced below 24 hours for most of the company's product range [Fernie, 1994]. Additionally, retailers started demanding a higher service level of their suppliers. In order to reduce their own stock levels, retailers increasingly required faster and more frequent deliveries (continuous replenishment). The manufacturers, being dependent on an ever-smaller group of clients, were generally left with no other option but to comply with these demands. In conclusion, we observe that cost-driven time-sensitivity appears in the food industry from the moment that retailers pursue (inventory) cost reductions.

Differentiation

In addition to striving for cost leadership, retailers can try to capture a market share as large as possible by implementing a differentiation strategy. This strategy is for example aimed at offering exactly those products the customers want, providing the freshest food products, or having an extensive range of products in store. The main target for these 'full-service' supermarkets will be to minimise the number of out-of-stocks, while at the same time controlling inventory costs.

Revenue-driven sources of haste

In pursuit of differential competitive advantage, supermarkets and manufacturers introduce countless numbers of 'new' products to the supermarket shelves every year. Despite the fact that no less than 80 per cent of all product introductions are a downright flop [Food Trends, 1999; Logistiek.nl, 1998b; Logistiek.nl, 1998c], this results in an increase of stock-keeping units (SKUs). Additional efforts to reduce inventory levels are a logical consequence. Moreover, reduced shelf space per product automatically means that stores need to be replenished more often. In this way, each product progressively becomes a fast-mover, causing a need for increased frequencies in secondary distribution. For this reason, Buck Consultants [1999] estimate that especially the 'full-service' supermarkets will raise the frequency of store deliveries to two or three times a day in the next few years.

Order cycle times and frequencies have developed towards a highly sophisticated level in the Dutch food industry. For example, it appeared that Albert Heijn (one of the early adopters of Efficient Consumer Response in the Netherlands) progresses towards establishing the same 'heartbeat' for almost every product sold. This means that, no matter the characteristics of the products, delivery frequency and order cycle times are equalised across the whole range of products. Ideally, peanut butter is transported in the same frequency and lead time as for instance frozen potatoes (using multi-temperature vehicles or boxes). Figure 6-3 summarises the average order cycle times for Albert Heijn.

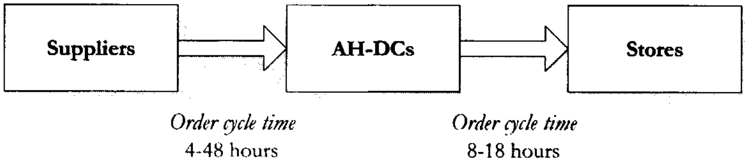


FIGURE 6-3 ECR IN PRACTICE: THE CASE OF ALBERT HEIJN

This revenue-driven form of time-sensitivity can be observed in the mentioned 'full-service' supermarkets, and is exemplified by the emergence of ECR. These companies potentially benefit the most from the implementation of ECR: finding the balance between minimum out-of-stocks and minimum inventory levels [Reichart, 1998].

6.5 QUANTIFYING TIME-SENSITIVITY: SETUP OF EXPERIMENT

Before we start describing the logistics impacts of increasing time-sensitivity in the next chapter, we will first determine just how time-sensitive the case study companies are. As was discussed in the previous chapter, the various aspects of time (transit time, reliability and frequency) are measured through the method of conjoint analysis. In this section we will discuss the operationalisation of this experiment.

Operationalisation of conjoint analysis experiment

In the previous chapter we discussed the backgrounds of conjoint analysis at full length. At the end of this discussion, we decided to formulate the conjoint analysis experiment as a hypothetical choice for a logistics service provider: the respondents are asked to evaluate different abstract-mode alternatives for a shipment of their typical product. On the basis of the stated-preference research of others (see previous chapter) and our own interviews with LSPs, we identified four attributes that are incorporated in the experiment:

- Transport costs.
- Reliability (per cent of shipments on time).
- Door-to-door transit time.
- Frequency (number of shipments per week).

For example, Vieira [1992] revealed that transit time and reliability are among the most sensitive dimensions of logistics service (e.g. compared to loss and damage, payment terms). Additionally, relevant attribute *levels* needed to be determined. First, the number of attribute levels was set at three for each attribute. Measuring three levels enables the evaluation of possible non-linear effects, and also reduces the number of profiles to be evaluated. All attributes were presented with three attribute levels, in order to avoid the possible *number-of-attribute-levels* effect mentioned in the previous chapter. Second, the attribute levels should be within a reasonable range in the opinion of the respondents. Since absolute levels for transport costs, door-to-door transit time and frequency could vary strongly among the different case study companies, we decided to formulate relative attribute levels for these attributes. For the attribute 'reliability' we used absolute figures. Based on the empirical research of AT Kearney [1993] and after two exploratory conversations with food managers, we decided to include three levels of reliability. The attribute levels were defined as follows:

- *Door-to-door transport costs*: 25 per cent lower, same level as current shipments, 25 per cent higher.
- *Door-to-door transit time*: 25 per cent shorter, same level as current shipments, 25 per cent longer.
- *Frequency*: halved, same level as current shipments, doubled frequency.
- *Reliability*: 90, 95 and 100 per cent on time.

The levels of 25 per cent higher and lower were expected to be within the range of acceptable variation: the range of attribute levels was chosen roughly as an average of attribute levels used in the previously discussed stated-preference research projects.

Main-effects design

The attribute levels of the four attributes were systematically combined to form so-called profiles. We used a standard statistical main-effects design that still guarantees orthogonality, while reducing the number of profiles to a minimum [Steenkamp, 1985]. It should be noted however, that the main-effects design assumes that no interaction effects exist: certain combinations of attribute levels are not valued disproportionately high or low by the respondents, but respondents assess the different alternatives in a strictly additive way. For example, if a certain profile combined 100 per cent reliability with a cost reduction of 25 per cent, the respondent's evaluation is assumed to be the simple sum of the part-worth utilities of 100 per cent reliability and –25 per cent costs (and not some product of these part-worth utilities).

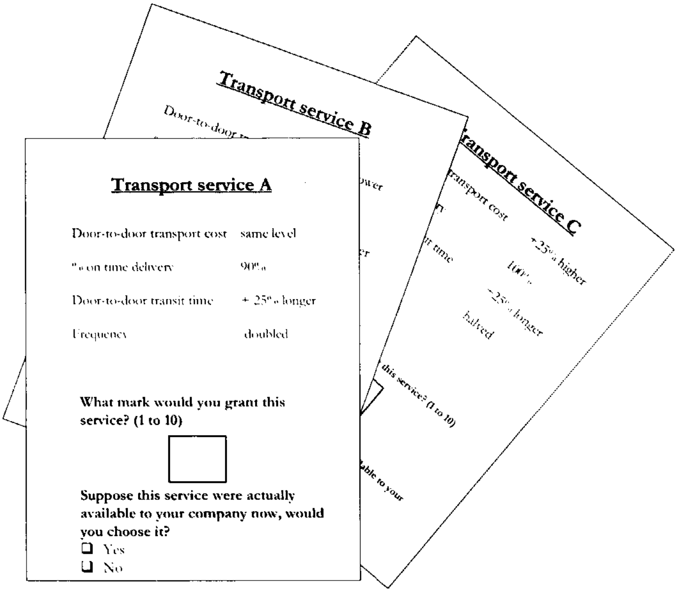
In this design, each attribute level is coded 0, 1 or 2. For example, the attribute 'transit time -25% shorter' is coded '0', 'same transit time' is coded as '1' and '+25% longer transit time' is reflected by the code '2'. The remaining attribute levels are coded accordingly (see Table 6-2).

TABLE 6-2 MAIN-EFFECTS DESIGN

Profile	Statistical design	Transit time	Frequency	Transport costs	Reliability
A	2 2 1 0	+25%	doubled	same	90%
B	2 1 0 1	+25%	same	-25%	95%
C	2 0 2 2	+25%	halved	+25%	100%
D	1 2 0 2	same	doubled	-25%	100%
E	1 1 2 0	same	same	+25%	90%
F	1 0 1 1	same	halved	same	95%
G	0 2 2 1	-25%	doubled	+25%	95%
H	0 1 1 2	-25%	same	same	100%
I	0 0 0 0	-25%	halved	-25%	90%

As can be seen from Table 6-2, the statistical design for four attributes with three levels each, yields nine profiles to be evaluated. Note also that each attribute level appears three times in the statistical design, and that the attribute levels vary systematically. We deliberately called the profiles 'A', 'B', 'C', etcetera, because numerical labels could mislead or influence respondents.

The above statistical design was transformed into nine showcards that could be used as visual aids during the interviews. Examples of these showcards are displayed in Figure 6-4.



Transport service A

Door-to-door transport cost	same level
% on time delivery	90%
Door-to-door transit time	+ 25% longer
Frequency	doubled

What mark would you grant this service? (1 to 10)

☐

Suppose this service were actually available to your company now, would you choose it?
☐ Yes
☐ No

FIGURE 6-4 **EXAMPLES OF SHOWCARDS**

Adjustment of attributes for parts services industry

We made two adaptations with regard to the conjoint analysis experiment in the parts service industry. First, whereas the attribute 'frequency' is relevant to food managers (i.e. regular shipments are common in the food industry), it is not a relevant logistics performance variable for service managers. Parts shipments to customers are not executed regularly, but on an irregular basis. Therefore, we had to change this attribute to make the experiment more meaningful to the service managers. Whereas 'frequency' can be seen as a measure for flexibility of food manufacturers, flexibility for service organisations is measured by the time that is needed in case of emergency repairs. Phone conversations with two service managers, who were not involved with the selected case study companies, confirmed that their logistics performance is usually measured in terms of time needed for preventive maintenance and corrective maintenance (i.e. emergency repair). We therefore replaced 'frequency' for 'transit time in case of emergencies' in the stated-preference experiment for service managers. The attribute 'door-to-door transit time' was rephrased as 'transit time in case of preventive maintenance'. The same attribute levels as for transit time in the food industry were used (-25%, same level and +25%), whereas the attributes 'costs' and 'reliability' remained unaltered.

Second, we slightly modified the introduction to the conjoint analysis experiment. We presented the different profiles not as hypothetical transport services of different LSPs (which would not have been relevant to service managers), but as potential 'service packages' offered by third-party service organisations.

Data collection experiences

As was described in the previous chapter, we incorporated the conjoint analysis experiment in the case study protocol. During the interviews, we first gained insight into the basic logistics characteristics of the particular company and subsequently moved on towards the stated-preference experiment. We explained the showcards and invited the respondents to examine and evaluate each alternative. While the respondents were assessing the alternatives, we asked the respondents to think aloud. The experiment itself usually induced a lively discussion about the basic performance requirements of the manager's own logistics organisation.

The respondents generally took the experiment quite seriously: the whole evaluation and discussion usually lasted for 10 to 20 minutes. Some respondents really seemed to enjoy the experiment and invested a great deal of effort into making the trade-offs between the various alternatives. Most respondents interpreted it as an evaluation process similar to actual multi-criteria rating procedures, used to select LSPs. Generally speaking, the respondents agreed with the chosen attributes as important evaluation criteria. During the additional discussions, respondents had the opportunity to mention other important factors that were left out in the experiment. We will incorporate the results of these discussions in the following chapter.

Two respondents out of 39 had serious objections to the presented attributes or attribute levels. These respondents could not identify with the hypothetical alternatives. The first of these respondents claimed that a reduced transit time of minus 25 per cent was simply impossible. This logistics manager could not be persuaded to imagine a hypothetical LSP offering shorter transit times of that order of magnitude. The second logistics manager found the performance measures cost, reliability and transit time as such, irrelevant. He asserted that these attributes are merely dependent variables: the main criterion that he would use to select an LSP would be the quality and density of the LSP's network of clients. If an LSP met these requirements, competitive costs and reliability levels would then automatically follow. For these two respondents, we could not perform the conjoint analysis.

Estimation procedure

Within the food industry, 27 respondents rated the alternatives, whereas 10 service managers did the same in the parts service industry. In order to estimate part-worth utilities from these ratings, we transformed the statistical main-effects design into a so-called analysis design. We used effect coding for this purpose: the estimated parameters reflect part-worth utilities defined as deviations from the average rating (constant term).

The codes '0', '1' and '2' from the statistical design are nothing more than nominal variables. In order to be able to apply ordinary-least-squares (OLS) regression, each of these codes is re-coded into two codes:

- 0 = 1 0
- 1 = 0 1
- 2 = -1 -1

This results in the following standard analysis design (see Table 6-3).

TABLE 6-3 EXAMPLE OF ANALYSIS DESIGN

Respon- dent	Profile	Rating*	Statistical design	Transit time	Frequency	Transport cost	Relia- bility
01	A	4	2 2 1 0	-1 -1	-1 -1	0 1	1 0
01	B	8	2 1 0 1	-1 -1	0 1	1 0	0 1
01	C	4	2 0 2 2	-1 -1	1 0	-1 -1	-1 -1
01	D	10	1 2 0 2	0 1	-1 -1	1 0	-1 -1
01	E	4	1 1 2 0	0 1	0 1	-1 -1	1 0
01	F	4	1 0 1 1	0 1	1 0	0 1	0 1
01	G	8	0 2 2 1	1 0	-1 -1	-1 -1	0 1
01	H	10	0 1 1 2	1 0	0 1	0 1	-1 -1
01	I	4	0 0 0 0	1 0	1 0	1 0	1 0
02	A	5	2 2 1 0	-1 -1	-1 -1	0 1	1 0
02	B	6	2 1 0 1	-1 -1	0 1	1 0	0 1
etc.	...	...	...	...	...	...	...

* example data.

These effect coding schemes are commonly used in conjoint analysis research. Alternative coding schemes result in other estimated parameters, but in the end produce the same part-worth utilities. OLS regression techniques can be applied to this analysis design to estimate the parameters belonging to each attribute level. The nine ratings per respondent are used as the dependent variables, and the coded attribute levels as independent variables.

Let us take the attribute of 'transit time' to illustrate the implications of the above. Three attribute levels represent the attribute transit time: -25 per cent, same as current and +25 per cent. Using the analysis design of Table 6-3 and applying OLS regression, we are able to estimate the parameters and part-worth utilities belonging to the first and the second attribute level: β_1 and β_2. Multiplying the parameters with the codes, we can calculate the part-worth utility for the third attribute level as well (see Table 6-4).

TABLE 6-4 EFFECT CODING FOR THREE ATTRIBUTE LEVELS

Attribute: ***transit time***	**Effect**	**Coding**	**Computed part-worth utilities**
-25% shorter	1	0	$\beta_1{*}1 + \beta_2{*}0 = \beta_1$
same	0	1	$\beta_1{*}0 + \beta_2{*}1 = \beta_2$
+25% longer	-1	-1	$\beta_1{*}{-1} + \beta_2{*}{-1} = -(\beta_1 + \beta_2)$
	▼	▼	
Estimated parameters	β_1	β_2	$\Sigma = 0$

It should be noted that, when effect coding is used, the different part-worth utilities add up to zero by definition. The estimated parameters β_1 and β_2 equal the part-worth utilities belonging to the first and second attribute level. The part-worth utility belonging to the third attribute level is a function of the already estimated parameters, namely $-(\beta_1 + \beta_2)$.

6.6 ESTIMATION RESULTS: FOOD INDUSTRY

Conjoint analysis models that are based on rating data can be estimated on the aggregate and individual level. By taking the average of the individually estimated utility functions, one obtains the aggregate or overall model. In this section, we will investigate aggregate and individual models for the food industry. We will start by discussing the aggregate model for the food industry.

Aggregate utility function for the food industry

The overall goodness-of-fit of the model is reflected by a relatively high R^2 of 0.66 (see bottom of Table 6-5), which means that there is relatively little variation in the preferences among the 27 respondents in the food industry. In other words, the aggregate model performs well in predicting individual part-worth utilities.

TABLE 6-5 MODEL ESTIMATIONS FOR THE FOOD INDUSTRY

Estimated parameter	Average part-worth utility	*t*-value*	Relative importance
-25% transit time	0.32	2.67**	9.2%
same transit time	0.11	0.93	
+25% transit time	-0.43		
halved frequency	-1.31	-10.89**	28.5%
same frequency	0.29	2.42**	
doubled frequency	1.02		
-25% transport costs	1.19	9.92**	31.1%
same transport costs	0.15	1.29	
+25% transport costs	-1.35		
90% reliability	-1.23	-10.23**	31.2%
95% reliability	-0.09	-0.77	
100% reliability	1.32		
Regression intercept (average rating)	5.58	65.69**	
overall R²	0.66		
n = 27			

* (*l*-1) parameters are estimated for *l* attribute levels; i.e. only (*l*–1) *t*-values are provided.
** significant at the 0.05 level.

The value of 0.32 (at the top of Table 6-5) involves the isolated effect of a transit time that is 25 per cent shorter than the current transit time. The value of 0.32 signifies that, compared to the average rating on a ten-point scale (5.58), respondents positively valued a shorter transit time. At the same time, respondents gave negative marks to alternatives with a longer transit time (-0.43).

The absolute difference between 0.32 and –0.43 is 0.75 points. This means that, with all other attributes being equal, a shorter transit time (-25 per cent) is valued 0.75 points higher than a longer transit time (+25 per cent) on the ten-point scale. This range of part-worth utilities also gives an indication of the *relative importance* of the attribute involved. In the following, we will also refer to this range of values as 'delta'. The relative importance of each attribute can now be calculated as the delta of the particular attribute, divided by the sum of all deltas (see last row in Table 6-5).

As can be deduced from Table 6-5, transit time as such is the least important criterion (9.2 per cent of the sum of the deltas). Other time aspects such as frequency and reliability are of more importance: 28.5 versus 31.2 per cent. Costs are equally important on the aggregate level, with 31.1 per cent.

A *t*-test is further executed to determine whether the estimated part-worth utilities significantly contribute to the overall preferences. All first attribute levels (–25% transit time, halved frequency etcetera) are significant at the 0.05 level. This also goes for the attribute level of 'same frequency' but not for the remaining second attribute levels: same transit time, same transport costs and 95% reliability. These latter attribute levels do not significantly differ from zero: their contribution to the average rating can be considered nil. In the following sub-sections, we will show that this also means that for these attributes a linear relationship exists between the attribute level and the utility value.

Individual utility functions for the food industry

Although the variation in part-worth utilities is relatively small, there are observable differences on the individual level. For this reason, we summarised the different utility functions in a series of graphs (see Figure 6-5 to Figure 6-8). The first attribute that we examine involves the effects of different transit times. The grey lines represent the individual part-worth utilities of each respondent, while the black line depicts the average preference, or the aggregate model.

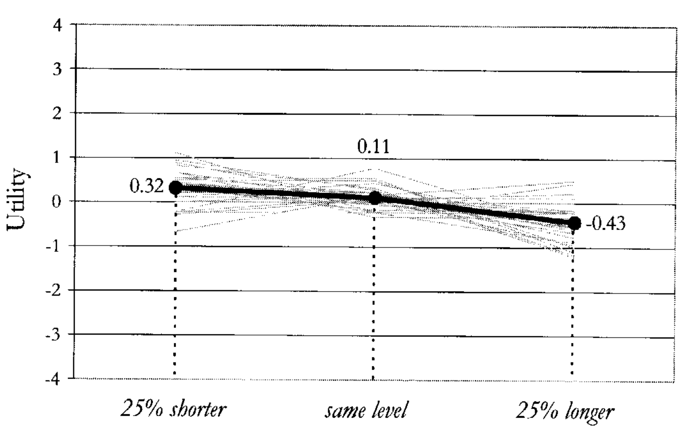


FIGURE 6-5 **EFFECT OF TRANSIT TIME: FOOD INDUSTRY**

The relatively flat course of the graphs means that food managers are relatively insensitive to transit time improvements. The part-worth utilities for the attribute transit time show a plausible direction: shorter transit times are generally perceived better compared to longer transit times. However, as some of the grey lines show, some respondents regard the transit time as is currently achieved as the optimum level: shorter transit times are valued lower than the 'same level'. In a few cases, respondents even preferred longer transit times. This reflects the opinion held by some respondents, that a further acceleration of logistics processes is not desired, because this triggers 'a race with no finish line'.

The black line in Figure 6-5 (average utility function) is almost a straight line. We also observed in Table 6-5 that the utility value of the second attribute level (0.11; part-worth utility of same transit time) does not significantly differ from zero. This means that the slight bend in the average utility function is not significant, and that that a linear relationship can be assumed for transit time. As we saw, this also goes for the cost and reliability utility functions.

The frequency of shipments is a more important time attribute in the eyes of the food managers than the absolute transit time (Figure 6-6). As we deduce from the larger range of part-worth utilities (28.5 per cent), most respondents attach more importance to frequency of shipments than to the transit time. Almost all respondents preferred higher or at least the same frequency, as the respondents strongly believed that their most important clients, the retailers, would require this. If the frequency were halved, this would lead to a strong negative evaluation of −1.31 utility points. Moreover, a doubled frequency receives a positive assessment of +1.02 points. The bend in the aggregate curve is found to be significant: an LSP that sticks to the current frequency of shipments is valued with +0.29 points on average.

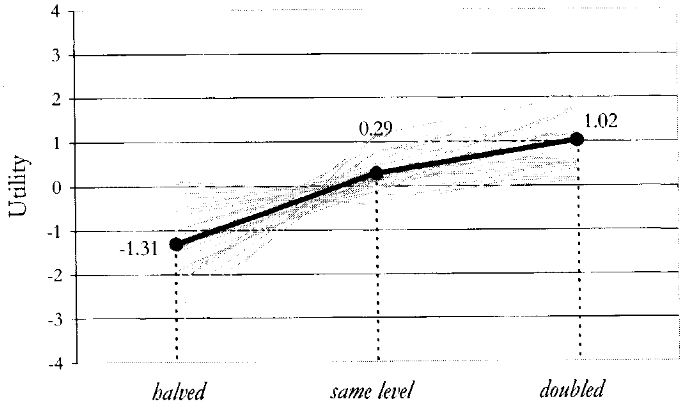


FIGURE 6-6 **EFFECT OF FREQUENCY: FOOD INDUSTRY**

The effect of higher door-to-door costs is predictable: higher costs are unwished-for, while lower costs are obviously strongly welcomed (see Figure 6-7). The range of part-worth utilities (delta) for costs is calculated at 31.1 per cent of all delta values, which indicates that costs are slightly more important than shipment frequencies. Some respondents would even subtract close to three points of the alternative, if costs rose by 25 per cent. Respondents are indifferent to unchanged cost levels: if an LSP offered the same cost level as is currently attained, the utility level hardly exceeds zero. The part-worth utility of the middle attribute level is found not to deviate from zero significantly.

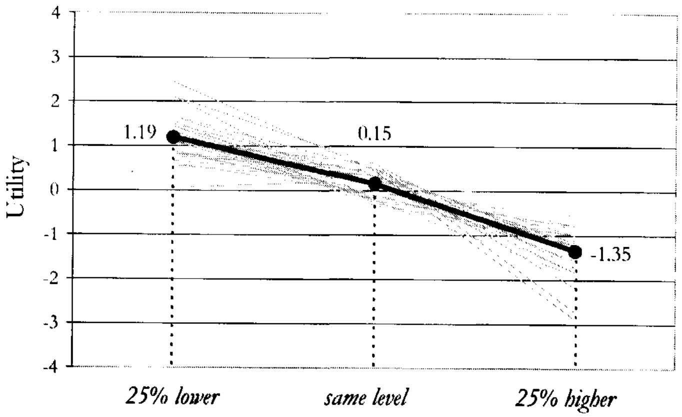


FIGURE 6-7 EFFECT OF TRANSPORT COSTS: FOOD INDUSTRY

Reliability is the most important feature in the logistics of the food industry, as is reflected by the relatively high delta of 31.2 per cent. A reliability level of 90 per cent is clearly very negative in the current practice of the food industry: -1.23 utility points on average. At the same time, 100 per cent of shipments arriving on time is an ideal situation that could contribute up to 3.5 points to the average rating. There are however also respondents who are less enthusiastic about a performance level of 100 per cent, since some of the respondents valued 100 per cent reliability barely higher than zero.

Comparison of estimation results with results of other research projects

In the previous, we used the range of observed part-worth utilities (delta) as a proxy for the relative importance of each attribute (the more important attributes display a larger range of utility values). This measure however only provides a rough indication. An alternative way of determining the relative importance of each attribute is to compute so-called trade-off ratios. HCG [1992] and Fowkes *et al.* [1989] for example expressed the utility of all attributes in terms of transport costs, and thereby calculated the value-of-time, the value-of-reliability etcetera. We will do the same for our attributes, in order to be able to compare our attribute coefficients with the ones of HCG and Fowkes. The trade-off ratios are determined in two steps.

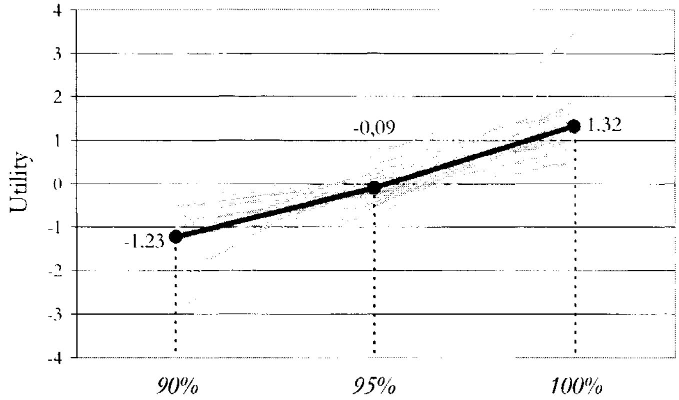


FIGURE 6-8 EFFECT OF RELIABILITY: FOOD INDUSTRY

First, based on the aggregated estimations in the food industry, we use the gradient of the aggregate utility functions to compute the change of utility caused by a one-per cent change in each attribute level. In so doing, we calculated that a change of the 'transit time' by one per cent causes a change in the utility value by 0.015 points. Because the middle attribute level (same transit time) did not significantly deviate from zero, we assumed a linear relationship and interpolated a straight line between a transit time of –25 per cent and +25 per cent. A linear relationship can be assumed for the attributes 'reliability' and 'transport costs' for the same reason. However, since we found that the middle attribute level of 'frequency' significantly differed from zero, we used two different gradients for the range between 'halved' to 'same' frequency, and the range between 'same' to 'doubled' frequency. The complete results of the first step are displayed in Table 6-6.

Second, each gradient in Table 6-6 is divided by 0.051 (the cost gradient). This results in a series of trade-off ratios for the Dutch food industry (see second row in Table 6-7). The ratios deduced from HCG and Fowkes are also displayed to allow comparison.

TABLE 6-6 GRADIENTS OF AGGREGATE UTILITY FUNCTIONS

Attribute	**Transit time**	**Frequency**	**Frequency**	**Reliability**	**Transport costs**
Range of attribute to which gradient applies to	*'-25%' to '+25%'*	*'halved' to 'same'*	*'same' to 'doubled'*	*'90%' to '100%'*	*'-25%' to '+25%'*
Utility change caused by 1% change in attribute level	0.015	0.032	0.007	0.255	0.051

TABLE 6-7 COMPARISON OF TRADE-OFF RATIOS

Group of respondents	**Transit time**	**Frequency**	**Reliability**	**Transport costs**
Firms in the Dutch food industry (14 different product groups)	**0.30**	**0.14*** to **0.63****	**5.02**	**1.00**
Dutch manufacturers of perishable consumer products [HCG, 1992]	0.93	0.16	0.47	1.00
Dutch manufacturers of durable consumer products [HCG, 1992]	0.83	N.A.	0.64	1.00
Firms in the British beer brewing industry [Fowkes *et al.*, 1989]	0.88	N.A.	5.00	1.00
Firms in the British chocolate and sugar confectionery industry [Fowkes *et al.*, 1989]	0.21*** to 0.39****	0.02*** to 0.29****	0.40*** to 5.00****	1.00

* pertains to the range of 'same' to 'doubled frequency'.
** pertains to the range of 'halved' to 'same frequency'.
*** ratio pertains to sub-group of small firms.
**** ratio pertains to sub-group of large firms.

The first figure of 0.30 for instance shows that the average logistics manager in the Dutch food industry is indifferent between a change of the transit time by one per cent and a change of the transport costs by 0.30 per cent. The most remarkable result is that, when measured in terms of costs, reliability appears much more important than was suggested before. For every additional per cent reliability improvement (anywhere between 90 and 100 per cent), the average logistics manager in the Dutch food industry is prepared to pay five per cent higher transport costs. When ranked according to this cost ratio, reliability clearly becomes the most important attribute in the Dutch food industry, followed by transport costs. Transit time and frequency share the third position.

The trade-off ratios for transit time and reliability that we encountered in the Dutch food industry especially match the results of Fowkes *et al.* [1989] shown in the last row. The trade-off ratio for frequency, particularly for the range of 'halved' to 'same frequency', is however higher than the ratio calculated by Fowkes. It appears that the Dutch food manufacturers considered frequency more important than their British counterparts.

Larger differences occur when we compare our ratios with the HCG-study. The differences in the trade-off ratios can mainly be explained by the *differences in the background characteristics of the respondents*; the sample of respondents in the HCG-study contains a larger variety of manufacturing firms than our sample and Fowkes' sample of food manufacturers. Therefore, differences in trade-off ratios can partly be explained by different sectoral origins. A second explanation for deviations in trade-off ratios is provided by *differences in absolute starting positions*: most of the experimental attribute levels were expressed in terms of relative changes (percentage change compared to current level). Problems of comparability may arise when the absolute starting levels differ strongly within and between the samples. However, we found that the current attribute levels do not vary strongly within the Dutch food industry. Moreover, we encountered similar absolute levels in Fowkes' study of the British food industry (though ten years earlier), which rules out this possible source of variation. However, data on starting positions are not described in the HCG-study.

6.7 ESTIMATION RESULTS: PARTS SERVICE INDUSTRY

Aggregate utility function for the parts service industry

Aggregate and individual models were estimated in the service industry in the same way as in the food industry. The estimation results are shown in Table 6-8.

As is explained in the above, we used a substitute attribute for frequency: transit time in case of corrective maintenance. The other attributes are the same as in the food industry. The number of cases (n=10) is smaller than in the food industry, but part-worth utilities vary stronger in the parts service industry: the R^2 of 0.48 reflects that individual part-worth utilities can be predicted less precisely by the aggregate model, due to stronger variations in preferences. This is undoubtedly connected to the more diversified nature of the parts service industry. Whereas food manufacturers basically deliver their goods to the same group of clients, the few Dutch retailer conglomerates, the case study companies in the service industry all serve different clients with different requirements.

TABLE 6-8 MODEL ESTIMATIONS FOR THE PARTS SERVICE INDUSTRY

Estimated parameter	**Average part-worth utility**	***t*-value***	**Relative importance**
-25% transit time (preventive)	0.34	1.16	16.9%
same transit time (preventive)	0.53	1.77	
+25% transit time (preventive)	-0.87		
-25% transit time (corrective)	0.54	1.83	20.5%
same transit time (corrective)	0.58	1.94	
+25% transit time (corrective)	-1.12		
-25% transport costs	1.21	4.06**	33.3%
same transport costs	0.34	1.16	
+25% transport costs	-1.56		
90% reliability	-1.31	-4.38**	29.3%
95% reliability	0.18	0.60	
100% reliability	1.13		
regression intercept (average rating)	5.56	26.36**	
overall R²	0.48		
n = 10			

* (*l*-1) parameters are estimated for *l* attribute levels; i.e. only (*l*–1) *t*-values are provided.
** significant at the 0.05 level.

Reliability and transport costs appear to be roughly just as important as in the food industry, the absolute transit time seems to be more important, while the average rating is practically the same. We will test differences in part-worth utilities between the food and parts service industry in the following section.

Individual utility functions for the parts service industry

Figure 6-9 displays the utility function for transit time in case of preventive, or planned, maintenance. The part-worth utilities show a high degree of variation. One respondent had a rather peculiar preference structure: in his opinion transit times should remain as they are right now, and every deviation from the current state was given a very negative evaluation. This respondent caused a large proportion of the variation in the part-worth utilities, that is, if we removed this respondent from the model estimation, the goodness-of-fit measure R^2 would climb up to 0.55 (instead of 0.48). However, since it is perfectly acceptable to have a dissenting opinion, we see no reason for a removal.

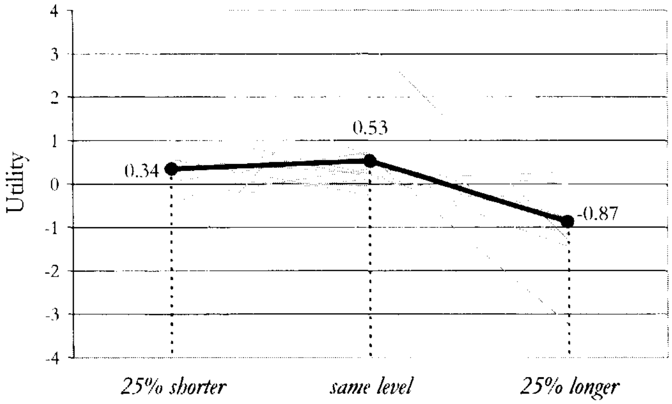


FIGURE 6-9 **EFFECT OF 'PREVENTIVE' TRANSIT TIME: PARTS SERVICE INDUSTRY**

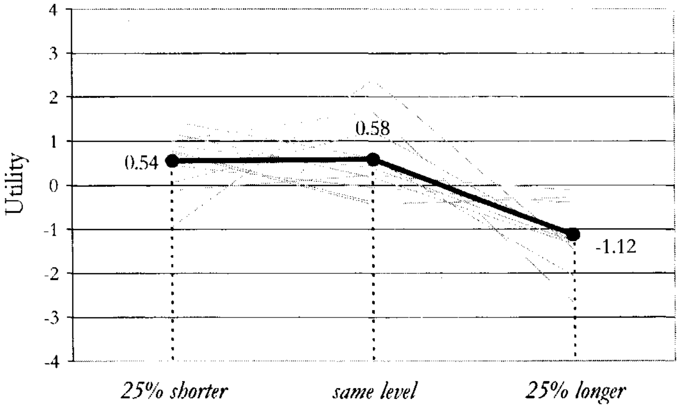


FIGURE 6-10 **EFFECT OF 'CORRECTIVE' TRANSIT TIME: PARTS SERVICE INDUSTRY**

Approximately the same phenomena can be observed for the transit times involved with corrective or emergency maintenance (see Figure 6-10). On average, we discern a trend in both graphs: faster services are not appreciated, or at least do not contribute to a better evaluation of the alternatives. Some respondents are even unfavourably disposed towards faster service performances. Apparently, service speed is already on a very high level in this industry, and further acceleration is not desired by most of the respondents. The optimum therefore lies at the current level of transit times, whereas slower services are still a *faux pas* in this industry.

The contribution of changes in transport costs is illustrated by Figure 6-11. A large degree of variation can be observed on the disaggregate level. Two respondents are almost entirely indifferent as regards the cost level (as shown by the two horizontal lines parallel to the zero line), while one respondent values lower costs with +3 points and higher costs with –3 points.

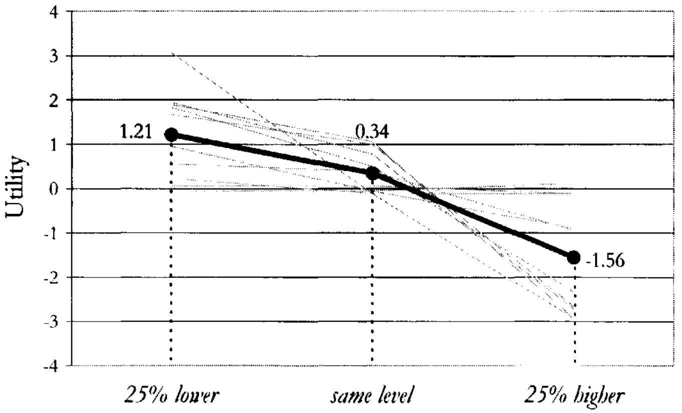


FIGURE 6-11 **EFFECT OF TRANSPORT COST: PARTS SERVICE INDUSTRY**

Figure 6-12 finally displays the part-worth utilities with respect to the reliability figures of a hypothetical third-party service provider. With a delta of 29.3 per cent, reliability is an important feature in the opinions of the service managers. From the disaggregate data we can deduce that two respondents value 95 per cent reliability higher or just as high as 100 per cent. However, most of the respondents prefer 100 per cent to 95 per cent. A performance of 90 per cent is clearly undesirable.

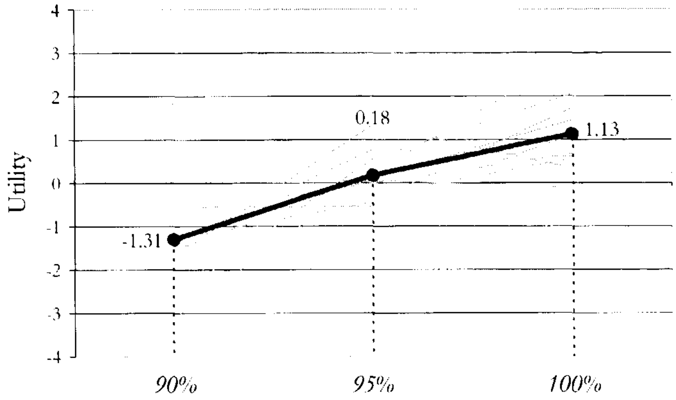


FIGURE 6-12 **EFFECT OF RELIABILITY: PARTS SERVICE INDUSTRY**

Trade-off ratio between reliability and transport costs

Since we found that the part-worth utilities of preventive and corrective transit times are not significant (see Table 6-8), we could not calculate a well-founded trade-off ratio for these attributes in the parts service industry. Hence, we only computed the trade-off ratio for the attribute reliability. We recorded a reliability/cost ratio of 4.40 (as compared to 5.02 in the Dutch food industry). The average service manager is prepared to pay 4.4 per cent higher transport costs for every per cent reliability increase between 90 and 100 per cent.

6.8 COMPARISON OF FOOD AND PARTS SERVICE INDUSTRY

In this section, we will compare the different models of the food and parts service industry. This can only be done for three attributes, as we used one diverging attribute in the parts service sector: transport costs, reliability and transit time.

The average rating (or regression intercept) proved to be almost identical: 5.58 for the food and 5.56 for the parts service industry. This means that the average profile was rated almost the same in both the food and parts service industry. Moreover, the part-worth utilities for transport costs and reliability measured in the food industry bear strong resemblance to those measured in the parts service industry. The average cost and reliability part-worth utilities for both industry sectors are represented by Figure 6-13 and Figure 6-14.

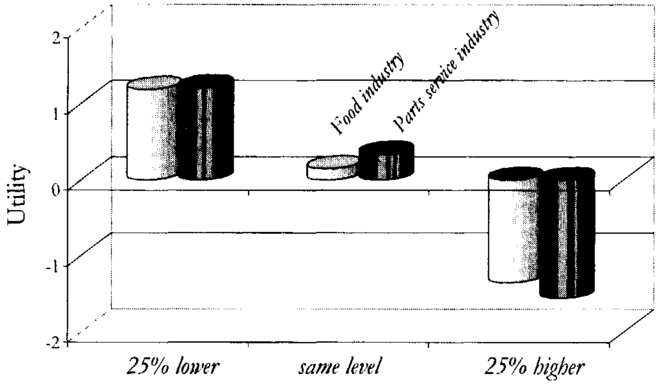


FIGURE 6-13 EFFECT OF TRANSPORT COSTS: FOOD AND PARTS SERVICES

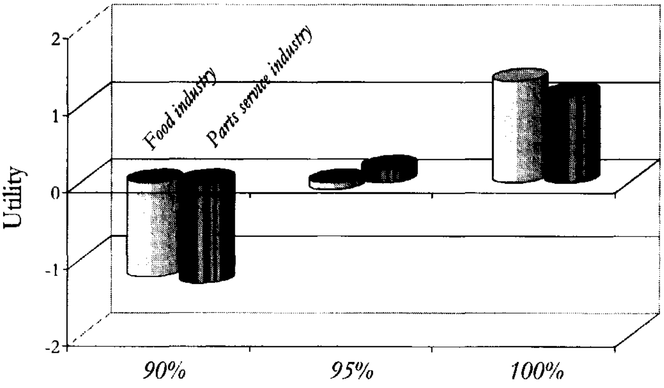


FIGURE 6-14 EFFECT OF RELIABILITY: FOOD AND PARTS SERVICES

Furthermore, the relative importance of the attributes cost and reliability also turn out to be practically the same: 31 versus 33 per cent and 31 versus 29 per cent respectively. We used analysis of variance (ANOVA) to determine whether utilities in the food industry differed significantly from utilities measured in the parts service industry. To this end, we compared the relative importance of each attribute (measured by the delta) between the individual food and parts services companies. This comparison was done by carrying out an *F*-test: the null-hypothesis H_0 being that there is no significant difference between the relative importance of each attribute in the food and parts service industry. In case of the attributes costs and reliability, H_0 is accepted: there is no significant difference between the food and parts service industry as regards the relative importance of these two attributes. A more detailed description of the test-procedure is given in Appendix H.

The attribute that does make a difference therefore is transit time (see Figure 6-15). We compared the relative importance of transit time within the food industry with the relative importance of transit time in case of preventive maintenance within the parts service industry, as we considered this planned transit time more comparable to the planned transit time of regular food shipments.

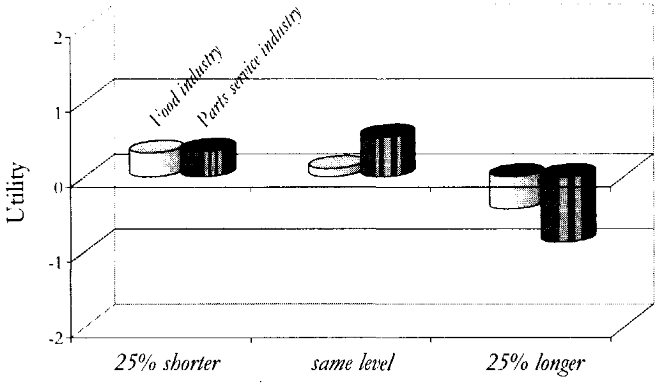


FIGURE 6-15 **EFFECT OF TRANSIT TIME: FOOD AND PARTS SERVICES**

ANOVA analysis confirms the difference in time-preferences between the food and parts service industry: H_0 is rejected at the 0.05 significance level, which means that transit time is significantly more important in the parts service industry than in the food industry (see Table 6-9; top row).

When the individual part-worth utilities for each attribute level are compared between the food and parts service industry by means of an F-test, we find a significant difference only for the attribute level of 'same transit time' (see Table 6-9). For the remaining attribute levels we fail to reject the null hypothesis (i.e. there is no difference between part-worth utilities in the food and parts service industry).

Service managers attach more value to keeping things as they are, i.e. giving a positive mark to service providers who offer the same transit time as is currently achieved. Food managers appeared to be more indifferent towards getting the same transit time. This is due to the fact that the current transit time levels in the parts service industry are already shorter than in the food industry. Furthermore, service managers seem to reject longer transit times, more so than do food managers (although this is not a significant difference). This is because absolute speed is more important in the service industry than in the food industry. As we saw, reliability is the most important logistics service characteristic in the food industry. The figures in both sectors however imply that acceleration may not be pursued, but deceleration is still out of the question given current market conditions.

TABLE 6-9 RESULTS OF F-TEST: DIFFERENCES BETWEEN PART-WORTH UTILITIES IN THE FOOD AND PARTS SERVICE INDUSTRY ($\alpha = 0.05$)

Test variable	Calculated F-ratio
Relative importance of transit time	5.882*
Relative importance of transport costs	0.521
Relative importance of reliability	0.008
-25% transit time	0.008
same transit time	4.176*
+25% transit time	3.340
-25% transport costs	0.006
same transport costs	2.196
+25% transport costs	0.465
90% reliability	0.061
95% reliability	2.665
100% reliability	0.452

* significant at the 0.05 level.

6.9 CONCLUSIONS

In this chapter we provided an introduction into the basic business trends observed in the case study sectors: the parts services and food industry. Furthermore, we used the conjoint analysis technique to measure the degree of time-sensitivity (the respondents' evaluations for transit time, frequency and reliability) within both of these sectors.

The conjoint analysis method opens up possibilities for estimating preference models at the aggregate and individual level. Within the food industry, we found that reliability (when measured as a trade-off ratio with costs) is by far the most important time variable, followed by costs. Frequency and transit time are found to be relatively less important. A comparison with the results of similar conjoint analysis studies revealed that our estimations lie within a plausible range.

The *individual models* showed that there is little variation in the preferences among the food manufacturers, while companies in the parts service industry display a greater deal of heterogeneity. The main explanation is found in the different market structures: whereas food manufacturers have to comply with the dominant logistics demands of a small group of powerful retailers, companies in the parts service industry face a much broader range of clients, with different requirements. On the *aggregate level*, the importance of the attribute 'transit time' was found to be significantly more important in the parts service industry than in the food industry. Other attributes did not deviate systematically between these two case study sectors.

7

Evaluating the conceptual model

The quantitative results of Chapter 6 unveiled that, in the Dutch food industry and parts service industry, on-time reliability of deliveries is the most important time-requirement, followed by frequency and transit time. In this chapter, we will examine the impacts of these requirements on logistics choice behaviour.

We will discuss the micro-impacts of time-sensitivity by means of the conceptual model presented in Chapter 4. This model included a series of *a priori* hypotheses about the micro-impacts of increasing time-sensitivity. Based on the empirical data gathered in the Dutch food industry, we will assess whether the conceptual relationships hold or not. Furthermore, we will extend the initial model with various variables and relationships that have been observed during the empirical fieldwork. Following this analysis, we will identify so-called causal chains; robust sequences of variables and relationships that together form important determinants of the logistics system's behaviour.

Finally, we will discuss the policy implications of the above: the policy scenarios that were based on the initial version of the conceptual model were tested in a series of interviews with logistics managers working in the Dutch food and parts service industry. We will present and interpret detected differences between expected and observed policy reactions, and provide suggestions for freight transport policy adaptations.

7.1 PRELIMINARY TEST OF CONCEPTUAL MODEL

Methodology

At the end of section 5.2 we explained our preference for using a multiple case study methodology: our primary aim is to refine the initial conceptual model presented in Chapter 4. This requires an in-depth understanding of the logistics decision–making process under increasing time-sensitivity. In this respect, McKinnon and Woodburn [1996] argue:

> *Given the complexity of firms' logistical systems, the multiplicity of intra- and inter-functional trade-offs and the wide variety of management structures, it is necessary to collect this information by in-depth interview* [McKinnon and Woodburn, 1996, p.159].

As was discussed in the previous chapter, we have interviewed 33 manufacturers within the Dutch food industry. Additionally, we interviewed one large retailer to crosscheck results. We used the questionnaire format that was presented in Chapter 5. The main purpose of the interviews was to generate a good understanding of the dynamics underlying logistics choice behaviour, that is, the *causality* behind the presumed model relationships.

Analysis procedure

We used the literal interview transcripts to discover causal relationships in the reasoning of the respondents. Of all 34 interviews in the food industry, 31 interviews were tape-recorded and later typed out. The transcripts were closely examined in order to detect verbal causal statements. The causal connections between identified model factors were recorded, and in case the respondents introduced new model factors, these were also registered. Every respondent was therefore enabled to add something of his own rationality to our theory. This can be seen as an advantage, since the case study methodology thereby fully exploits the expertise of the respondents. The semi-structured questionnaire allowed for and invited to add all possible factors and relationships in relation to the central theme of the interview: what causes increasing time-sensitivity and what are the impacts on logistics choice behaviour? Consequently, the resulting extended theory (or refined conceptual model) reflects the actual experiences of the logistics managers, as respondents were not forced to give predefined answers.

The status of the conceptual model and the chosen approach imply that formal statistical testing of (part of) the conceptual relationships is left for future research efforts. Therefore, we refer to this stage of our research as a *preliminary* test of the conceptual model.

The test results can take four different forms:

- *Confirmation*: expected conceptual relationships that are verified by the observations in the Dutch food industry.
- *Rejection*: based on the case study material, falsification of relationships is not appropriate. The fact that respondents did not mention certain model factors or relationships does not imply that the relationships are non-existent, except when respondents explicitly stressed their non-existence. Hypothetical relationships are therefore only rejected on the basis of direct evidence provided by the logistics managers.
- *Undecided*: we will speak of 'no evidence found' in those cases when anticipated conceptual relationships could not be observed in the Dutch food industry. This however does not mean that the relationship can be rejected categorically, as specific characteristics of the Dutch food industry might be responsible for the seeming or apparent non-existence of the relationship.
- *Addition*: respondents could add aspects to the theory that are important according to them. Unanticipated model factors or relationships were recorded and incorporated in the conceptual model.

During the series of in-depth interviews, we gradually experienced that the respondents (independently from each other) were repeating the same model factors and relationships. The marginal contribution of each extra interview decreased as in later interviews no new factors or relationships were being introduced. We are therefore confident that the resulting theory captures the important issues with regard to logistics decision-making under time pressure, at least for the Dutch food industry. The question of generalisation of results to other business industries will be dealt with in the final chapter.

7.2 MODEL OF LOGISTICS CHOICE BEHAVIOUR IN THE FOOD INDUSTRY

Figure 7-1 shows the revised model resulting from the preliminary test. The crisscross of lines illustrates the multitude of interrelations and trade-offs that is typical of the complex issue of logistics decision-making. The same test results are discussed in full length in Appendix I to M, with an explanation of the specific model factors and relationships. Note that the same codes are used for the model factors as in Chapter 4 (e.g. C10 reflects increasing customer requirements). In order to disentangle the model's complexity, we will focus on certain subsets of logistics decisions in the following sub-sections. Therefore, causal chains or 'routes' within the complex system are identified in the following.

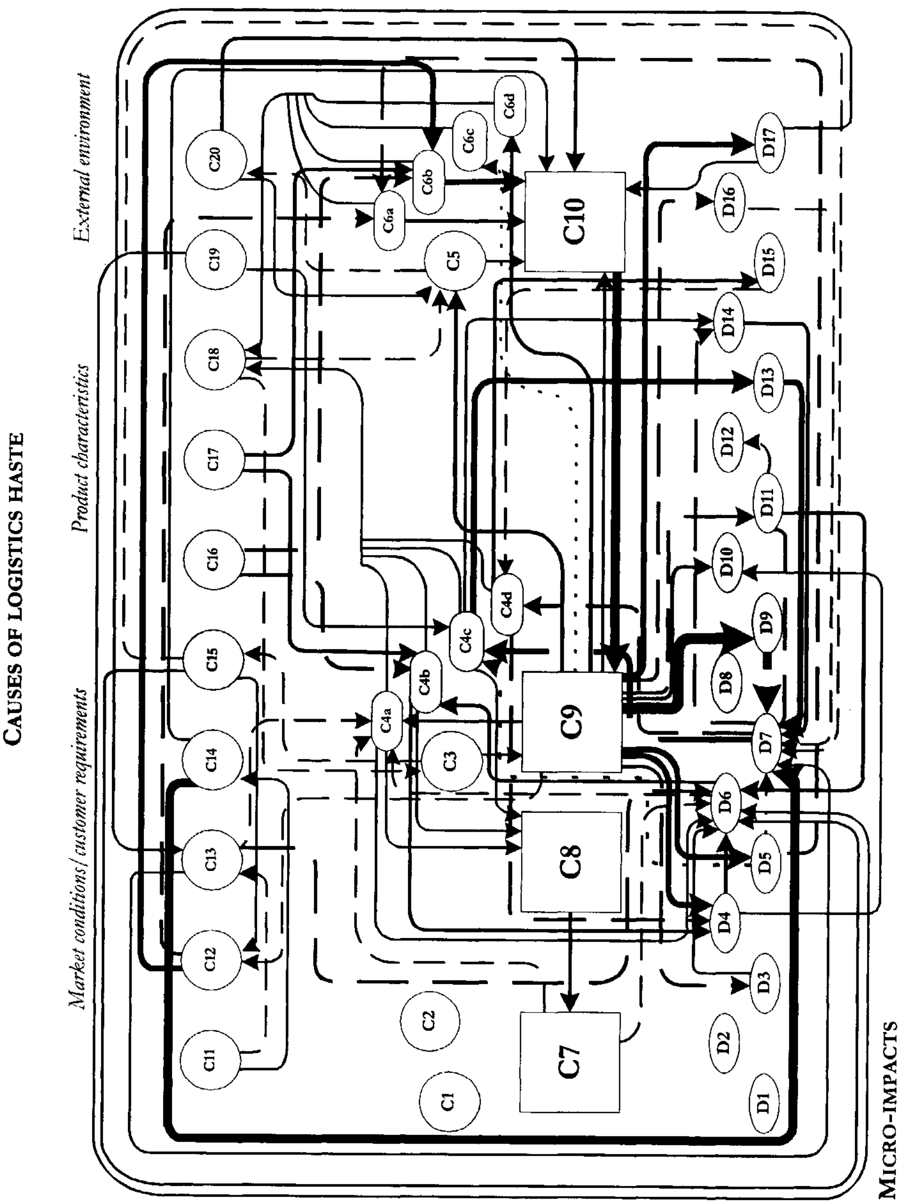


FIGURE 7-1 REVISED CONCEPTUAL MODEL

The solid lines in Figure 7-1 reflect positive relationships between the model factors, the broken lines represent negative relationships, and the dotted lines show that the respondents disagree about the direction of the relationship. The thickness of the lines reflects how many times the relationship concerned was mentioned by the logistics managers. Again, the relationships should not be seen deterministically, but probabilistically: the logistics managers' freedom of choice implies that no specific relationship *has to* occur, but rather *could* occur.

With respect to the scope of the tested model, we have to make two reservations. First, making use of the logistics managers' expertise implied that we concentrated on the domain of their know-how, namely the *causes* and *micro-impacts* of increasing time-sensitivity. The links between *micro- and macro-impacts* (see Chapter 4) have not been examined during the empirical fieldwork in the Dutch food industry. The face validity of the micro-macro linkages has been discussed with scientific experts within the field of logistics and freight transport research instead (see Appendix N). Second, no evidence was found to support relationships connected with the model factors C1 (*market share/revenue of supplier*) and C2 (*logistics costs of supplier*). This is because we have mainly asked logistics managers of *OEMs* (and not their suppliers) to explicate their experiences with respect to their *own* logistics choice behaviour. Consequently, we can neither confirm nor reject the existence of relationships between the model factors C1/C2 and other variables.

Additions to the initial conceptual model

Apart from the initial model factors, we identified additional factors that were found to be indispensable aspects in relation to time-sensitivity in the Dutch food industry. As it appeared important to distinguish between the different cost types, we further decomposed the cost factors (as already presented in Figure 3-4).

- *For the OEM*: stockout costs (C4a), inventory-carrying costs (C4b), transport costs (C4c), and handling/order costs (C4d).
- *For the customer*: stockout costs (C6a), inventory-carrying costs (C6b), transport costs (C6c), and handling/order costs (C6d).

The series of interviews with logistics managers in the Dutch food industry also yielded the following additional *causes* of increasing time-sensitivity:

- *Market conditions/customer requirements*: number of promotions (C11), inventory level of the customer (C12), predictability/stability of demand (C13), sales volume per customer (C14) and the number of stock-keeping units (SKUs)/introductions (C15).
- *Product characteristics*: the product's shelf-life (C16), value density (C17) and product price (C18).
- *External environment*: road congestion delays (C19) and shop opening hours (C20).

When we look at the *logistics decisions* that are affected by increasing time-sensitivity, we found four additional factors that had not been incorporated in the initial version of the conceptual model:

- Performing own-account transport for other OEMs (D14).
- Mechanising handling (D15).
- Number of separate backorders (D16).
- Usage of EDI (D17).

The exact meaning of the additional factors will be discussed in the following section when we discuss the relationships between all model factors.

7.3 CAUSAL CHAINS OF INCREASING TIME-SENSITIVITY

The most important causal chains between the model factors will be highlighted in this section. The causal chains discussed, which are all sub-sets of the revised conceptual model in Figure 7-1, include:

- Causes of higher customer demands.
- Micro-impacts of increasing time-sensitivity.
- Cost impacts of increasing time-sensitivity.
- Compensating cost increases.

We will explain the causality behind the relationships, as stated by the logistics managers, and we will illustrate the causal chains by means of practical examples.

Causes of higher customer demands in the Dutch food industry

This sub-section deals with the main reasons why retailers have become more demanding customers (note that we will refer to retailers as 'customers' in this chapter). On the basis of the empirical work in the Dutch food industry, we have identified seven groups of causes for increasing time-sensitivity, which are depicted in Figure 7-2. The white shapes display the main causes of customer time-sensitivity, while the grey circles represent underlying reasons. We will now examine the main causes separately.

Decreasing market share/revenues of customer (C5)
Retailers that are losing market share and revenues tend to raise their service demands placed upon their suppliers. Dropping market shares could be caused by relatively high product prices (C18) or low service levels offered by OEM (C9). Therefore, higher service demands are sometimes used as strategy to regain market share. Freshness of supermarket products will for example make or break the business of full-service supermarkets: the fresher the products the higher the

revenues will be. If suppliers were asked to deliver their products more frequently, freshness and subsequently revenues could be improved.

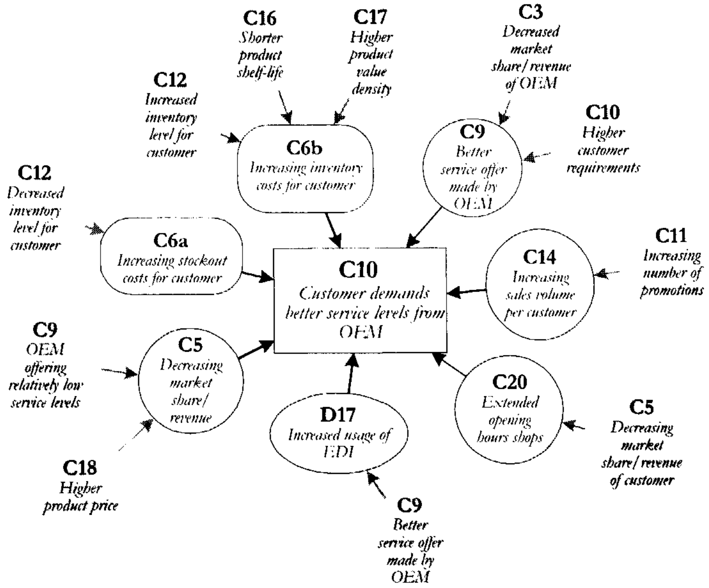


FIGURE 7-2 CAUSES OF INCREASING TIME-SENSITIVITY

Increasing stockout costs for customer (C6a)

If a time-based retailer is confronted with empty shelves and lost sales (e.g. because buffer stocks have been eliminated), he will tend to demand higher service standards from his suppliers: higher frequencies, faster replenishment and more reliable delivery times enable the optimised use of scarce shelf space. Furthermore, space can instantaneously be made available for 'hot items' without having to get rid off other unsold products that fill up the shelves. This process is called category management, and is often mentioned as an effective way of raising supermarket revenues while at the same time minimising stockout costs (C6a).

Increasing inventory costs for customer (C6b)

Higher inventory costs of retailers (C6b) provide an incentive to demand higher service levels from the manufacturers, because this could result in lower integral logistics costs for the customer. Retailers are faced with increasing inventory costs owing to three reasons:

- *Increased inventory levels (C12)*: increased storage space, risk or capital costs can be caused by a higher number of product variations or by mediocre service levels provided by the OEMs.
- *Shorter product shelf-life (C16)*: inventory risk costs are higher for perishable or fashionable products. While many food products are perishable for biological reasons (e.g. fish or milk), food products have also become more and more 'fashionised' (e.g. packaging adjusted to sports events such as the Olympic Games, beer or tea for specific seasons), which reduces the average shelf-life of the products involved.
- *Higher product value density (C17)*: more valuable products are more expensive to store. More tied-up capital is accumulated and higher insurance expenses are incurred.

Better service levels offered by OEMs (C9)

A better service offer can induce even higher customer service demands: if an OEM offers better service performance, retailers get the impression that higher service levels are still possible. One respondent claimed to have pampered his customers too much by providing the best possible service performance (originally intended to support marketing targets). Some retailers had grown to believe that they could demand even higher frequencies of delivery, despite the modest sales volumes involved. The motives for OEMs to provide higher service levels in the first place are twofold: first, higher customer requirements (C10) are an obvious trigger for providing better service levels. Second, OEMs could impose higher service standards on themselves because they are confronted with decreasing market shares and revenues (C3). Providing better service levels could be seen as a defensive strategy in those cases.

Increasing sales volume per customer (C14)

Larger retailers wield a greater deal of influence over OEMs. OEMs are more dependent on larger retailers than on the smaller ones, and are keener on pleasing the larger customers. The larger retailers evidently use the power they can exert and consequently demand higher service standards. Indirectly, OEMs have made some retailers more important through more co-operation on the shop floor (e.g. promotion of products in certain supermarkets): retailers that engage in closer relationships with manufacturers are generally more demanding.

Extended opening hours of shops (C20)

Owing to deregulation and increasing competition of other food channels (e.g. pizza delivery services, restaurants), it has become common practice for supermarkets to be opened until eight or nine o'clock in the evening. The extension of opening hours for shops (including evening and Sunday trade) obviously also had impacts on the service demands of the retailers. Replenishment of fresh products needs to be guaranteed during the evening and weekends as well, in order to avoid stockouts. This calls for the upgrading of service standards upstream the distribution channel: DCs have to be opened round the clock. It is claimed that, because these adjustments have not been fully implemented yet, current weekend stockout levels are one of the retailers' major problems.

Increased use of EDI (D17)

Electronic data interchange (EDI) is an indispensable tool in a co-makership relationship: the use of EDI will undoubtedly be challenged by the opportunities of the internet, but still seems to have acquired an important position in the Dutch food market. All the large food manufacturers nowadays communicate with their most important customers by means of EDI. Using EDI also implies that the OEMs and retailers co-operate in a more open relationship. OEMs receive aggregate sales figures from retailers to determine the required inventory replenishment quantity. The customers, now knowing precisely what the OEMs should be able to deliver and within what time frame, have become more demanding and less tolerant as a consequence of the new openness that went along with the introduction of EDI.

In conclusion, customers can become more time-sensitive owing to either defensive (e.g. battling decreasing market shares, rising inventory costs) or offensive reasons (e.g. exploiting the opportunities of EDI, extension of opening hours). That is, demanding better service levels can be interpreted as a company's way of coping with internal or external threats and opportunities. In order to realise their own business objectives, customers need the co-operation of their suppliers: the reasons why customers have become more demanding can therefore be traced back to the assumption that better service levels ultimately translate into better business performance.

Micro-impacts of increasing time-sensitivity in the Dutch food industry

In this sub-section, we will concentrate on the changes in the OEMs' logistics choice behaviour that have taken place as a consequence of the increasing time-sensitivity of the retailers (see Figure 7-3). We thereby focus on the direct and the indirect logistics adaptations that are implemented by the OEMs themselves.

Reduced supplier base (D3)

A few respondents had reduced their supplier base under the new time-based regime: limiting co-operation with a smaller number of preferred suppliers means better opportunities of controlling the required service standards. It is commonly believed that achieving a high level of service reliability can only be realised with a certain group of dedicated suppliers. Resulting from the supplier base reduction, the OEM can hold lower levels of inventory (D6). This is because the OEM can now depend on his suppliers' delivery performance and can therefore reduce his safety stocks.

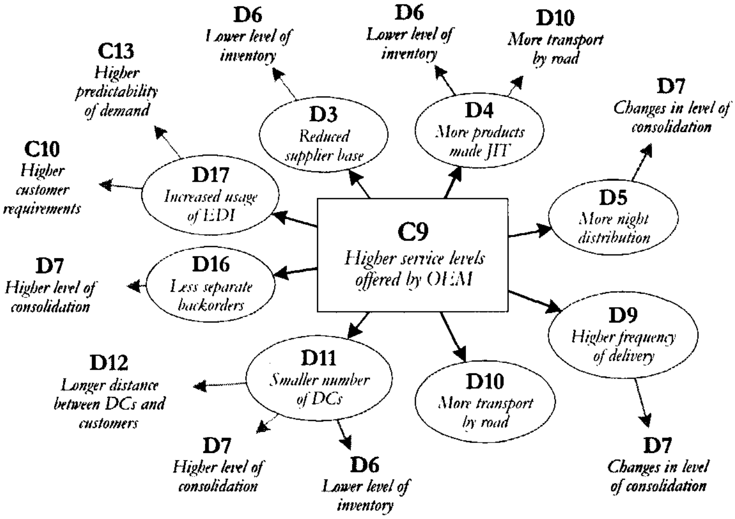


FIGURE 7-3 LOGISTICS DECISIONS AFFECTED BY INCREASED TIME-SENSITIVITY

Increased JIT production (D4)

As providing improved service levels to customers could lead to extra inventory build-ups for OEMs, some respondents adapted their production concept to the new conditions. Implementing the JIT philosophy in the production process implies an upstream shift of the order penetration point (OPP, see Chapter 2). This means that a larger proportion of products is made to order: inventory costs are controlled while customer service requirements are guaranteed. Nevertheless, another group of respondents insisted that they were incapable of making production processes more flexible or sales-based, owing to inherent production lead times or prohibitive losses of production efficiency. Some products can simply not be produced any faster: e.g. beer has to ferment or cheese needs time to ripen on the shelf. Furthermore, some vegetables can only be harvested during certain seasons. In those cases, a make-to-order approach would lead to unacceptable customer lead times.

More night distribution (D5)

It is generally observed that the emergence of time-sensitivity has stimulated the growth of off-peak distribution. Supermarkets nowadays require a continuous flow of incoming goods: incoming freight flows are synchronised with actual demand patterns as much as possible. Products that are sold on the one day are replenished overnight. Consequently, OEMs are increasingly requested to deliver their products during the evening or night, when the shipments for the individual supermarkets are 'crossdocked' at the retailers' hubs.

Higher frequency of delivery (D9)

Continuous replenishment does not automatically imply that delivery schedules are intensified, as plummeting markets would require less frequent shipments. However, the respondents leave no doubt about the general rise in frequencies in the last few years. Whereas OEMs used to deliver to Albert Heijn two or three times per week (on average), the same OEMs have started to deliver five to six times per week since the introduction of ECR.

Higher frequencies have implications for the load factor of vehicles. It is claimed that higher frequencies only lead to lower consolidation levels in case of mature markets, because in those cases existing full loads are split up into part shipments. A manufacturer of meat products for example confirmed that ECR-orders (with an order cycle time of eight hours instead of the 'normal' 48 hours) do not allow for groupage with additional loads. Conversely, higher frequencies may not be a problem at all when product demand is growing and trucks are still fully loaded.

Larger proportion of road transport (D10)

The logistics systems in the Dutch food industry had already been entirely geared towards the use of transport by truck, long before time-based competition came into existence. Nonetheless, it is argued that road transport has become even more attractive with the emergence of time-sensitivity. The truck is conceived as the only feasible alternative when it comes to fulfilling the common customer service requirements. This implies that the truck 'sits firmly in the saddle' in the Dutch food industry, and even more so under the current market conditions.

Smaller number of DCs (D11)

A few respondents mentioned that higher service standards require a smaller number of DCs to operate from. With a smaller number of DCs, one can achieve the dual goal of providing high service levels and controlling costs: higher levels of consolidation are more easily achieved in a centralised distribution system than in a decentralised logistics structure.

Reduction of separate backorders (D16)

Having to provide higher service levels to customers can also be used to the advantage of the OEM himself. Formerly, OEMs had to organise expensive and separate urgency shipments in case an order could not be loaded on the regular shipment. In the new situation of higher service standards, the number of regular shipments has been multiplied. Whenever a backorder is required nowadays, it can usually be shipped along with the next regular shipment, and no separate urgent shipment is required any longer.

Increased usage of EDI (D17)

The use of EDI has become a requirement in order to comply with higher customer service demands. Vendor-managed inventory systems are not possible without some form of structured, reliable and fast information and communications system. For this reason, EDI is often presented as an enabler of ECR. As we have seen in the previous sub-section, increased usage of EDI can in turn invoke extra customer service demands (C10). EDI, or the availability of sales information throughout the supply chain, could also result in higher predictability of demand (C13). Higher predictability in turn contributes to the avoidance of inventory amplification effects and increasing freight consolidation opportunities.

The sooner an OEM receives orders (e.g. through EDI), the more time is available for planning routes and collecting additional freight. We encountered an example of a meat product manufacturer:

> *The time to schedule routes arose by the implementation of EDI. Before noon, we receive the retailers' orders. From that moment on, we can start organising and planning the routes for the next day. This allows us to find additional loads. In the old days, we only received next-day orders at 22.00 hours, which did not leave room for efficient route planning.*

Thus, load factors can be improved by getting order information earlier through the use of EDI.

Logistics decisions not affected by increasing time-sensitivity

However interesting it is to identify the logistics decisions that have been affected by increasing time-sensitivity, it is equally relevant to identify the decisions that remain unaffected. On the basis of the literature research and the exploratory case studies (see Chapter 3), we expected several other logistics decisions to be influenced by increasing time-sensitivity as well. However, empirical findings in the Dutch food industry did not confirm a relationship between time-sensitivity and the following factors:

- *Number of products contracted out (D1)*: none of the respondents touched upon the issue of making-or-buying in conjunction with increasing time-sensitivity. Apparently, there are other, more important factors that determine whether certain products should be produced in-house or sourced out.
- *Shorter distances between suppliers and OEM (D2), between production facility and DCs (D8) and between DCs and customer (D12)*: agglomeration effects resulting from increased time-sensitivity seem to be absent in the Dutch food industry. The prime explanation for this is that locational structures have already been designed mainly at the national

> level for many years. Service levels are raised within the context of the existing spatial pattern of suppliers, production facilities and DCs. The well-established distribution structures therefore already satisfy the minimum requirements of 'closeness in lead time' (see Chapter 2).

In summary, we have observed that the emergence of time-sensitivity has mainly produced operational impacts. Offering more frequent shipments (D9) and turning to night distribution (D5) are the most popular changes in logistics choice behaviour under the new time regime. The manufacturers in the Dutch food industry obviously try to meet higher customer service levels within the existing logistics system first, explaining why the operational logistics changes seem to dominate. OEMs only invest in more tactical and strategical adaptations as soon as the existing logistics operation becomes too costly.

Cost impacts of increasing time-sensitivity

All of the above logistics decisions that are affected by increasing time-sensitivity influence cost structures across the entire supply chain. Some cost elements are transferred from one supply chain member to another. These cost shifts have far-reaching impacts on the logistics choice behaviour of the supply chain partners involved. As it appeared from the empirical work, OEMs and retailers have divergent views with respect to the fair division of cost and benefits of higher service standards. One group of OEMs insists that retailers use every means to improve their own position regardless of the (cost) consequences for the OEMs. Another group of OEMs, and the retailers themselves, however contends that it really is a matter of mutual give and take.

Higher stockout costs of the OEM (C4a)

It is found that stockout costs for the OEM have risen as a direct consequence of the higher service levels offered. For example, if the OEM has to deliver his products within four hours, the odds for being incapable of fulfilling the order will be higher than in a situation where the required order lead time runs up to three weeks. As opposed to the potential rise of stockout costs, there are also opportunities for the OEM to reduce stockout costs. For instance, the increased usage of EDI (D17) raises the predictability of customer demand (C13), because orders are transmitted faster and without distortions. In this sense, EDI can function as an 'early-warning system' that contributes to the avoidance of stockouts.

Changes in inventory costs of the OEM (C4b)

Some OEMs realised a reduction of inventory costs by making adaptations to their logistics choice behaviour. These adaptations include a reduction of the supplier base (D3), the implementation of JIT-production (D4), a reduction of the number of DCs (D11) and the increased usage of EDI (D17). As was described in the previous sub-section, all of these measures could lead to lower inventory levels and consequently to lower inventory costs. Despite the positive cost impacts, some respondents assert that they are incapable of making these adjustments to their logistics organisation, so that inventory reductions are unattainable. For instance, not every product is suitable for JIT-production. As one respondent said:

> *It is nonsense to apply sales-based or synchronised production systems to a jar of beans or a bar of chocolate. For these products, customer demand can be predicted fairly well, and stocks have already been reduced to a minimum level. A change to JIT-production would only raise plant inefficiency.*

Another logistics manager however claimed that most OEMs have not paid enough attention to making their production plant operations more flexible:

> *Of course costs rise when you do not change anything. Under the current market conditions, one cannot pretend as if nothing has changed in the logistics organisation in the last few years. Most manufacturers still work in large production batches, whereas they should have invested in shorter setup times and flexible production processes.*

Retailers also have the opinion that it is up to the OEMs to make their logistics organisation more flexible in order to take advantage of the new market conditions. It is claimed that most manufacturers still produce months in advance and that the introduction of ECR did not change anything in this respect.

Higher transport costs (C4c) and handling costs of the OEM (C4d)

Several OEMs' logistics decisions that are taken as a result of increasing customer service demands indirectly affect transport and handling costs. Some respondents claimed that higher service levels lead to higher transport and handling costs for two reasons:

- *Higher service levels lead to a larger proportion of night distribution (D5)*: the respondents did not entirely agree whether increased night distribution causes a reduction or increase in transport costs. On the one hand productivity gains (less delays for personnel and trucks) imply a transport cost reduction, on the other hand salary costs rise. Moreover, the level of consolidation might deteriorate, as current routes would be split up in several smaller consignments. Therefore, in order to maintain acceptable load factors, off-peak distribution is a matter of all-or-nothing: either every customer needs to co-operate, or the transport operation becomes too expensive.
- *Higher frequency of delivery (D9)*: as was explained in the above, higher frequencies lead to lower consolidation levels in case of stable demand figures, because in those cases existing full loads are spread over several part shipments.

Conversely, a reduced number of DCs (D11) and a reduced number of separate backorders (D16) could result in a higher level of consolidation (D7) and consequently in a reduction of transport and handling costs. Overall however, respondents share the view that increasing customer demands eventually produce higher transport costs. Handling costs have generally also risen due to higher customer service requirements: full pallets are sometimes halved and as a result, average handling costs per unit increase.

Some respondents also observed that retailers are reconsidering the applicability of the ECR concept: it is claimed that slow-moving or small products (e.g. sweets and chocolate bars) are not suitable for just-in-time deliveries, as the potential inventory reductions are outweighed by the increased transport and handling costs involved. Consequently, most retailers store these products for several days in advance. The continuous and daily replenishment model is not applied to these product segments, such as for fast-moving bulk products (e.g. beer and milk). The most dramatic changes as regards transport efficiency have occurred in the segments that are in between: less-than-truckloads have arisen in product groups such as salads and long-life milk. It is no coincidence that LSPs have emerged in these segments, specialising in the consolidation of LTL shipments.

Higher stockout costs of the customer (C6a)
There is considerable debate about the question whether accelerated replenishment cycles result in higher or lower stockout costs for the retailers. Theoretically, higher service levels (e.g. through night distribution) lead up to lower stockout risks. In practice however, the removal of buffer stocks (C12) that coincided with the higher service levels offered by the OEMs exacerbated the stockout problem. If something goes wrong in the delivery process nowadays, stockouts immediately come to the surface in the form of empty shelves and lost sales.

Lower inventory costs of the customer (C6b)
All respondents agree that their higher service standards have been cashed in by the retailers in the form of inventory reductions. The main inventory reductions have been achieved in the segments of fast-moving and bulky products (e.g. beer, soft drinks, dairy products), where 'quick wins' can be achieved. For example, one retailer reduced his beer inventory level to a mere two hours, enabled by extremely short order cycle times offered by the beer manufacturer. Retailers are reluctant to strive for higher service levels for slow-moving, small and low-value segments (e.g. sweets/candy products, canned vegetables), as the potential inventory gains are relatively limited in these segments.

Unaltered transport costs (C6c) and handling costs of the customer (C6d)
Many OEMs contend that the retailers' transport costs have not risen, despite the higher service levels offered. The OEMs are often not in a position to calculate increased transport costs. The simple explanation for this perceived inequality lies in the market power of the retailers. Retailers however hold an opposite view: they claim not to accept inefficient and expensive pallet and truck loads anyway, as these contribute to the already large problem of backdoor congestion at the retailers' DCs. Some retailers therefore actually force producers of slow-movers to use so-called backhaul services (consolidation services of LSPs hired by the retailers) for their deliveries to the retailer's DC.

Generally speaking, cost levels for OEMs have risen as a consequence of increasing customer demands. In the next sub-section however, our analysis will show that OEMs cannot be portrayed solely as 'victims' of higher customer demands, but rather as supply chain members that usually do have opportunities to compensate for cost increases.

Compensating for cost increases

In the previous sub-section, we saw that higher customer service demands have been a reason for certain cost increases for the OEMs. A general impression shared by many logistics managers in the Dutch food industry is that OEMs have had to face higher costs, while retailers reap the benefits in terms of lower inventory costs and higher revenues. This impression is not always appropriate because:

- *Higher cost levels are not exclusively caused by customer demands*: higher costs can just as well be caused by external factors (e.g. higher transport costs as a result of more congestion delays).
- *OEMs themselves may not always have taken enough compensating measures*: OEMs in the Dutch food industry can generally use different ways to compensate for cost increases by adjusting their own logistics choice behaviour (e.g. hire third-party LSPs to reduce transport costs).

The various compensation opportunities for cost increases will be discussed in the following sub-sections.

Compensating stockout costs (C4a)
The left half of Figure 7-4 displays the identified causes for rising stockout costs. First, failing service levels offered by suppliers (C7) could result in higher stockout costs for the OEM. Second, as was already discussed in previous sub-sections, higher customer demands (C9) lead to rising stockout costs as well. Third, the risk of running out of production materials is influenced by the occurrence of unpredictable or unstable demand patterns (C13). Stockout costs can therefore

also possibly be reduced if the OEM would be able to influence either the supplier performance (e.g. co-maker relationships with only a few certified suppliers) and/or to improve predictability of demand. The latter could be realised by limiting the number of promotions (C11) or by improved demand management by both retailers and manufacturers.

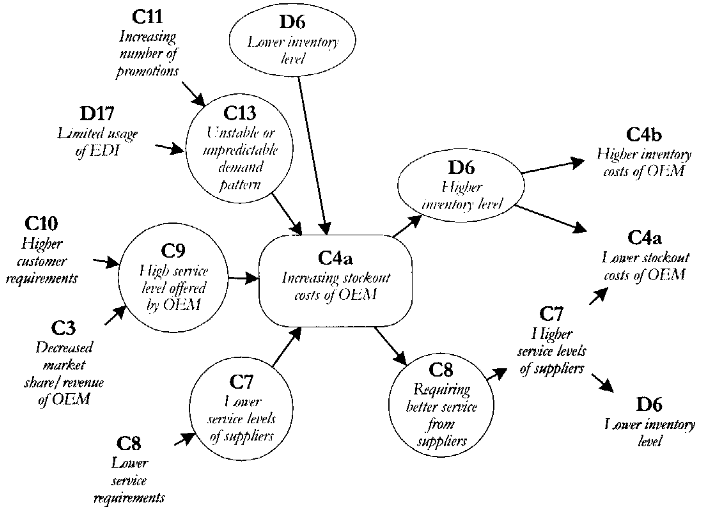


FIGURE 7-4 **OPPORTUNITIES TO COMPENSATE FOR RISING STOCKOUT COSTS**

In today's volatile business environment, promotions prove to be an art with a capital A, because the success of a promotion can not be predicted very well. Increased co-operation and sharing of sales figures between retailers and OEMs is an obvious solution in this respect, but retailers are said to be very protective with respect to their sales data. Real demand management (knowing what products are sold to which customers and for what reasons) still proves to be an uphill battle.

The right part of Figure 7-4 shows the encountered logistics adaptations to rising stockout costs. First, a conventional solution to stockouts is to raise the inventory level (D6): creating extra buffer stocks to cushion the impact of unreliable suppliers or demanding customers. Obviously, the accompanying increase of inventory costs has to be balanced by the decrease of stockout costs. Second, OEMs will try to demand better service standards (C8) from their own suppliers in order to reduce both stockout and inventory costs.

Compensating inventory costs (C4b)

Inventory costs can go up as a consequence of relatively autonomous developments such as the shortening of product shelf-life (C16), the higher value density of products (C17) or increasing congestion delays (C19) (see Figure 7-5). As has been reported, customer service expectations can also cause the need for holding more inventory, but these are not the sole reason for inventory rises. Part of the inventory costs belongs to the responsibility of the OEMs themselves. Some of these inventory 'drivers' include the choice to introduce more product variations (C15), having relationships with too many suppliers (D3) or the decision not to engage in JIT-production (D4). These decisions are usually legitimate in terms of enhancing the competitive position (through offering a larger product assortment) or maintaining production efficiency (producing in large batches), but from a logistical point of view these choices lead to higher costs.

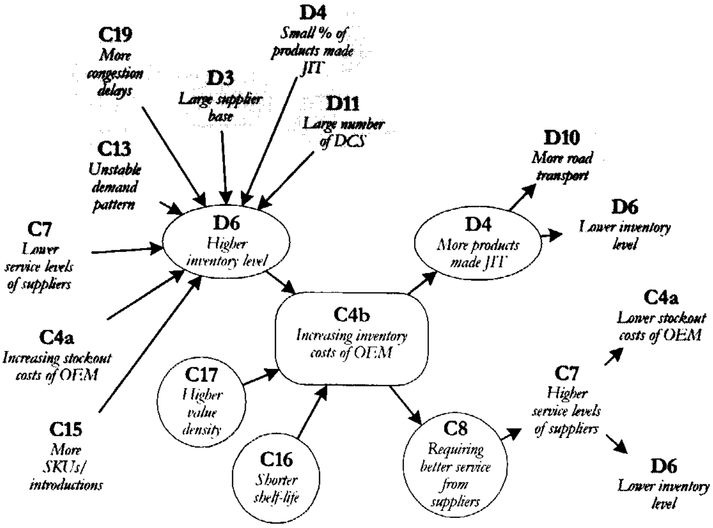


FIGURE 7-5 OPPORTUNITIES TO COMPENSATE FOR RISING INVENTORY COSTS

OEMs seek compensation for these inventory cost increases by adjusting the production concept (D4) and by contracting out part of the problem to the suppliers (C8). The scope for changing to a JIT-based production concept is sometimes limited. The order penetration point can usually not be completely shifted to the suppliers, but an upstream shift within the production process of the OEM is generally conceivable. The long ferment process of beer for example limits the possibilities of sales-based brewing, but the packaging process is nowadays closely connected to actual demand fluctuations. The beer itself is stored in large tanks, but the filling of bottles and tins is postponed to the latest possible moment. Likewise, canned vegetables (shelf-life of several years) are stored without labels. The labels are only added as soon as the products are sold. In this way, semi-products or modular products are stored, instead of the more expensive and risky final products.

Compensating transport costs (C4c)

Transport costs are determined by external factors such as road congestion (C19), personnel costs and diesel prices, but also by logistics factors. The central logistics variable is the level of consolidation (D7), i.e. the efficiency of the transport operation (see Figure 7-6).

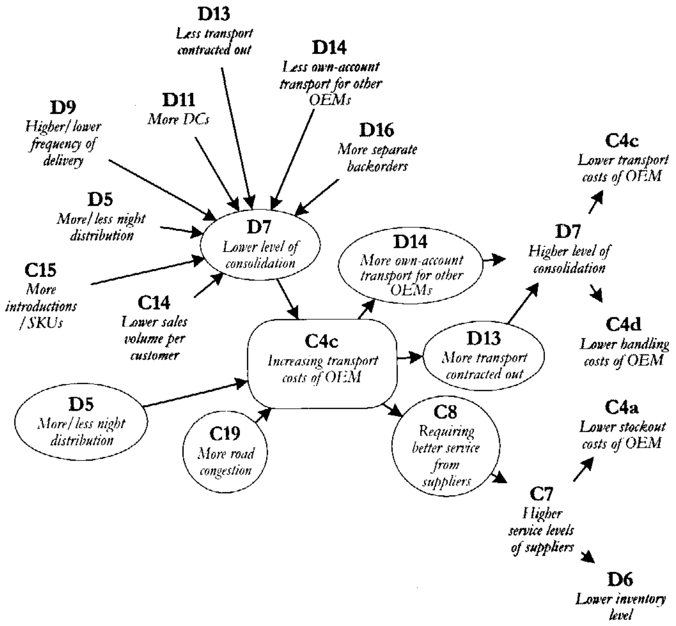


FIGURE 7-6 OPPORTUNITIES TO COMPENSATE FOR RISING TRANSPORT COSTS

Some OEMs tend to point to the ever-higher customer requirements (D9) when it comes to explaining lower consolidation levels and higher transport costs. Figure

7-6 however shows that the OEMs' own logistics decisions can also influence transport efficiency. For instance, rising numbers of SKUs (C15) or decentralised distribution patterns (D11) seem to have a negative influence on the transport efficiency. An autonomous compensatory trend is the increase in sales per customer (C14). The pervasive trend towards concentration among the retailers has brought about a general rise of drop sizes: order quantities that used to be delivered to different retailers are now shipped to one large DC. It is however argued by the OEMs that the cost advantages evolving from the concentration in the retailer's world have to be shared with the powerful retailers, whereas cost rises resulting from higher customer demands are not compensated for.

Common responses to transport cost increases employed by the OEMs again include shifting part of the problem to their suppliers (C8). Acquiring the co-operation of suppliers could result in lower inventory and stockout costs, to counterbalance higher transport costs. Additionally, OEMs attempt to improve transport efficiency by contracting out distribution activities (D13) or by performing own-account transport for other OEMs (D14). Most food producers have chosen to source out their transport activities to specialised LSPs, because these can combine several part shipments of different shippers into full loads. According to some OEMs and retailers these network economies have not been exploited enough, although some consolidation services have proven to be very successful.

We have encountered two examples of consolidation services organised by LSPs. Two competing salad manufacturers provide the first example. Both manufacturers produce approximately the same product range but combine their shipments to their main customer. An independent LSP collects and distributes the salads and in this way network advantages are created. The salads require the same delivery frequency and order lead time, so that the mutual adjustment of delivery schedules was limited. A second example of consolidation by LSPs includes combinations of 'sympathetic' products, such as canned vegetables, soft-drinks and crisps. As one participating producer explained, heavy goods such as soft-drinks and canned vegetables will soon reach the maximum weight limit of a truck. That is why OEMs and their LSPs are constantly searching for 'smart combinations' of products: products that require approximately the same service standards and that can be delivered within the same time windows of the retailers. The LSP combined the heavy canned vegetables with relatively light sweets, candies and crisps. This required the agreement of the retailer involved but eventually resulted in better consolidation levels in terms of both weight and cube-fill.

It is not surprising that the mentioned consolidation efforts are mainly found in the segments that have been confronted by decreasing load factors due to higher customer requirements (i.e. the slow-moving products). Some OEMs claim that, as a consequence of decreasing consolidation levels, ever more market opportunities for LSPs will arise in these segments.

Compensating handling costs (C4d)

Handling costs are determined by the level of mechanisation of the handling processes (D15) and by the level of truck consolidation (D7). Full truckloads are more efficient as (un)loading a full truck or trailer consumes less time compared to handling part shipments.

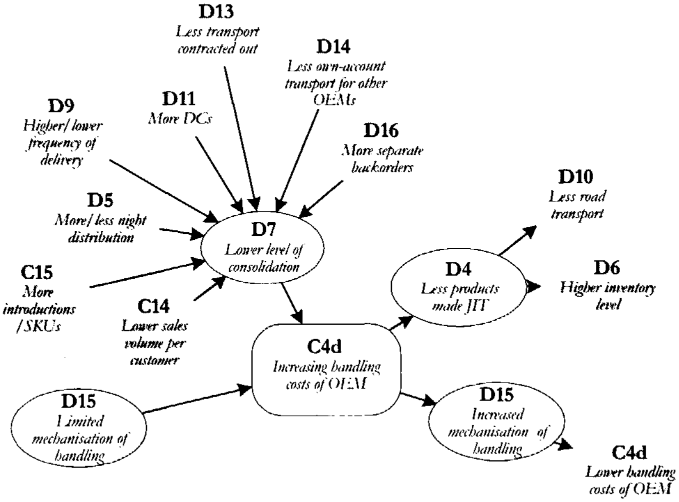


FIGURE 7-7 OPPORTUNITIES TO COMPENSATE FOR RISING HANDLING COSTS

The underlying factors that influence the level of consolidation have already been discussed in the previous sub-section. The observed reactions to handling cost increases are however somewhat different than for rising transport costs. Some manufacturers of slow-moving products believe that, in the long run, mechanisation of handling activities (D15) produces cost reductions, as the larger part of handling costs consist of personnel costs. This relationship holds more and more, since night distribution involves hiring personnel during expensive hours. Replacement of manpower by machines can therefore contribute to lower handling costs. Another option to off-set higher handling costs would be to reduce the proportion of products made to order (D4), and subsequently turn back to a logistics concept based on large production batches and full truck loads.

This last option is however not considered being economically viable or likely in today's business environment.

To sum up, the previous sub-sections revealed that changes in customer demands and the shifting power balance between retailers and OEMs caused cost dynamics in the Dutch food industry. In the opinion of some OEMs, retailers are reducing their own inventory costs at the expense of the manufacturers, who are faced with higher transport and handling costs. In turn, OEMs try to pass on cost increases as much as possible to their own suppliers and LSPs. A typical external solution to cost rises is found in contracting out responsibilities to suppliers. For instance, a salad manufacturer who set up a vendor-managed inventory system together with a retailer, successfully applied the same VMI-system to his own suppliers. The potato suppliers of the salad producer started delivering the required production quantity on a daily basis, thus reducing the inventory costs of the OEM. In other words, the order penetration point is shifted upstream as much as possible by each of the supply chain members, implying that larger parts of the supply chain have to be executed within a shorter period of time. It can therefore be stated that transferring responsibilities and costs is not a strategy typical of retailers, but also of the OEMs themselves.

Conclusions: macro-impacts of time-sensitivity

One of the central research questions of this dissertation deals with the macro-impacts and policy implications of the observed micro-level logistics changes. Before we discuss the results of the policy scenario test in the next section, we can also draw conclusions about macro-impacts on the basis of the micro-level analysis done in this section.

First, on the basis of the literature review in Chapter 4 we expected increasing logistics time-sensitivity to have locational impacts (see Figure 4-8): the distances between suppliers, production facilities, DCs and customers were expected to decrease as a consequence of the advantages of co-location (model factors D2, D8 and D12). However, owing to the absence of clear agglomeration effects caused by logistics time-sensitivity, the links between logistics decision-making at the micro-level and macro-level spatial impacts are not observed in the Dutch food industry.

Second, the emergence of time-sensitivity did have impacts on transport efficiency (D7) and modal choice (D10). In this respect, increasing time-sensitivity essentially has contributed to the rise in vehicle-kilometres. Mainly in the slow-moving and less-than-truckload segments, higher shipment frequencies (D9) have caused lower consolidation levels (D7). This trend towards lower consolidation rates has been exacerbated by the continuous introduction of new products and SKUs (C15). At the macro-level, these logistics trade-offs contribute to a reduction of average utilisation rates (I5) and an increase in the number of empty returns (I6). The introduction of time-based competition has also strengthened the position of road transport (D10) compared to alternative modes of transportation. The implementation of JIT-based production systems and the general rise in customer service requirements have made road transport ever more indispensable. This contributes to a rise (or at least a prolongation) of the modal split in favour of road transport (model factor I1) and a reduction of the average vehicle carrying capacity (I4).

However, it would be too simple to state that increased customer time-sensitivity can directly be translated into lower levels of consolidation and more vehicle-kilometres. It is important to note that current business trends do not all result in lower load factors and higher costs for the OEM. Some of the transport inefficiencies are compensated by autonomous market trends (e.g. concentration among retailers (C14) and increasing drop sizes) and by the logistics decisions that have been taken by the OEMs:

- *Increasing night distribution (D5)*: depending on whether enough volume is generated, night distribution could ultimately lead to improved consolidation and lower transport costs for the OEM.
- *Smaller number of DCs (D11)*: higher levels of consolidation are more easily achieved in a centralised distribution system than in a decentralised logistics structure.
- *Increased outsourcing of transport activities (D13) and own-account transport for other OEMs (D14)*: higher transport costs have caused many OEMs to look for efficiency improvements in the form of network advantages, either by organising third-party transport activities by themselves or by contracting out distribution activities to specialised LSPs.
- *Reduction of separate backorders (D16)*: if service levels are raised, backorders can often be sent along with the next regular shipment, and still be on time.
- *Higher predictability/stability of demand (C13)*: with the help of information and communication technology and more open information sharing, retailers can send their orders more reliably and faster to the OEMs. Consequently, the production and shipments plans of the OEMs can be scheduled pro-actively, which improves efficiency.

The observed logistics systems therefore contain some *self-regulating* or *stabilising mechanisms*. On the one hand, consolidation levels decrease as a consequence of higher customer demands, the introduction of ever more product variations and the like. On the other hand, concentration among retailers and outsourcing of transport activities to specialised LSPs result in higher load factors. Whereas the concentration trend among Dutch retailers may have reached its maximum, several respondents assert that there is still scope for improvement in terms of consolidation services offered by LSPs.

Although cost considerations have forced increasing numbers of OEMs to contract out their distribution activities, and despite the successes of certain consolidation services, the actual consolidation of freight is still in its infancy. As the OEMs themselves admit, too many lorry journeys consist of dedicated routes serving different retailers, instead of the more efficient multi-client shipments to one or a few retailers. Backdoor congestion problems at the retailers' DCs are an illustration of this.

7.4 STATED-ADAPTATIONS: REACTIONS TO POLICY SCENARIOS

In the previous section, we have discussed and analysed how logistics choice behaviour changes as a consequence of increasing time pressure. This analysis provided important insights in the most common logistics choice behaviour of individual companies within the context of their respective supply chains. Among other things, we found that increasing time-sensitivity does affect modal choice and transport efficiency. Furthermore, we could draw conclusions about the macro-impacts of the observed micro-level logistics changes.

In Chapter 1, we discussed the freight transport policy goals, which are aimed at achieving a modal shift and a rise in transport efficiency. In Chapter 4, we formulated four policy scenarios to support these objectives (based on the results of an expert workshop). In this section, these policy scenarios are tested. Respondents in a series of interviews in the Dutch food and parts service industry were requested to reflect on conceivable impacts of the mentioned scenarios: logistics managers were not given a prompt, but were completely free in their reactions (so-called stated-adaptations). The only limitation introduced by the interviewer was that the answer of the respondent had to be plausible compared to the current logistics organisation of the respondent. This means that (if needed) the interviewer reminded the respondents of the practical constraints connected to logistics changes, which the respondents had mentioned themselves during the first part of the interview. Moreover, the feasibility and realism of the policy reaction was explored by asking why the mentioned logistics adaptations had not been implemented earlier by the logistics manager.

In this section, we will discuss each policy scenario separately. For each scenario, we will briefly repeat the anticipated micro- and macro-level impacts of the policy scenario involved. Second, we will report the observed stated-adaptations mentioned by the respondents.

Policy scenario 1: Impose higher charges on road transport

Anticipated effects

The first policy scenario involved the increase of variable transport costs for road shipments. Respondents were asked how they would react if a kilometre charge and a rush hour tax were introduced, and if transport costs rose by 25 per cent. Such a pricing policy was expected to influence micro-level logistics choice behaviour on several points. First, the proportion of products shipped during off-peak hours (D5) might rise because of the time-dependent nature of the policy tactic. Second, the level of consolidation (D7) is expected to increase, because firms might be stimulated to improve utilisation rates in order to reduce the extra costs per product transported. Third, pricing policies are expected to reduce the modal share of road transport (D10), because the relative attractiveness of road transport decreases as its price goes up. The anticipated micro-impacts of the policy tactics would contribute to the realisation of macro-level freight transport policy goals: a modal shift (I1), higher average utilisation rates (I5) and reduced empty returns (I6).

Stated-adaptations

Table 7-1 shows the mentioned responses to the first policy scenario in the food and parts service industry. Note that the percentages do not sum to 100 per cent, as respondents usually gave more than one response.

TABLE 7-1 RESPONSES TO HIGHER CHARGES ON ROAD TRANSPORT

Policy reaction	**Percentage of respondents *food industry*** (n=20)	**Percentage of respondents *parts services*** (n=14)
Accept price increase/ do nothing	70	57
Consolidate part shipments via LSP *	60	21
Shift to off-peak distribution *	30	29
Pass on to customers	25	93
Adjust route planning	10	21
Consult/ inform customer	10	0
Stop deliveries to very small customers	10	0
Compensate through cost reductions elsewhere	5	0
Decentralise pattern of DCs	0	7
Consider alternative modes *	0	7

* anticipated effect.

One of the most popular policy reactions in both industry sectors is to simply *accept* the transport cost increase of 25 per cent, and not to change anything at all in the logistics organisation. The main explanation for this response lies in the fact that, in the food industry, transport costs often do not exceed three or four per cent of the product price. This figure is confirmed by a study of the Institute of Logistics & Touche Ross [1995], which revealed that the transport costs of a broad set of European food manufacturers only accounts for 2.4 per cent of sales on average. The inelasticity with regard to transport costs goes all the more for the parts service industry, since a lot of money is usually involved with downtime costs or expensive parts. Typical responses therefore include statements such as 'not amused, but not impressed, either' or 'such a tax will not cause our bankruptcy'. The policy tactic of transport cost increases will therefore not produce the desired effects in these cases.

The second policy response encountered in the food industry is to *consolidate part shipments* and thereby compensate for the suggested transport cost increases. This policy response was indeed intended by the policy scenario. It is claimed, as a consequence of the higher transport costs caused by the higher customer demands, that OEMs are already more inclined to seek co-operation with other manufacturers anyway. An additional transport cost increase would therefore promote existing consolidation efforts, but would generally not invoke these by itself. An important requirement for this policy response is the co-ordination of delivery schedules among OEMs. This in turn requires the approval of the customers involved. Another mentioned bottleneck could be the still present conservatism among some manufacturers, who are afraid of sharing strategic sales information with competitors. We have however encountered examples of competing OEMs who rely on the independence of third-party LSPs, and who co-operate to generate synergy in their logistics networks.

A *shift to off-peak distribution* is mentioned by one third of the respondents in both the food and parts services industry. It is claimed that the field engineers in the parts service industry are already accustomed to irregular working times, as those are 'part of the job'. In the food industry, the permanent shift to a 24-hour operation is not so common yet. However, by contracting out the distribution activities to third-party LSPs, the food manufacturer's own logistics organisation remains relatively unaffected. The consignments are prepared by the OEM during ordinary business hours, and the LSP collects the shipments at the end of the day. This policy response can therefore be accepted by the OEMs without much trouble.

A remarkable difference between the food and parts service industry occurs when it comes to *passing on cost rises* to customers. Almost every interviewed logistics manager in the parts service industry suggested to transfer at least part of the extra transport costs to the customer, whereas the same option is mentioned by only 25 per cent of the food managers. This can be explained by the difference in the power balance between OEMs and customers and the type of orders: the orders in the parts service industry often involve ad hoc and urgent shipments, for which the customer is prepared to pay almost any price. Moreover, the service contracts often include a 'logistics menu' the customer can choose from: e.g. guaranteed response times within four hours are more expensive than next-day repairs. Such an obvious system of 'service pricing' has not been implemented in the food industry as yet. In the food industry, retailers often receive better service performance levels without being charged, because the food managers usually lack the countervailing power that is common to the service managers. It is no coincidence that the food managers who did suggest to pass on increased transport costs were all (relatively powerful) manufacturers of branded products. It is claimed by these companies that competitors are in the same boat: charging for additional costs will therefore not affect the competitive position.

The policy responses that are mentioned by only a minority of the respondents include *adjustments to route planning* ('we have already adjusted routes as much as possible to avoid congestion'), *giving up small customers* ('although we cannot afford to lose any customer'), *compensating costs elsewhere* (e.g. reduction of inventory costs) or *decentralised inventory patterns* (e.g. having customers hold more service parts in stock). The most striking is however the relative small proportion of companies that considers using alternative modes of transportation. Only one service manager, because of the claimed cost advantages, suggests a modal shift from vans to motorcycles. A bottleneck mentioned by the same respondent is the limited storage space when using a bike. None of the food managers thought of a modal shift as an appropriate answer to road transport taxes, which correlates with the relatively limited share of transport costs in the total costs and the perceived unavailability of intermodal alternatives. Finally, a limited number of logistics managers suggested to consult the customer in order to find a common solution. Most respondents take the customer demands for granted and assume that transport cost rises provide a weak basis for price negotiations.

Effectiveness of policy scenario 1

The first policy scenario can be regarded as a partial success when compared to the anticipated effects. Judging from the respondents' reactions, a pricing policy does stimulate parties to strive for improved transport efficiency (i.e. through increased consolidation via LSPs and increased off-peak distribution), but a modal shift is hardly noticeable, if at all. Most of the respondents claim not to change anything in the logistics organisation, while considerable numbers of respondents would pass on the increased costs if possible, or compensate through cost reductions elsewhere. The description of the cost compensation strategies (see section 7.3) also revealed that cost rises are often balanced by improved efficiency or outsourcing of distribution activities. The different sources of evidence therefore confirm each other.

With respect to the role of transport costs we did however detect inconsistencies between the stated-adaptation responses of the respondents and the conjoint analysis results discussed in the previous chapter. The stated-responses suggest that transport costs are relatively insignificant when it comes to logistics choice behaviour. The main argument for the claimed indifference is that transport costs usually constitute only a minor part of the total costs of a company. McKinnon and Woodburn [1996] executed a comparable experiment in the British food industry and envisaged a rise in transport costs of 50 per cent. They also found that transport costs are unlikely to have a major impact on logistics choice behaviour, at least in the short-term: most firms either pass on the extra costs or accept the price increase. Our conjoint analysis experiments however unveiled that transport costs form the second most important attribute when choosing between alternative LSPs (see Chapter 6). That is, in a final trade-off, transport costs may not be so insignificant after all. A policy response bias might therefore have crept into the stated-adaptation experiment: respondents might have deliberately underrated the effectiveness of pricing policies in order to prevent future policy initiatives in this direction.

Policy scenario 2: Extend time windows and promote 24-hour economy

Anticipated effects

The second scenario dealt with a national policy to abolish all time window restrictions in inner cities. Furthermore, respondents were asked to assume that all of their main customers opened their DCs round the clock. The central idea behind these time policies is to deregulate time restrictions, as these could effectively reduce the opportunities for gaining full loads. The anticipated effect of liberalisation is an increase in the proportion of off-peak or night distribution (D5), which could eventually result in higher levels of consolidation (D7). For example, it is estimated that a shift to night distribution in the Dutch retail industry, combined with increased consolidation, could save 3.5 million vehicle-kilometres in the Dutch Randstad [Logistiek.nl, 1998]. Subsequently, the macro-level average utilisation rate (I5) and the number of loaded return flows (I6) might be improved.

Stated-adaptations

Table 7-2 summarises the stated responses to the second policy scenario.

TABLE 7-2 RESPONSES TO EXTENDED TIME WINDOWS /24 HOUR ECONOMY

Policy reaction	**Percentage of respondents *food industry*** (n=20)	**Percentage of respondents *parts services*** (n=14)
Contract out night distribution to LSP	70	21
Shift to off-peak distribution *	65	64
Do nothing/ no night distribution	20	29
Adjust layout of DC	10	0
Increased mechanisation of handling processes	5	0
Remote diagnosis/ repair	0	14

* anticipated effect.

The most common reaction of the food managers to the second policy scenario is to *contract out the off-peak or night distribution activities to LSPs.* This policy reaction is far less common in the service industry, since most of the interviewed service managers operate their own service activities without the assistance of third-party LSPs. In the food industry, the common practice exists of an LSP who collects the OEM's shipments during ordinary business hours (or who stores the consignments in his warehouse), while the final consignments to the retailers are combined and shipped by the LSP during the evening. LSPs can even collect the consignments at night if the OEM installs a safe-deposit or video transmission systems that allow the opening of doors and the switching off of alarm devices. At the most, the OEM may decide to re-schedule his order entry or order picking activities in order to reduce the average waiting time of consignments at the loading docks. However, this policy reaction largely disconnects the OEM's own distribution activities from the LSP's, and can therefore be adopted relatively easily. The contribution of this policy response to the achievement of macro-level policy goals (increased average utilisation rate and loaded returns) eventually depends on the LSP's consolidation capabilities, and his skills to generate adequate freight volumes during off-peak hours.

The second response, a *shift to off-peak distribution*, is equally popular in the food and parts service industry. As we saw in the above, in the food industry, such a shift generally implies contracting out the distribution activities. This explains why the food managers readily go along with the trend towards night distribution. The readiness among the service managers is however more noticeable. This is because business partners have already been accustomed to entering into 24-hour service contracts for years. Customers often explicitly require service activities at off-peak hours in order to reduce downtime costs. For example, a restaurant owner will not allow non-urgent service activities on his automatic coffee-maker during lunch or teatime. Likewise, copy shops prefer to receive service engineers in the early morning or after closing time. Service organisations comply with these requirements, because this enables the field engineer to work without a stressed customer who is constantly informing whether progress is being made. Moreover, the productivity of field engineers is expected to rise, as less time is lost in traffic jams.

A much smaller, but still significant, group of logistics managers explained unequivocally that they would reject the created opportunities of off-peak distribution and abolished time windows (*do nothing*). Although the potential merits of night distribution are acknowledged (increased productivity of personnel and capital investments), the main barriers to increased night distribution are summarised as:

- *Higher salary expenses*: working at night can involve extra allowances on top of the normal salaries of up to 15 or 25 per cent.
- *Availability of personnel*: working overtime occasionally is not problematic, but hiring personnel for night distribution on a structural basis proves to be difficult given the current labour market conditions.
- *Lower efficiency*: night distribution requires a certain critical volume to be efficient. If insufficient numbers of customers engage in night distribution, average vehicle load factors could be too low to justify the increased salary expenses. It is claimed that the current market for night distribution is still too fragmented to be efficient. OEMs only participate in off-peak distribution, provided that all large retailers join in the project, and retailers want the same from the most important OEMs. This is confirmed by the recent experiences of the Dadira-pilot project [Van Stijn, 2000]: night distribution has come to a deadlock, because everybody seems to be waiting for everyone else.

As some of these respondents claimed, the current circumstances (customer requirements, congestion delays) do not necessitate or justify the shift towards night distribution as yet. One respondent even asserted that he would only consider night distribution as soon as congestion delays would rise up to three or four hours a day.

Two other responses to increased time-flexibility include the *adjustment of the DC's layout* (in order to reduce the noise nuisance for neighbours) and the increased *mechanisation of handling activities* (to circumvent the higher salary costs and/or labour market problems discussed above). These responses can however be viewed as creating the necessary preconditions for a future shift towards off-peak distribution.

The final reaction to the second policy scenario involves the implementation of remote diagnosis in the parts service industry. If customers were prepared to allow service activities at night, some service managers would try to let the field engineers work from their homes in the first place. With the help of modern information and communication technology, it is sometimes possible to solve electronic problems with a remote control system. In such a system, the field engineer is stand-by for emergencies, and may be able to repair the customer's system without having to leave his home (prevention of service trips).

Effectiveness of policy scenario 2
The second policy scenario does contribute to the expected shift to off-peak hours, mostly in the form of contracting out the off-peak activities to LSPs. Unfortunately however, as the policy responses revealed, this does not necessarily lead to higher transport efficiency. To date, night distribution is claimed to be too fragmented, which results in transport inefficiencies. The OEMs claim to be prepared to engage in night distribution, provided that all retailers participate. Therefore, one fifth of the respondents in the food industry would choose not to change anything as a consequence of the new opportunities offered. Consequently, policy efforts will have to be aimed at promoting the critical volume required to make night distribution more efficient. This could be done by facilitating a platform for shippers, retailers and LSPs, in order to generate sufficient economies of scale.

Policy scenario 3: Promote modal shift

Anticipated effects
Under this scenario we pictured a future where the relative attractiveness of road transport (in terms of transit time and on-time reliability) would be seriously endangered by a dramatic rise of congestion delays and by the emergence of competitive intermodal alternatives. According to the findings of the expert workshop, such a direct modal shift policy could result in reduced modal share of road transport (D10) and relaxed customer service requirements (C10).

The expected impacts of a decreasing modal share of road transport are obvious: a contribution to a lower macro-level modal share. Assuming that the above modal shift policy effectively leads to lower service standards (C10; e.g. lower frequency of delivery) we projected several impacts on the logistics choice behaviour of the OEM. Reduced service levels (e.g. established in a co-makership relation) would for example lead to higher levels of consolidation (D7). In this way, a modal shift policy could contribute to the realisation of macro-level efficiency goals. In Chapter 4 we however realised that service levels could well prove to be irreversible, or that lower service levels might not have too many micro-level logistics impacts because of choice inertia.

Stated-adaptations

The stated-adaptation experiment among food and service managers revealed that the suggested modal shift policy generally does not produce the intended impacts (i.e. modal shift and relaxation of customer service requirements). Nevertheless, modal shift policies could contribute to improved transport efficiency (see Table 7-3). The main message from Table 7-3 is that logistics managers first use up operational choice options before taking more radical measures such as a modal shift or a change of customer service levels. In the following, we will discuss these forms of 'buffer capacity' within the existing logistics systems.

TABLE 7-3 RESPONSES TO INCREASED CONGESTION/ MODAL SHIFT POLICY

Policy reaction	**Percentage of respondents *food industry*** (n=20)	**Percentage of respondents *parts services*** (n=14)
Consolidate part shipments via LSP/ other OEMs	50	21
Shift to off-peak distribution	45	93
Adjust route planning	25	36
Consult/ inform customer *	20	71
Accept delay/ do nothing	15	57
Decentralise pattern of DCs	10	50
Consider alternative modes *	5	21
Remote diagnosis/ repair	0	57

* anticipated effect.

In the food industry, the first response to increasing road congestion is to *combine part shipments* more intensively. This response is less usual in the service industry, as outsourcing of service activities is not always appropriate. The consolidation option is employed by a number of food manufacturers in order to reduce increasing transport costs caused by congestion. By contracting out distribution activities, OEMs also hope to reverse some of the time delays and uncertainties, as specialised LSPs are believed to control logistics processes better than the OEMs themselves. A statement that summarises the attitude of many respondents in this respect is:

> *We have deliberately contracted out our distribution activities to an LSP to prevent congestion problems. We pay congestion surcharges of around 70 NLG per hour, but other than that, it remains the responsibility of the LSP to meet customer requirements.*

Despite the evident opportunities, some respondents had also experienced barriers to increased consolidation:

- *Insufficient returns on investment*: vehicle or facility sharing usually involves investment costs that have to be recovered by a more efficient operation. However, the potential benefits of freight bundling are not always high enough to justify the required investments.
- *Lack of mutual trust among OEMs*: competing OEMs are sometimes reluctant to share the same vehicle for strategic reasons. Further freight consolidation might therefore require a change in attitudes towards the sharing of facilities.
- *Lack of confidence in capabilities of LSP*: OEMs do not always believe in the efficiency and effectiveness of the LSPs' services and consequently do not risk using the services offered.
- *Choice inertia*: the historic relationship between an OEM and an LSP also appears to play an important role in the decision whether or not to change between service providers. The OEM often has worked with one LSP for a long time and is therefore not inclined to switch to another LSP in order to enable co-operation with other OEMs.

These four reasons are mentioned by the respondents to explain why current consolidation initiatives often come to a standstill.

The most mentioned policy response in the service industry (and the second response in the food sector) is the *shift to off-peak distribution*, in order to avoid congestion delays. Whereas field engineers regularly had to pass by a distribution centre to collect service parts, they are nowadays often provided with the required parts during the night. Consequently, the field engineers can directly drive to the first customer and thereby avoid part of the traffic jams. Moreover, as has been discussed in the previous, the service and food organisations tend to shift part of their own service and distribution activities to off-peak hours in order to reduce productivity losses.

An *adjustment of route planning* is the third option mentioned by the food managers. It is claimed that traffic jams have become structural and therefore more easy to incorporate in delivery schedules. Mainly in the parts service industry, logistics managers exploit the advantages of dynamic route planning systems that allocate service tasks to the field engineer who can be on site most rapidly. Sometimes these systems are also equipped with traffic updates. Nevertheless, respondents recognise that alternative routes are not always available, especially for the regular shipments to retailers.

As is claimed by certain respondents, as congestion problems rise, customers will also be more prepared to reconsider their demands. At particular times of the day, orders cannot be delivered 100 per cent on time. Therefore, some respondents in the parts service industry would choose to *change the terms of service contracts*, and guarantee fix times of eight instead of four hours. Additionally, on-board tracking and tracing systems could be used to inform a customer as soon as possible in case of delays. Transhipment schedules can possibly be revised online, which reduces waiting times at loading docks. Moreover, the customer's patience increases when such systems give reliable information about the modified estimated time of arrival. It should be noted that the percentage of OEMs that would consult the customer is significantly higher in the service industry than in the food industry: the food managers usually do not have the required countervailing power with respect to customers.

As can be seen from a comparison between Table 7-1 and Table 7-3, food managers are more impressed by a drastic deterioration of transit times and unreliability than by cost increases: the proportion of managers who would *do nothing* as a consequence of the policy scenario is smaller in case transit times and transit time reliability are endangered. This is consistent with the results of the conjoint analysis (see previous chapter), which showed that on-time reliability is by far the most important logistics performance attribute in the food industry. Only 15 per cent of the food managers would just accept the suggested delays, as they can usually not afford to offer unreliable services. Compared to the percentage of food managers who would accept a rise of transport costs by 25 per cent (see first policy scenario; 70 per cent), the respondents are far less tolerant with regard to congestion delays. The OEMs clearly cannot accept the combination of extra transport costs, longer and unreliable lead times: time delays necessitate action of the logistics managers in the food industry.

More than 50 per cent of the service managers partly decide to do nothing and accept the congestion delays. This attitude is accounted for by the relative power position of the service organisations and the reimbursement system employed: the first two hours driving time per day are unpaid working hours for the field engineers. Although the number of calls per day is effectively reduced when the field engineer spends more time in his car, the service managers are generally only concerned about the congestion delays that consume more than half an hour or so.

Another response to increased congestion and improved intermodal services would be to *decentralise distribution networks*. DCs are located closer to customers in the food industry, and in the service industry smaller districts are defined for field engineers (i.e. hiring more field engineers). Surprisingly few logistics managers would *consider using an alternative mode* of transportation, as intermodal alternatives are still believed to be infeasible for time-sensitive national shipments. Despite this general belief, some respondents claim to be receptive to new intermodal concepts. That this is not just a lip service is demonstrated by the fact that some of these OEMs actually use intermodal alternatives for export shipments. Finally, *remote diagnosis and repair* is mentioned by more than half of the service managers to cope with increased congestion. These services can only be employed for certain routine and non-mechanical service activities. The proportion of services eligible for remote repair can be enlarged when the call centre is manned by in-house technicians, who can readily judge whether the call requires a visit by the field engineer or not.

Effectiveness of policy scenario 3

The third policy scenario of increased road congestion and improved intermodal alternatives was aimed at achieving a modal shift (D10) and a relaxation of customer service requirements (C10). These policy goals are attained according to the responses of the respondents, but only to limited extent. A very small minority would consider using another mode than road transport, while in the food industry just one fifth of the logistics managers thought about renegotiating customer service requirements. Due to the different market conditions, this last proportion lies well above 70 per cent in the parts service industry. It should be noted however, that the modal shift policies could contribute to the achievement of transport efficiency goals, since the first two responses to this policy scenario include efficiency measures such as increased consolidation via LSPs and a shift to off-peak distribution.

Policy scenario 4: Promote efficiency

Anticipated effects

The last proposed scenario involved the re-negotiation of customer service standards between customer and supplier, in order to improve transport efficiency. A relaxation of customer demands (C10) forms the basis of this scenario. The frequency of delivery might be reduced by stronger co-ordination and information exchange between the various chain members (e.g. vendor-managed inventory). Furthermore, a direct increase of inventory levels (D6), a higher level of consolidation (D7) and a larger proportion of transport contracted out (D13) would be the result of this scenario. Ultimately, these model factors would help to achieve the policy goals of reduced modal share of road transport (I1), increasing average vehicle carrying capacity (I4), improving transport efficiency (I5) and reducing the number of empty returns (I6).

This policy scenario created disunity among the respondents with regard to the realism of the scenario itself. One group of respondents could hardly imagine a future where customers would agree to lower service levels. They additionally argued that the frequency of delivery is not the core problem, but rather the limited co-operation among OEMs. Another group of respondents could however envisage a reduction of service levels, based on current developments. Food managers identified the trend towards vendor-managed inventory as a means of controlling frequency levels and load factors, while retailers increasingly demand full loads of their suppliers because of backdoor congestion problems: too many trucks occupy the loading and transhipment facilities at the retailers' DCs, as a result of which retailers have started to demand a lower number of consolidated shipments or organised backhauling (collection shipments) themselves. Furthermore, some service managers claimed that many shipments have been prevented by better product quality and better call screening. One service company for example reported a reduction of the number of yearly service trips from 7.000 to 5.000 (while the same turnover was realised), owing to stricter call screening. Potentially, these changes in logistics choice behaviour lead to the desired macro-impacts of increased transport efficiency (I5).

TABLE 7-4 RESPONSES TO PROMOTION OF EFFICIENCY

Policy reaction	**Percentage of respondents *food industry*** (n=20)	**Percentage of respondents *parts services*** (n=14)
Do nothing/ outsourcing of distribution activities	45	57
Comply with decreased frequency *	35	50
Use larger vehicles	15	0
Change production concept/ larger batch sizes	10	0

* anticipated effect.

Stated-adaptations

The service managers who claim to *change nothing* as consequence of the suggested policy scenario claim that condition-dependent service (i.e. only in case of technical malfunction) is already implemented in reality. This suggests that the number of service trips has already been reduced to the minimum. Therefore, this group of respondents asserts that the described scenario would not be able to bring about changes to the current actual situation. Most OEMs in the food industry tend to also leave service levels unaffected under the suggested scenario and claim to contract out distribution activities to compensate for the higher transport costs caused by higher frequencies.

The second group of respondents *complies with lower customer requirements*, if that is what the customer really wants. If the scenario of reduced service levels persisted, a few of these OEMs would consider *using larger vehicles* because of the larger order sizes. A potato products manufacturer could use larger trucks than are currently allowed, in order to improve transport efficiency. In connection with economies of scale in transport, a minority of respondents would contemplate a return to an *inventory-based production concept*: large series to cash in on economies of scale in production processes. This (relatively unlikely) choice option would ultimately cause a rise in the average vehicle carrying capacity (14).

Effectiveness of policy scenario 4

According to the respondents, this policy scenario was the most unlikely of the four. It however elicited a response with regard to the stated behaviour of logistics managers in case customer service demands were in fact reduced. This scenario materialises as retailers gradually start to identify product segments for which different shipment frequencies are demanded. As it appeared, service levels are not reversed immediately after a customer would request to do so. The choice inertia observed among almost half of the respondents in the food industry can be traced back to the persistent assumption that better service levels ultimately pay off in terms of higher market shares and revenues. For this reason, the intended policy goals are only achieved for 35 to 50 per cent of the respondents. A small minority of (bulk products) manufacturers would consider using larger trucks, as current vehicle sizes are limited by legal regulations.

Evaluation

The types of stated-responses that were recorded in the experiments with service and food managers were mainly permissive responses; i.e. they invited rather than demanded a response. This is because we have deliberately selected policy scenarios that take into account current business trends.

The three basic responses we have recorded are summarised as:

- *Do nothing*: the changes described in the policy scenario do not incite the respondent to take action of any kind. The opportunities offered or the restrictions imposed are not strong enough to justify changes made by the logistics manager. The intended effects of the policy package are not realised.
- *Involve other supply chain members*: as we saw in the above, logistics managers often rely on the co-operation of other chain members such as LSPs or customers. This kind of response requires the forced or agreed transfer of responsibilities, in order to protect the logistics manager from having to make too many adjustments himself. The effectiveness of the policy scenario is therefore often undermined, except when the policy measures have the desired effects on other supply chain members.
- *Make changes to own logistics organisation*: this involves the direct adjustment of the logistics manager's own logistics operations, needed to cope with the policy change. The policy scenario is potentially the most effective in this case, apart from the fact that undesired or unintended effects could appear.

The first two basic responses reflect the circumstances under which the buffer capacity of the logistics system is the largest: the system can absorb or neutralise the policy change without affecting the intended target population. We saw in the food industry, that the policy scenarios, which affect the on-time reliability performance of logistics organisations (e.g. a scenario with drastically deteriorating road congestion), offer less 'escape routes' than pricing policies. This confirms the results of the conjoint analysis discussed in the previous chapter: logistics managers in the Dutch food industry proved to be more susceptible to on-time reliability than transport costs. In the parts service industry, logistics managers have more opportunities to either do nothing or involve other supply chain members in a solution. This is caused by the relative supply chain power of the service organisations.

Possible response biases

The stated responses to the policy scenarios could contain biases. First, it is likely that the respondents' reactions are more elastic in an interview than in a real world setting. We have attempted to limit this *overstating bias* by constantly linking the feasibility of the suggested adaptations to the current logistics organisation of the respondent. The price we had to pay for the increased realism of the experiment is that we mainly recorded short- to medium-term logistics adaptations. However, short-term constraints can be expected to play a decisive role in determining the success of a policy measure, and therefore require our attention. Second, so-called *policy response biases* might have occurred, especially with regard to the 'threatening' scenario 1 (*higher road charges*) and to a lesser extent scenario 3 (*increased congestion*). We found indications for this bias in the answers to the first policy scenario, by cross-checking the stated-responses with the conjoint analysis results. The other two scenarios involve more positive action and new choice options, which largely cancels out policy response biases.

The results of the stated-response experiments cannot (but were not intended to either) be used to quantify the actual behaviour of the respondents under various policy scenarios. The experiments were intended as a first and rough appraisal of the policy effects. The research methodology used proved to be sufficient in order to identify the most promising elements of the policy scenarios. In the next section, we will elaborate and interpret the findings of the stated-response experiments by means of the revised conceptual model.

7.5 INTERPRETATION OF STATED RESPONSES

In order to achieve a vehicle-kilometre reduction in a business environment that is characterised by increasing time-sensitivity, we found that two elements in our revised conceptual model hold a crucial position: factor D7 (*level of consolidation*) and D10 (*modal share of road transport*). All the discussed policy scenarios ultimately attempt to influence these two factors. In the stated-adaptation experiments, we found that the policy initiatives aimed at achieving improved efficiency have better chances than the proposed modal shift policies.

In this sub-section, we will discuss the main reasons why the suggested policy scenarios do or do not work in the intended direction. We will do this by means of two subsets of relationships that are deduced from the revised conceptual model. This analysis provides lessons for policy directions and enables us to take into account the realities of logistics choice behaviour when formulating policy suggestions.

Realising higher level of consolidation (D7)

Figure 7-8 shows the conceptual model factors that together determine the level of consolidation. A higher sales volume per customer (C14) or a smaller number of SKUs (C15) for example contributes to a higher level of consolidation. The underlying second-order as well as third-order requirements for these factors are also displayed in Figure 7-8.

Interpretation of asymmetric relationships

The majority of the (solid) arrows in Figure 7-8 mirror confirmed relationships between the model factors. Three relationships are however asymmetric relationships (see the broken arrows). Let us use the relationship between C3 (*market share of the OEM*) and C15 (*number of product variations or SKUs*) as an illustration. This relationship was recorded in a particular direction, namely, if an OEM is confronted with *decreasing* market shares, he will tend to introduce *more product variations* in order to strengthen his market position. The asymmetry of this relationship lies in the fact that it does not hold the other way round. If the same OEM is successful and obtains a larger market share, he will not automatically reduce the number of products introduced. The same goes for the relationships between C3 (*higher market share OEM*)/C10 (*higher customer service demands*) and C9 (*lower level of service offered by the OEM*). The OEM will raise his service levels in case of *decreasing* market shares and *more demanding* customers, but a reduction of service levels is unlikely in the event of *rising* market shares and *less demanding* customers. The grey boxes in Figure 7-8 therefore represent model factors for which effectively no relationship with lower level factors exist, and consequently, for which no relevant points of leverage can be identified.

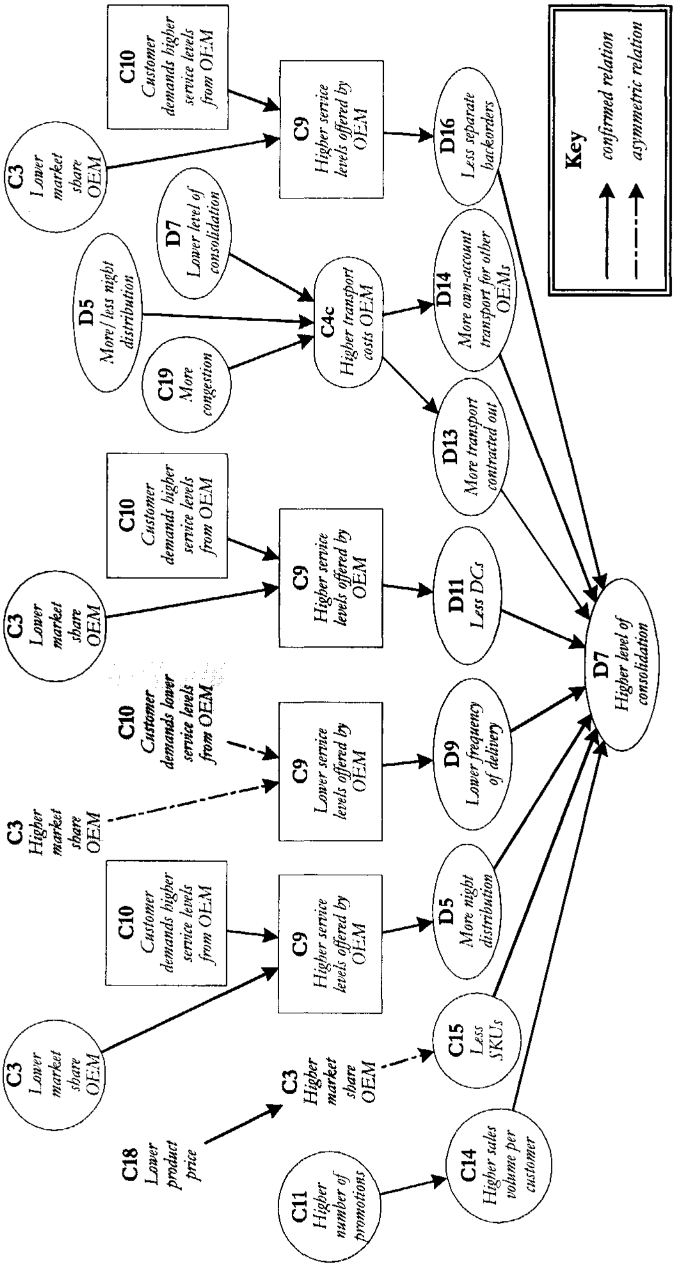


FIGURE 7-8 REQUIREMENTS FOR HIGHER LEVEL OF CONSOLIDATION

We had to make assumptions with respect to the relationship between D5 (*proportion of night distribution*)/D9 (*frequency of delivery*) and the level of consolidation (D7). First, we saw that the impact of night distribution on the level of consolidation depends on whether enough critical volume can be generated during off-peak hours. In Figure 7-8 we assumed that more night distribution leads to higher levels of consolidation. Second, we presumed that a higher frequency of delivery essentially causes lower load factors, although in practice we have encountered a few exceptions to this rule.

When we look at the points of leverage in Figure 7-8, we can see some autonomous developments that are beyond the sphere of influence for transport policy initiatives. The first of these is C14 (*higher sales volume per customer*): this model factor autonomously develops in the desired direction, since the market concentration among retailers in the food industry seems to continue. The second autonomous market development is the number of SKUs (C15). The average level of consolidation would be improved if OEMs could be induced to reduce the number of product introductions. However, since product variations are introduced for marketing or competitive reasons, opportunities for policy intervention seem to be limited. Market forces such as the increasing scarcity of shelf space might be able to reverse the seemingly unrelenting 'introduction-mania' among OEMs.

Some remaining factors that can contribute to a higher consolidation level may nevertheless be subject to policy influence:

- *D5 (more night distribution)*: the trend towards more night distribution is also an autonomous trend that is pushed by market considerations such as threatened market shares and higher customer service demands. As we found in the previous section however, several barriers (e.g. insufficient volume) trouble the existing off-peak distribution initiatives. In the next section, we will discuss some of the policy opportunities that could help overcome these barriers.
- *D9 (lower frequency of delivery)*: some examples encountered in the interviews with logistics managers revealed that a trend towards lower service levels could sometimes be discerned. Especially in the cases where OEMs take up the responsibility of managing the inventory levels at the retailers' DCs, OEMs gain more control over the frequency of delivery. Increased supply chain integration is therefore beneficial to raising load factors. Nevertheless, it should be noted that these examples reflect the state-of-the-art rather than the common practice in the Dutch food industry. For this reason, policy support for this model factor might be advisable.
- *D13 (more transport contracted out)/D14 (more own-account transport for other OEMs)*: as transport costs rise (e.g. as a result of increasing congestion, low load factors), OEMs are inclined to contract out their distribution activities or to organise third-party transport by themselves. The policy responses to scenarios 1 and 3 also confirmed this way of conduct. Policy initiatives could be formulated in order to remove some of the encountered barriers to further consolidation.

We will discuss the policy implications and suggestions following from this analysis in more detail in section 7.6.

Realising a modal shift (D10)

Figure 7-9 shows that the circumstances for achieving a modal shift are far less favourable than for realising transport efficiency. Most of the model relationships that are connected to the modal share (D10) prove to be asymmetric model factors. As the previous stated-adaptation analysis already showed, an imaginable reduction of service levels (or any other logistics change) that would create opportunities for a modal shift would hardly result in a reduction of the modal share of road transport. Again, the asymmetry of model relationships implies that effectively no relationship between the model factors exists.

The first-order factors that would contribute to a modal shift include the reduction of service levels (C9) and a reduction of the percentage of products made just-in-time (D4). If for some reason, both of these factors would be reduced (e.g. as a result of VMI- or co-maker relationships), the OEM would not actually change to another mode of transportation. Even if it came to that, we observed that the conditions needed to realise a reduction in the customer service requirements (C10) are hardly attainable. For instance, *lower* market shares of the customer (C5) often lead to higher customer service demands, but *higher* market shares do not cause the opposite. Likewise, *higher* inventory costs (C6b) cause the customer to demand higher service levels, but a *decrease* in inventory costs does not translate into lower service demands.

In conclusion, despite the presence of the conditions for a 'modal shift', the arguments for a 'modal stay' remain unaffected. These include factors such as customer service requirements, existing investments (e.g. load units, handling equipment, vehicles), installed production systems, historic relations with road carriers, and a lack of faith in the service performance of intermodal alternatives. The current logistics systems of the OEMs are completely geared towards the use of road transport, which obviously provides an unfavourable breeding ground for new alternatives. Our findings match Short's [1995], who maintains that the forces that keep the position of road transport in place are very powerful. He adds that very strong measures will be needed to halt and reverse the trends. The shift to a more efficient transport operation is less path-dependent than a modal shift, which explains why policy initiatives that are placed in a time-sensitive business environment and which are aimed at efficiency improvements, have better chances than modal shift policies.

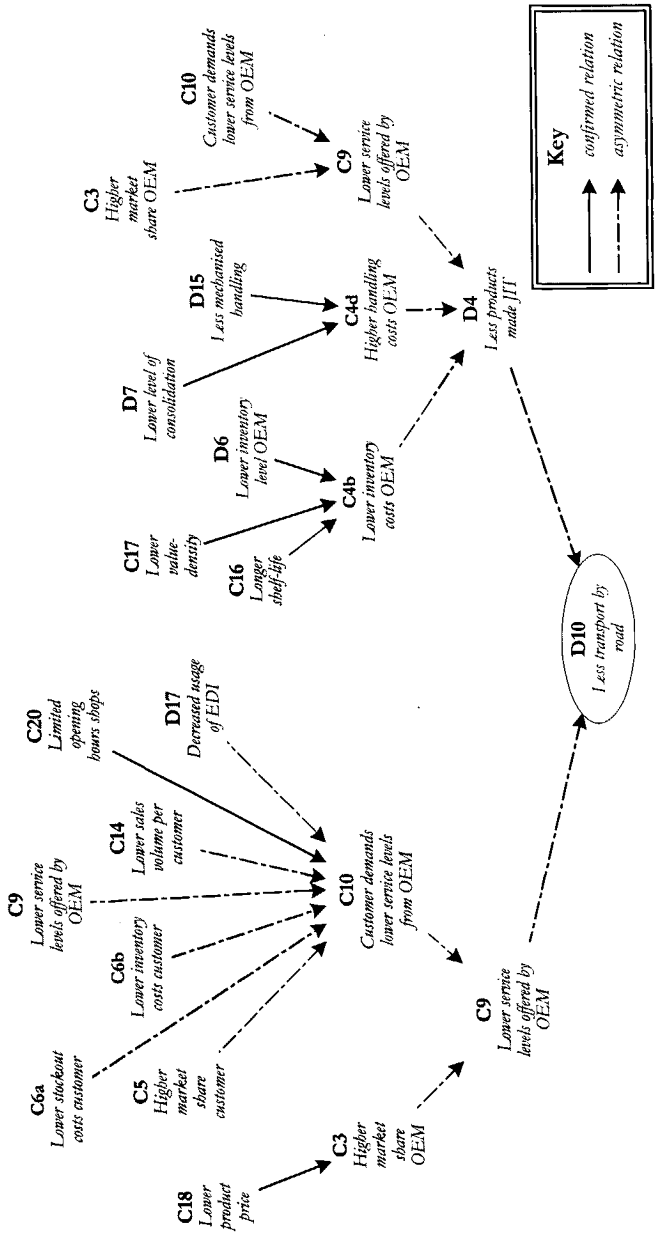


FIGURE 7-9 **REQUIREMENTS FOR MODAL SHIFT**

7.6 CONCLUSIONS: POLICY DIRECTIONS AND RECOMMENDATIONS

The road towards the formulation of effective freight transport policies is paved with all kinds of difficulties. Not to mention the practical implementation problems of policy initiatives (which are a question of policy *management*), we have concentrated on the challenges of policy *analysis*: how to influence the relevant actors' behaviour, so that the system moves in the desired direction? The limited effectiveness of policy initiatives can often be traced back to the fact that the proposed policy tactics are not able to come to grips with the complicated and interrelated logistics decision-making process of suppliers, OEMs, customers, LSPs and other supply chain members. With our empirically based approach, we have tried to put some pieces of the large puzzle together.

To this end, we have developed a conceptual model that describes logistics choice behaviour of the different supply chain members. Moreover, we tested four policy scenarios during a series of interviews with real-life logistics decision-makers, in order to make a rough appraisal of the effectiveness of the proposed policy initiatives. The combination of these two analyses allows us to make recommendations about policy directions that might be successful in reducing the number of vehicle-kilometres in a logistics environment that is characterised by increasing time-sensitivity.

The resulting model of logistics choice behaviour produces two seemingly incompatible messages, namely one of ***overall system stability*** and one of ***dynamism in logistics choice behaviour***. First, the behaviour of the logistics managers gives evidence of a strong pull in the direction of stability. When faced with external or internal stimuli (e.g. higher customer service requirements, policy measures), many of the logistics managers' efforts appear to be aimed at retaining the status quo of the overall logistics system's performance; i.e. adjust the logistics choice behaviour in such a way that higher-level logistics goals (e.g. contribution to market share, cost reductions) can still be achieved. Second, the process of maintaining the status quo sometimes involves dynamism. The logistics manager will first consider doing nothing if he believes that the stimulus does not affect his logistics system too much, but if it does, other supply chain partners could be involved or logistics adaptations to the logistics manager's own logistics organisation are made. For instance, we saw that the rise of customer service requirements caused all kinds of cost transfers in the logistics food chain, followed by a series of logistics adaptations that are all aimed at compensating the cost rises.

Our empirical analyses also revealed that not all model factors develop in a (from a policy perspective) undesired direction. Some of the autonomous logistics changes resulting from increased time-sensitivity actually support the macro-level policy objectives. The emergence of consolidation services provides an illustration of these self-regulating mechanisms. However, as promising as these mechanisms may be, according to the respondents they are most probably insufficient to turn the tide of ever-increasing vehicle-kilometres. This is because some of the discussed mechanisms are hindered by several barriers. Therefore, policy initiatives will continue to be important to either reverse undesired trends or further support otherwise 'self-regulating' mechanisms.

Policy instruments

Before we discuss our suggestions for freight transport policy directions, we will briefly discuss the policy instruments that are available to public authorities in order to operationalise policy initiatives. Based on overviews produced by the European Conference of Ministers of Transport [1998] and Geurs and Van Wee [1997] we identified the following policy instruments:

- *Communication*: breaking dominant (and sometimes erroneous) perceptions by providing information about alternative choice options (so-called re-framing), for instance by marketing of alternative modes of transportation, organising demonstration projects.
- *Regulation*: laws and physical measures, e.g. through spatial planning.
- *Voluntary agreements*: covenants in which public and private parties agree upon future behaviour.
- *Infrastructure*: providing new choice options, removing or adapting choice options, e.g. in the provision of infrastructure.
- *Economic instruments*: financial instruments, such as subsidies or taxes in order to promote desired behaviour.

In the following sub-sections, we will refer to these instruments when formulating the policy suggestions based on our analysis. We will start the discussion with the policy option of increasing transport efficiency, followed by the lessons learned for modal shift policies. Finally, we will briefly examine remaining directions as regards future policy initiatives.

Towards increased transport efficiency

Two factors from the conceptual model, C14 (*higher sales volume per customer*) and D11 (*number of DCs*), autonomously promote higher transport efficiency, since the market concentration and rationalisation among retailers and OEMs in the food industry seem to continue. These self-regulating mechanisms therefore do not require policy support. Another model factor, C15 (*number of introductions/SKUs*) clearly shows an undesired trend, as ever more products are introduced every year. The only market restraint on the 'introduction-mania' is provided by the decreasing shelf space in shops. Covenants in order to reduce the number of product variations appear unfeasible, because variation is one of the core competitive factors of many food companies.

The remaining points of leverage for achieving more efficient transport systems are concentrated around two policy directions: *increased off-peak distribution* and *increased consolidation.* We have examined the option of *night or off-peak distribution* extensively in the exploration of the second policy scenario. We found that the current initiatives in this direction are confronted with various barriers. The main challenge appeared to be the acquisition of enough critical volume to enable an efficient off-peak operation. It was found that the widespread implementation of night distribution has come to a deadlock so far, since the supply chain partners seem to be waiting for each other's initiatives. In this sense, the main role of governmental intervention would be to create or facilitate a project platform for increased co-operation and commitment (e.g. the Dadira-project in Haarlem). Provided that they are successful, these policy initiatives could serve to demonstrate the advantages of off-peak distribution. If needed, projects like these could be supported by allowing larger vehicles, especially designed for large night shipments.

Other barriers to the increased adoption of off-peak distribution include the higher salary expenses, the availability of personnel and noise regulations. Apart from collective labour agreements, it is questionable whether public authorities can or even should interfere with these issues. If night distribution proves to be successful, salary expenses will be recovered anyway. The regulations originating from the Noise Nuisance Act proved to be a relatively minor problem for the dissemination of night distribution. Policy tactics could however be formulated to support the further development of motor silencers, silent tailboards and materials handling equipment.

The second point of leverage for achieving more efficient transport systems encompasses increased consolidation through either lower frequency of delivery (D9) or the consolidation of consignments via LSPs and third-party transport (D13/D14). Whereas outsourcing of distribution activities has become the norm, we have encountered only a few examples of promising consolidation services originating from market initiatives. As is argued by the respondents, the common practice within the Dutch food industry still leaves room for considerable efficiency improvements. Policy initiatives could be formulated in order to remove some of the existing barriers to further consolidation.

One of these barriers is formed by a *lack of mutual trust among OEMs.* Co-operation among OEMs and retailers does not have a long history in the Dutch food industry. OEMs are sometimes reluctant to share the same vehicle or facilities for strategic reasons. Establishing a change of attitudes would therefore be a major challenge for future policy ambitions. Demonstration projects with a clear economic advantage could promote such a behavioural change. With respect to the co-ordination of delivery schedules, the approval of the retailers is required. If needed, these customers should be convinced to co-operate, possibly by a public authority who facilitates the re-negotiation process. In addition, issuing a 'green hallmark' for successful co-operative projects could be a way of rewarding market initiatives in this direction. Finally, as was shown by the policy scenario tests, road transport taxes or increased congestion delays could support existing consolidation efforts, but would generally not invoke these by themselves.

Second, a *lack of confidence in capabilities of LSPs* is observed. OEMs do not always believe in the efficiency of the LSPs' services and consequently do not risk using the services offered. Moreover, choice inertia plays a role in the decision whether or not to change between service providers. It is up to the LSPs to acquire a well-balanced set of clients and smart combinations of goods, and thereby offer attractive and efficient services. Demonstration projects can be employed to persuade future clients, while the (possibly subsidised) development of compartmentalised vehicles and pallet-containers could contribute to increasing the consolidation potential.

Finally, *insufficient returns on investment* are sometimes mentioned as a bottleneck. The potential benefits of freight bundling are not always high enough to justify the required investments (e.g. in terms of standardised load units, information systems). Governmental institutions could, if necessary, accept some of the investment costs involved (e.g. development costs of standardised load units).

Towards a modal shift

Modal shift policies, especially in the national setting, only advance with difficulty. We identified the time-sensitive forces that help keep the modal share of road transport in place. For policy efforts to achieve 'quick wins', it would seem advisable to first exhaust all possible efficiency measures, before putting one's money on modal shift policies. The logistics system and logistics choice behaviour have to be changed fundamentally, and many asymmetric model relationships have to be overcome before other modes of transportation will have a chance.

First, the *(perceived) unavailability of intermodal alternatives* is an important issue. In terms of service performance and tariffs, intermodal alternatives are still believed to be infeasible for time-sensitive national shipments. The Modal Shift-project (executed by the Dutch Shippers' Association [EVO, 1999] and involving 100 companies) also revealed that a modal shift can often not be established because of the non-competitive transport rates and lead times offered. Moreover, intermodal services are often non-available on specific routes. As we saw that customer service requirements can hardly be reduced due to the asymmetry of model relationships, the only remaining option is to develop competitive services. Policy efforts could be aimed at stimulating the development of intermodal alternatives, concepts and infrastructures by demonstration projects and subsidies to cover part of the development costs.

Second however, the *arguments for a 'modal stay'* usually prove to be persistent. The main risk of a modal shift policy is that, even if competitive intermodal services were offered, logistics choice behaviour is restrained by so-called switching costs. These include factors such as existing investments (e.g. load units, materials handling equipment, vehicles), installed production systems and historic relations with road carriers. These factors caused the very limited number of respondents who would even consider using alternative modes under the various policy scenarios. The problem with the suggested 'permissive' policy changes is that another choice option is offered, but numerous escape routes exist. We found that even a presumed dramatic deterioration of road congestion and a tax increase would not cause a modal shift. Effective pricing policies (causing a reversal of the described asymmetric relationships) would probably go well beyond the socially, and therefore politically, acceptable range. The gradually rising diesel prices for example already led to a wave of strikes and roadblocks all over Europe in the autumn of 2000. Forced, instead of permissive policy actions will not be feasible for the same reason. The best remaining policy options would be to support the development of competitive door-to-door intermodal services and thereby involving the existing LSPs as well.

The suggested policy directions of increased efficiency and modal shift imply the use of several policy instruments. Both the policy directions turned out to be hindered by factors such as limited trust among supply chain members, faith in the capabilities of LSPs and intermodal services, and the like. The obvious policy instruments that can and are already used to overcome these barriers involve communication and economic instruments: organising and partly financing demonstration projects to generate critical volumes, break dominant perceptions and show that economic benefits are attainable through increased co-ordination and co-operation. Voluntary covenants that formulate the desired logistics behaviour (e.g. adjusting delivery schedules in order to allow for higher load factors) have however gained ground only to a limited extent. Flanking measures, such as subsidising silent transport technologies, compartmentalised vehicles, road charges (economic instruments) or the deregulation of truck sizes (regulation) can further support these policy initiatives.

Towards transport prevention

Apart from efficiency and modal shift policies, the ideal policy direction would be to make transport activities redundant altogether. The respondents have mentioned the opportunities for transport prevention as well. First, in the parts service industry, remote diagnosis and repairs show that the possibilities for this policy direction are present. However, these service activities can only be applied to a certain subset of non-mechanical malfunction, and furthermore, not every electronic system is equipped for remote services as yet. Second, in the food industry we have encountered the first steps towards integrated and shared warehouses. A large LSP for example controls and facilitates the frozen food warehouse for two different retailers and some OEMs at one and the same facility. This means that incoming goods can be shipped in large bulk quantities. When a retailer requires a certain amount of products, the LSP only needs to make administrative changes, without the need for additional replenishment shipments. The removal of double or triple inventories therefore offers opportunities for the removal of transport activities as well.

8

Conclusions

In this final chapter, we will first summarise the main conclusions of the research project. In section 8.2, we will recapitulate the problem statement and the research questions of this dissertation. Furthermore, we will comprehensively discuss the findings for each research question in section 8.3. Finally, the methodological contributions and implications are examined in section 8.4.

8.1 MAIN MESSAGE

Time-based logistics strategies cause logistics impacts that partly undermine the freight transport policy objectives: transport inefficiencies become more likely and the position of road transport is strengthened rather than weakened. These impacts mainly set in when there is a strong power imbalance between the customer and supplier and/or when transport costs are less important than other costs (e.g. inventory or stockout cost). It should be stressed however, that not all time-based logistics decisions lead to negative macro-impacts: some actually contribute to the achievement of transport policy objectives, such as increased night distribution and increased outsourcing of distribution activities. Moreover, the cost transfers between chain partners, which are started off by the higher time-sensitivity of customers, also bring about compensating measures that reduce the potential negative macro-impacts. Following these self-regulatory mechanisms and points of leverage, we found that the policy measures that are aimed at improving the overall transport efficiency have better chances than modal shift policies. The limited number of policy instruments that can be applied to achieve efficiency improvements are already put into action by the current Dutch policy initiatives (e.g. demonstration projects), but could still be intensified to make the policy efforts more effective.

In order to be able to draw these conclusions, we have observed changes in logistics choice behaviour on the basis of a broad empirical base and translated these into a theoretical model. This model enables us to explain how and why logistics choice behaviour has changed as a consequence of the emergence of time-sensitivity. Moreover the macro-impacts of the observed changes can be assessed and analysed by means of the resulting model.

8.2 PROBLEM STATEMENT

In addition to time-sensitivity caused by the physical and economic perishability of goods, it is found that an increasing number of companies in different business industries have deliberately chosen to be time-sensitive. This is exemplified by the emergence of *time-based competition*: a business strategy that is built on the premise that time is a source of competitive advantage throughout every business process. These strategies are expected to have impacts on the logistics choice behaviour of individual firms (*micro-impacts*), as well as on the overall demand for freight transport (*macro-impacts*).

Societal relevance

The presumed macro-impacts of increasing time-sensitivity can be grouped in two categories: a decrease of shipment consolidation and a stronger preference for faster modes of transportation. Consequently, the emergence of time-based strategies would contribute to the rise in vehicle-kilometres, whereas the Dutch transport policy is aimed at reducing the demand for freight transport. Our research sheds light on the influence of micro-level logistics changes on the macro-level demand for transport. Moreover, the results of this research project help to identify and analyse possible points of leverage for transport policy measures.

Scientific relevance

The research was aimed at improving the understanding of the determinants of the demand for transport and the manner they interact and affect the evolution of traffic volumes. We have concentrated on the logistics changes brought about by the growing importance of time in logistics decision-making, since these could contain important clues as to how further freight transport developments can be directed towards the freight transport policy goals. This research therefore contributes to the extension of theoretical and empirical knowledge in the field of logistics choice behaviour and its societal impacts. In this sense, we have contributed to a better understanding of logistics choice behaviour. Based on an empirical bottom-up research approach, rather than the normative approach that is so often encountered in the logistics literature, we have systematised the knowledge and experiences of the logistics managers in different business industries. Consequently, this dissertation contributed to theory building and resulted in the formulation of a conceptual model. With the revised conceptual model, we were able to interpret the reactions of respondents to the policy scenarios and subsequently formulate recommendations for freight transport policy.

These research challenges were translated into five research questions:

Q1. *In which business industries does time-based competition appear as an important trend?*

Q2. *What caused the emergence of time-based competition in these economic sectors?*

Q3. *What are the micro-impacts of time-based strategies on logistics choice behaviour?*

Q4. *What macro-impacts do these changes in logistics choice behaviour have?*

Q5. *If macro-level demand for freight transport increases as a result of the implementation of time-based strategies, what suggestions for freight transport policy can be made?*

In the following section we will discuss the results of our research activities with respect to each of these research questions.

8.3 RESEARCH FINDINGS

Research question 1: relevance

Information for this research question was obtained from a literature review and a series of interviews with large logistics service providers. The results of the literature review were confirmed by the empirical research in the transport industry: the respondents recognised increasing time-sensitivity as a general business trend across all economic sectors. When asked to indicate which business sectors had witnessed the most marked increase in time pressure, the respondents pointed to sectors such as the automotive industry (including spare parts), the consumer electronics industry (especially cellular phones and computers), the food industry and the pharmaceutical industry.

The case study sectors that we concentrated on were the pharmaceutical, the food and the parts services industry. In the food and service industry, we measured the relative importance of the various aspects of logistics time (transit time, on-time reliability, frequency) by means of the conjoint analysis methodology. *On-time reliability* was found to be the most important time aspect in both the food and service industry. Furthermore, this analysis showed that service managers reject longer transit times, more so than do food managers. Transit time is therefore significantly more important in the parts service industry than in the food industry. This finding confirms observations from the literature, which suggested that the service industry can be seen as a benchmark industry as regards time-sensitivity and the degree of logistics sophistication implemented to comply with the extremely high customer service requirements. The causes and impacts of these time-requirements are discussed in the following two sub-sections.

Research question 2: causes

A first exploration of the causes of increasing time-sensitivity was executed by means of the already mentioned interviews with logistics service providers, as well as by a case study in the pharmaceutical industry. Based on the empirical analyses, we discerned three sets of explaining factors for the emergence of logistics acceleration: causes of increasing time-sensitivity stemming from the interaction between supply chain members and sources of haste originating from the supply chain member himself. Additionally, *technology-driven causes* of time-sensitivity can be discerned: the new opportunities of speedy transport and communications offer possibilities that are exploited to further accelerate logistics processes.

The interaction with other chain members consists of three aspects. First, the extent to which higher customer service demands are met depends on the degree of *supply chain power* the customer has in relation to its supplier. Second, once service standards have evolved to a higher level, they are often considered to be *irreversible*. This is because customers soon adjust their own logistics operations to fast, reliable and frequent supply and subsequently rely on higher service levels. Third, *mutual reinforcement* occurs in a situation of induced demand: a supplier offers higher service levels, which wakens the latent demand for such services.

The intrafirm causes of increasing time-sensitivity are divided in two sub-groups. *Revenue-driven sources of haste* mean that offering better logistics services contains competitive advantages or is needed to keep up with competing firms. Revenue-driven time-sensitivity is important in mature business sectors, as logistics performance has become an important competitive battleground (in addition to product's prices and physical qualities) in these sectors. This kind of revenue-driven time-sensitivity can for example be observed in the food sector. *Cost-driven sources of haste* consist of increased inventory risks and inventory reduction schemes implemented by supply chain partners. The move towards inventory (cost) reductions for example caused the need for fast replenishment cycles, as there is a smaller amount of buffer stock available. The computer, electronics, automotive, pharmaceutical and specialty chemical industry (sectors with introductory and growth products) are more likely to be time-sensitive due to cost-driven factors, because of the higher inventory risk costs of new products.

In the pharmaceutical case study, we learned that the materials management part is the least time-sensitive: revenue-driven time-sensitivity is only observed as far as the introduction of new drugs is concerned. Conversely, time is crucial for the shipment of drugs from wholesalers to pharmacists/general practitioners. Deliveries within two to three hours are normal, due to the legislative regulations and the oligopolistic market structure. The limited number of competing wholesalers and relatively powerful customers (pharmacies/GPs) leads to revenue-driven time-sensitivity among wholesalers, as lagging behind the industry norm could result in decreasing market shares and revenues.

Later analysis of the test cases in the food industry revealed that the mentioned groups of causes of time-sensitivity capture the most important factors: on the basis of the empirical work in the Dutch food industry, we identified seven main causes for increasing time-sensitivity in this industry:

- Better service levels offered by suppliers (mutual reinforcement).
- Increasing sales volume per retailer (increasing supply chain power).
- Extended opening hours of shops (irreversibility).
- Decreasing market share/revenues of retailer (revenue-driven).
- Increasing stockout costs for retailer (cost-driven).
- Increasing inventory costs for retailer (cost-driven).
- Increased use of EDI (technology-driven).

Research question 3: micro-impacts

A first exploration of the micro-impacts of increasing time-sensitivity was executed by means of an analysis of so-called time-space prisms. With the help of this 'chronogeographical' approach, we identified various time-reduction variants. The main groups of deduced time-reduction alternatives include:

- Accelerate order shipment (e.g. choose faster modes of transportation).
- Compress inert processes (e.g. reduce order transmittal and order processing time).
- Choose for co-location (e.g. concentrate on nearby customers).
- Eliminate links from the supply chain (e.g. reduce supplier base).
- Replace sequential by parallel processes (e.g. concurrent engineering).

These alternatives were illustrated by practical observations from a broad selection of logistics journals, in order to examine if and how these variants are put into practice. The list of time-reduction alternatives formed the basis of a conceptual model that identified the main logistics choices that are affected by increasing time-sensitivity. As became clear from the analysis, companies are faced with a broad set of choice options when faced with time pressure.

One of the aims of the follow-up research in the food industry was to recognise the prevalent logistics impacts of time-sensitivity. The following impacts turned out to be most common:

- Reduced supplier base.
- Increased JIT production.
- More night distribution.
- Higher frequency of delivery.
- Stronger position of road transport.
- Smaller number of DCs.
- Reduction of separate backorders.
- Increased usage of EDI.

We have observed that the emergence of time-sensitivity has first and foremost produced operational impacts: following from the answers of the respondents, *offering more frequent shipments* and *turning to night distribution* are the most popular changes in logistics choice behaviour under the new time regime.

We found two logistics decisions in the food industry, which were expected to, but appeared not to be affected by increasing time-sensitivity. These included *contracting out production activities* and *co-location.* None of the respondents touched upon the issue of making-or-buying in conjunction with increasing time-sensitivity, while agglomeration effects (shorter mutual distances) caused by logistics acceleration seem to be absent in the Dutch food industry as well.

The mentioned logistics decisions influence cost structures across the entire supply chain. Some cost elements are transferred from one supply chain member to another. These cost shifts in turn have far-reaching impacts on the logistics choice behaviour of the supply chain partners involved. A general impression shared by many logistics managers in the Dutch food industry is that manufacturers have had to face higher logistics costs, while retailers reap the benefits in terms of lower inventory costs and higher revenues. This impression is not always appropriate, because higher cost levels are not exclusively caused by customer demands, and because manufacturers themselves may not always have taken enough compensating measures. Manufacturers in the Dutch food industry can generally compensate for cost increases by adjusting their own logistics choice behaviour (e.g. hire third-party logistics service providers to reduce transport costs).

Research question 4: macro-impacts

The links between micro-level logistics impacts and macro-level impacts were established in the second part of the conceptual model. To this end, we have decomposed the overall number of vehicle-kilometres into a series of constituting elements (e.g. modal split, average distance, average shipment size, etcetera).

These elements were connected to the observed micro-impacts of increasing time-sensitivity on the basis of a literature review. For example, the micro-level decision to increase the frequency of delivery can be expected to have consequences for the level of consolidation. This in turn contributes to a change of two macro-level factors: the number of empty returns and the average utilisation rate of vehicles.

Our analysis of the logistics changes in the food industry showed that the main micro-impacts, which relate to the macro-level, focus on the *level of consolidation* and *modal choice*. In this respect, increasing time-sensitivity essentially has contributed to the rise in vehicle-kilometres. Mainly in the slow-moving and less-than-truckload segments, higher shipment frequencies have caused lower consolidation levels. This trend towards lower consolidation rates has been exacerbated by the continuous introduction of new products and stock-keeping units (e.g. soft drinks in bottles of 1.5 litres, 0.33l and 0.5l, cans, six-packs, crates, etcetera). This trend leads to a further disintegration of existing transport volumes. At the macro-level, these logistics trade-offs contribute to a reduction of average utilisation rates and an increase in the number of empty returns. The introduction of time-based competition also strengthened the position of road transport compared to alternative modes of transportation. The implementation of JIT-based production systems and the general rise in customer service requirements have made road transport ever more indispensable. This contributes to a rise (or at least a prolongation) of the modal split in favour of road transport and a reduction of the average vehicle carrying capacity.

However, it would be too simple to state that increased customer time-sensitivity can directly be translated into lower levels of consolidation and more vehicle-kilometres. It is important to note that current business trends do not all result in lower load factors. Some of the transport inefficiencies are compensated by autonomous market trends (e.g. concentration among retailers and consequently increasing drop sizes) and by the logistics decisions that have been taken by the manufacturers (often as a reaction to higher costs):

- *Increasing night distribution*: depending on whether enough volume is generated, night distribution could ultimately lead to improved consolidation and lower transport costs for the manufacturer.
- *Smaller number of DCs*: higher levels of consolidation are more easily achieved in a centralised distribution system than in a decentralised logistics structure.
- *Increased outsourcing of transport activities and own-account transport for other OEMs*: higher transport costs have caused many manufacturers to look for efficiency improvements in the form of network advantages, either by organising third-party transport activities by themselves or by contracting out distribution activities to specialised logistics service providers.
- *Reduction of separate backorders*: if service levels are raised, backorders can often be sent along with the next regular shipment, and still be on time.

- *Higher predictability/stability of demand*: with the help of information and communication technology and more open information sharing, production and shipments plans can be scheduled pro-actively, which improves efficiency.

The observed logistics systems therefore contain some *self-regulating* or *stabilising mechanisms*. Whereas the concentration trend among Dutch retailers may have reached its maximum, several respondents assert that there is still scope for considerable improvement in terms of consolidation services offered by logistics service providers.

Research question 5: policy implications

The goals of the Dutch transport policy plans were summarised in a goal tree. From this we could deduce the policy directions that can be used to attain the sustainability objectives: a shift to off-peak operations, reduced road traffic growth, improved driving practices and cleaner/quieter vehicles. A reduction in the growth of road transport can in turn be obtained by more efficient road transport, a modal shift to rail and waterway transport, and a reduction in the demand for freight transport.

The already mentioned conceptual model was not only used to analyse causes, micro-level logistics impacts and their macro-impacts, but also to deduce points of leverage for freight transport policy tactics. These ideas were combined with the results of an expert workshop. This workshop involved 13 policy-makers from different Dutch ministries and representatives of freight transport interest groups. The ideas for policy tactics that were put forward during the workshop were analysed by means of the conceptual framework, and combined into four policy scenarios.

- *Policy scenario 1*: Impose higher charges on road transport.
- *Policy scenario 2*: Extend time windows and promote 24-hour economy.
- *Policy scenario 3*: Promote modal shift.
- *Policy scenario 4*: Promote efficiency.

The preliminary test of both the conceptual model and the deduced policy scenarios was pursued in the food and parts service industry. This was done by examining the causality behind the conceptual model relations and by executing a so-called *stated-adaptation experiment*: the respondents were asked how they would react to the suggested policy scenarios and what logistics adaptations they would consider. This behavioural test provided a first appraisal of the policy tactics' effectiveness.

We saw in the food industry, that the policy scenarios, which affect the on-time reliability performance of logistics organisations (e.g. a scenario with drastically deteriorating road congestion), offer less 'escape routes' than pricing policies. This confirms the results of the conjoint analysis: logistics managers in the Dutch food industry proved to be more susceptible to on-time reliability than transport costs. In the parts service industry, logistics managers have more opportunities to either do nothing or involve other supply chain members in a solution. This is caused by the relative supply chain power of the service organisations.

All the discussed policy scenarios ultimately attempt to influence the modal split and transport efficiency. In the stated-adaptation experiments, we found that the policy initiatives aimed at achieving improved efficiency have better chances than the proposed modal shift policies. The analysis of the conceptual model provided explanations for this: efficiency measures seem to be more effective, because the underlying logistics choices are obstructed by asymmetric relationships to a much lesser extent for efficiency improvements than for modal shift policies. This means that points of leverage for efficiency measures are more widely available, while self-regulating trends already point in the desired direction as well.

Some of these mechanisms are however hindered by several barriers. Therefore, policy initiatives will continue to be important to either reverse undesired trends or further support otherwise 'self-regulating' mechanisms. Two of the encountered barriers to increased consolidation are formed by a *lack of mutual trust among manufacturers* and a *lack of confidence in capabilities of logistics service providers.* Policy initiatives such as demonstration projects and flanking measures (e.g. green hallmark for successful projects, road transport taxes, research for compartmentalised vehicles) could contribute to improved transport efficiency. Additionally, *insufficient returns on investment* are sometimes mentioned as a bottleneck for further consolidation.

The remaining points of leverage for achieving more efficient transport systems are centred around two policy directions: *increased off-peak distribution* and *increased consolidation.* In this sense, the main role of governmental intervention would be to create or facilitate a project platform for increased co-operation and commitment (such as the Dadira-project in Haarlem). Provided that they are successful, these policy initiatives could serve to demonstrate the advantages of off-peak distribution or consolidation services. If needed, allowing larger vehicles especially designed for large night shipments could support projects like these.

The stated-adaptation experiments and the conceptual model analysis clearly showed why modal shift policies, especially in the national setting, only advance with difficulty. The main reasons why a modal shift comes to a standstill are not only connected to the well-known breakeven distance that is not achieved in national shipments. We identified the time-sensitive forces that also keep the modal share of road transport in place; the logistics system and logistics choice behaviour have to be changed fundamentally, and many asymmetric model relationships have to be overcome before other modes of transportation will have a chance (e.g. 'irreversible' customer service levels). The main risk of a modal shift policy is therefore that, even if competitive intermodal services were offered, logistics choice behaviour is restrained by so-called switching costs, leading to choice inertia. These include factors such as existing investments (e.g. load units, materials handling equipment, vehicles), installed production systems and historic relations with road carriers.

Policy initiatives often do not entirely produce the desired results, even if a fundamental understanding of the logistics systems involved is available. This can mainly be attributed to the fact that only a limited number of leverage points can be identified, because of the asymmetry in relationships between decision elements, and the limited capacity of policy instruments to undo these irreversibilities. The permissive rather than the forced character of the existing tool box of policy measures still offers numerous escape routes to the target groups (e.g. passing on road charges, or contracting out distribution activities), which can sometimes undermine the effectiveness of the policy measure.

8.4 METHODOLOGICAL IMPLICATIONS

Empirical cycle

As the problem statement of our research project mainly required observations and analyses based on real-life problems, we used the empirical cycle as a design guideline for our research approach. The *observation* phase included an exploration of the relevance, causes and micro-impacts of time-sensitivity. This exploration was done by means of a literature study, a theoretical exploration of time-space prisms and a series of in-depth interviews and case studies in the transport industry (logistics service providers) and the pharmaceutical industry.

The time-space prisms yielded an exhaustive list of time-reduction alternatives and thereby formed the basis of the conceptual model developed in later stages of the research. This framework was supplemented with literature and case study data. The results of these research activities led to the *induction* of the descriptive conceptual model, which summarised the main groups of causes and micro-impacts of increasing time-sensitivity. The explorative nature of the literature review and interviews allowed us to keep track of practically all relevant logistics decision elements, without having to make too rigid restrictions or assumptions.

The conceptual model was employed for the *deduction* of two sets of hypotheses. The first included the hypothesised relationships between causes and micro-impacts of increasing time-sensitivity, while the second set involved presumed relationships between the micro- and macro-level impacts (including hypotheses about the effectiveness of different policy scenarios). The formulation of policy scenarios was also supported by the ideas generated during an expert workshop with policy-makers.

The second empirical phase was preceded by the development of a case study protocol, which consisted of three elements:

- *Direct questions* in order to refine the conceptual model, record causality behind the hypothesised relationships, detect asymmetric relationships and identify additional model factors and relationships.
- *Conjoint analysis* to quantify the degree of time-sensitivity of the case study companies.
- *Stated-adaptation techniques* to explore the future reactions of actual logistics decision-makers with regard to the proposed policy initiatives and determine the degrees of freedom at their disposal.

The *preliminary testing* of the hypotheses was executed in case studies in the food and service industry, involving in-depth interviews with almost 50 logistics managers, whose daily work involves logistics choice behaviour under increased time pressure. Every respondent was enabled to add something of his rationality to our theory. This can be seen as an advantage, since the case study methodology thereby fully exploits the expertise of the respondents. This phase therefore yielded a large amount of insights and information about actual logistics choice behaviour and the underlying considerations.

The use of different research methods provided a powerful combination, and enabled the mutual comparison of research findings:

- The results of the stated-adaptation experiment could be compared with the results of the descriptive part of the case study protocol: inconsistencies or wildly implausible responses could be detected through this link with reality.
- The results of the stated-adaptation experiments could be cross-checked with the conjoint analysis measurements, in order to identify policy response biases.
- The conjoint analysis usually invoked a lively discussion about the respondent's logistics requirements and logistics choices, and thereby contributed to the refinement of the conceptual model.
- The results of the direct questions and the conjoint analysis experiment, which were summarised in the revised conceptual model, could be used to interpret the results of the stated-adaptation experiment, and explain why certain policy scenarios are effective or not.

The case study methodology met the objective of being able to describe, interpret and explain recent and current logistics system behaviour, and moreover record causality and conceivable asymmetry of conceptual relations, whereas the conjoint analysis results produced interesting insights in the final trade-offs between different time aspects. The stated-adaptation experiments were intended as a first behavioural test and rough appraisal of the policy effects, and indeed enabled us (in combination with the other research results) to identify the most promising policy directions.

Generalisation of results

On the basis of a literature review and interviews in the transport sector, we identified the main business industries in which time-based competition has gained ground. Although the respondents claimed that logistics acceleration is a general phenomenon, some industry sectors could be regarded as the most time-sensitive: the automotive (including spare parts), the consumer electronics, the food and the pharmaceutical industry. We have selected the case study companies within all of these sectors except for the consumer electronics industry, in order to identify the causes, micro- and macro-impacts of time-sensitivity encountered in these types of firms. Within these companies, we have chosen to contact the general logistics manager, being the person who actually deals with logistics choice behaviour on a daily basis.

Therefore, the sampling strategy that we used was not random, but what is called *judgemental sampling*. The case study companies were deliberately selected because they could contribute to the construction of a conceptual model; i.e. they would support us in determining the impacts of increasing implementation of time-based strategies. Consequently, results are principally not representative of the whole of the case study industries or even the entire economy, but only of the subset of companies that engage in time-based business strategies. That is, we cannot, nor intended to, extend our conclusions to companies that are characterised as 'non-time-based competitors'.

In the food industry, we interviewed 33 logistics managers, most of them being market leaders in their product category. Consequently, we interviewed representatives of the companies who are responsible for the bulk of branded and own-label products available in the Dutch retail outlets. Moreover, during the series of in-depth interviews, we gradually experienced that the respondents (independently from each other) were repeating the same model factors and relationships. The marginal contribution of each extra interview decreased as in later interviews no new factors or relationships were being introduced. We are therefore confident that the resulting revised conceptual model captures the important issues with respect to logistics decision-making under time pressure in the Dutch food industry. As regards the applicability of the revised conceptual model to time-based companies in other business industries, we have to take into account the specific *model factors* and the character of the conceptual *model relationships*.

First, the model factors (causes and micro-impacts of increasing time-sensitivity) that are incorporated in the revised conceptual model are based on our experiences in the Dutch pharmaceutical and food industry. The overall framework of the model is however general enough to apply to other sectors as well, as the main groups of logistics causes and micro-impacts that were identified in the food industry have also been observed in the spare parts industry.

Second, the model relationships were characterised as *probabilistic* since the logistics managers' freedom of choice always allows for deviations or 'anomalous' choices. On the basis of the stated-adaptations experiment, we found that the logistics managers' freedom of choice is mainly constrained by the balance of power between supplier and customer. This proved to be an important explanatory variable for the probability of certain logistics choices of individual supply chain members. For example, in business industries that are characterised by strong power imbalances (such as in the food and pharmaceutical industry), costs transfers and transport inefficiencies are more likely than in sectors such as the service industry, where the seller has the countervailing power to manipulate customer service demands. The results from the food and pharmaceutical industry can therefore be seen as representative for the time-sensitive logistics choice behaviour of the 'powerless', whereas the service companies reflect the relatively 'powerful'.

Finally, it should be noted that all case study sectors mainly operate on the *national level*. This means that the revised conceptual model is typical of domestic companies: time-based logistics choice behaviour could be different in more internationally operating sectors, such as the consumer electronics and automotive industries. The scope of our research findings is therefore confined to nationally oriented time-sensitive companies.

8.5 RECOMMENDATIONS FOR FURTHER RESEARCH

Throughout this dissertation, we have also paid attention to the limitations of this research project. In this last section, we will discuss the leads for future research that follow from our research activities.

Recommendations for further methodological developments

First, our research was aimed at developing a strong empirically based theory, which extends the knowledge on logistics choice behaviour, and subsequently enables us to deduce policy implications. The quantification or statistical testing of the model relationships was not the prime objective, since we needed to explore the causality of the relationships first. Future research efforts could be aimed at statistical testing of (part of) the observed causal relationships (e.g. by means of a survey).

Second, the stated-adaptation experiments that we used were intended to identify the most effective policy directions. The results of the stated-adaptations can however not be used to quantify the actual behaviour of the respondents under various policy scenarios; how many respondents would actually choose which policy response. Moreover, the experiment was constantly linked to the actual logistics organisation of the respondent (in order to retain realism of the experiment). This may have had the effect that we did not discover what long-term adaptations the logistics managers might employ. In order to identify possible long-term adjustments, the stated-adaptation experiment could be extended to form a simulation game with realistic cost- and revenue consequences tied to every suggested logistics adaptation, but with opportunities to identify and assess long-term logistics adaptations.

Recommendations for further empirical research

Third, our research has been concentrated on time-sensitive logistics choice behaviour in a national setting. Replication of the research activities in internationally operating business sectors could be executed in order to determine whether the same kind or different micro- and macro-impacts are observed at the international scale.

Fourth, we found that choice inertia or asymmetric model relationships play an important role in logistics decision making, especially when it comes to the effectiveness of policy initiatives. Certain thresholds need to be crossed before routine behaviour is changed, and this especially goes for the most permissive policy scenarios. Because our stated-adaptation experiments did not include varying levels of policy instruments (e.g. different levels of road transport taxes), further research could be aimed at discerning the threshold levels for which the observed asymmetries are reversed.

Fifth, our conceptual model and policy suggestions were mainly based on the experiences of manufacturers and some of their customers in the food and parts service industry. From their perspective, it is a 'fact' that more outsourcing of transport activities to specialised logistics service providers and centralisation of distribution centres have led to improved transport efficiency. This may sound plausible from their point of view, but upstream or downstream supply chain links could well be confronted with transport inefficiencies as a consequence of outsourcing and centralisation. These spill-over effects have been discussed implicitly in this dissertation, but may require focused attention in future research efforts.

Sixth, we have encountered uncertainties in the relation between night distribution and transport efficiency. We have found that the contribution of off-peak distribution is potentially beneficial to the efficiency of transport operations, but its implementation is currently mainly obstructed by a wait-and-see attitude of concerned partners. Furthermore, there are several other relevant aspects that require further research: first, does the provision of additional loading and unloading opportunities in time lead to the activation of latently present transport demand (induced demand) and secondly, does increased night distribution lead to the usage of smaller and relatively more polluting vehicles, in order to comply with noise regulations?

Finally, we started our research as an empirically based bottom-up research project. This implies that we described the logistics choice behaviour as it could be observed. We subsequently based our policy implications on the model that was formulated on the basis of that description. Consequently, the deduced policy implications are mainly aimed at redirecting existing trends and freight transport flows through efficiency and modal shift measures; the policy direction of transport prevention may not have received enough attention. De-materialisation of food products (e.g. microwave popcorn, soluble instant food products) or remote diagnosis and repair services are examples of this policy direction. Another form of transport prevention, namely spatial policies aimed at reducing the distances between origins and destinations of goods, has not been evaluated in this research either. Therefore, empirical research that is concentrated on the opportunities and effects of transport prevention policies would be valuable.

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Appendices

A

Exploratory case study protocol

Core business

- What are the core products of your company?
- What is the largest product group (measured in sales)?

Product characteristics

- Do you produce bulk or consumer products?
- What is the average value of these products?
- What is the average shelf-life of these products?
- Do these products require special transport facilities?

Logistics chain analysis

- What elements does the materials management part of the logistics chain consist of?
- What are the basic steps in the production process?
- What elements does the physical distribution part of the logistics chain consist of?

Materials management

- Which part of the chain is your responsibility?
- Has something changed in this for the last five years? What caused these changes?
- What modes of transportation are normally used in this part of the chain? Why are these modes preferred?
- Has the number of distribution centres for resources changed in the last five years? What caused these changes?
- What is the average number of inventory days for resources?
- What is the average shipment size of incoming goods?

- Has anything changed in this respect for the last five years? What caused these changes?
- What is the average transit distance for incoming shipments?
- What is the average on-time reliability of incoming shipments?
- Which of the following words best describes the logistics concept of your company:
    - Make to stock.
    - Assemble to order.
    - Make to order.
    - Purchase and make to order.
    - Design, purchase and make to order.

- Has anything changed in the last five years with respect to the logistics concept? What caused these changes?
- What is the average number of suppliers used by your company?
- Has anything changed in this respect for the last five years? What caused these changes?
- What is the average lead time offered by these suppliers?
- Has anything changed in this respect for the last five years? What caused these changes?
- Do you structurally measure the logistics performance level of your suppliers?
- What information technologies are used to transmit order data to the supplier?

Operations management

- Which of the following words best describes the logistics concept of your company:
    - Make to stock.
    - Assemble to order.
    - Make to order.
    - Purchase and make to order.
    - Design, purchase and make to order.

- Has anything changed in this respect for the last five years? What caused these changes?
- Which production location produces which products?
- What are the most important requirements imposed on you by your customers?
- What is the basic layout of the production process?
- Are production lead times structurally measured? If yes, how do you use these data?
- How do you handle setup and waiting times?
- Do you have the disposal of information of your suppliers and customers, so you can adjust your production planning? If yes, do you use these data as such?
- Is production personnel cross-trained?

Physical distribution

- Which part of the chain is your responsibility?
- What modes of transportation are normally used in this part of the chain? Why are these modes preferred?

- Has the number of distribution centres for final products changed in the last five years? What caused these changes?
- Which of the following words best describes the function of your DCs:
    - Storage function.
    - Value-added logistics centre.
    - Crossdocking centre.
- What is the average number of inventory days for final products?
- What is the average shipment size of outgoing goods?
- Has anything changed in this respect for the last five years? What caused these changes?
- What is the average transit distance for outgoing shipments?
- What is the average on-time reliability of outgoing shipments?
- How many LSPs does your company use?
- Has anything changed in this respect for the last five years? What caused these changes?
- Do you structurally measure the logistics performance level of your LSPs?
- What information technologies are used to transmit order data to the customers?

B

Relationships between causes, micro- and macro-impacts

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	I1	I2	I3	I4	I5	I6
market share/revenue supplier	**C1**							-																						
logistics costs supplier	**C2**							-																						
market share/revenue OEM	**C3**									-																				
logistics costs OEM	**C4**								+	-																				
market share/revenue customer	**C5**																													
logistics costs customer	**C6**																													
supplier offering better service to OEM	**C7**	+	+/-	+	-				+																					
OEM demanding better service from supplier	**C8**							+		+																				
OEM offering better service to customer	**C9**			+	+/-	+	-		+		+	+/-	-	-	+	+	+/-	+/-	-	+	+	-	-	+						
customer demanding better service from OEM	**C10**									+																				
% products contracted out	**D1**													+/-												+				
distance between suppliers and production facility	**D2**																			-							+			
# suppliers in supply chain	**D3**												+/-				+													
% of products made JIT	**D4**												-				-			+	+									
% night distribution	**D5**																	+/-												
inventory level finished goods/materials	**D6**																			-	-									
level of consolidation	**D7**																												+	-
distance between OEM and DCs	**D8**												+/-							-							+			
frequency of delivery	**D9**																	-			+									
% by road transport	**D10**																-					-			+			-		
# DCs in supply chain	**D11**																+	+/-	-				-							
distance between DCs and customers	**D12**																		+/-	-							+			
% transport contracted out	**D13**																	+												
modal split	**I1**																													
total traffic volume	**I2**																													
average distance	**I3**																													
vehicle carrying capacity	**I4**																													
average utilisation rate	**I5**																													
empty returns by road	**I6**																													

Note:
C = cause of logistics haste
D = logistics decision
I = macro-impact

C

Participants of expert workshop

Mr J.Ch.M. Besselink (Dutch Transport and Logistics Association (TLN))

Mr A.I.J.M. van der Hoorn (Transport Research Centre (AVV))

Mr H. Jansma (Ministry of Transport, Freight Transport Division)

Mr B. Kuipers (Transport Research Centre (AVV))

Mr M. Leuvenink (Province of North-Holland, GOVERA)

Mr H.C. Meuldijk (Ministry of Transport, Freight Transport Division)

Mr M. Muller (Ministry of Transport, Freight Transport Division)

Mr G.J. Prummel (Ministry of Economic Affairs)

Mr B.G. Radstaak (Holland International Distribution Council (NDL))

Mr H. ten Velden (Ministry of Spatial Planning)

Mr J. Visser (Ministry of Transport, Road Haulage Division)

Mr G. Wesselink (Province of South-Holland, GOVERA)

Mr S. Weijers (Transport Research Centre (AVV))

D

Policy tactics derived from expert workshop

Idea	**Description**
(01) Impose higher charges on road transport (spread, modal shift, efficiency)	Increase motor vehicle tax while charging for external costs, introduce time variable road pricing.
(02) Extend time windows (spread)	Time windows in cities lead to inefficient shipments to cities. Creating more time for deliveries means less haste.
(03) Support intermodal transport projects (modal shift)	Intermodal transhipment centres offer value-added logistics services, in some instances this reduces the need to transport to other locations.
(04) Improve alternatives to truck (modal shift)	Make alternative modes of transportation cheaper, more reliable and faster, especially with regard to transhipment.
(05) Invest in innovative transport concepts (modal shift)	New alternatives such as delivery bicycles, gasoline and electric trucks, combination between passenger and freight transport, AGV.
(06) Develop alternative transport systems for small packages (modal shift)	Alternatives such as underground logistics tube system to replace shipments by vans.
(07) Regulate freight transport on highways (modal shift)	Use separate lanes for trucks on highways.
(08) Introduce automated transport network (modal shift)	Introduce a system between and within regions, based on the paternoster concept: high frequency but relatively slow.
(09) Organise pilot projects together with industry (modal shift)	Pilot projects should increase awareness of the external effects of logistics decisions and the alternatives available.
(10) Make chain transparent and show alternatives (efficiency/modal shift)	Improve information exchange between suppliers and customers about the real service requirements.

(11) Introduce 'green certificate' for chain supervisors (efficiency/ modal shift)	Introduce a reward for using a certified 'green' logistics service provider. Using green services should be cheaper.
(12) Support scale increase in production (efficiency)	Reduce the need for urgent shipments while products are more produced to stock.
(13) Influence consumer behaviour (efficiency)	Reduce volatility and time requirements of customers by making them pay for external costs caused by this behaviour.
(14) Better control of production processes (efficiency)	Better control over production lead times creates more time available for transport. Emphasise shifts from speed to reliability.
(15) Optimise inventory management (efficiency)	Companies should optimise their inventory control, thereby creating a more stable, predictable and reliable environment for transport planning.
(16) Improve shipment consolidation (efficiency)	Companies should pay more attention to consolidating freight by means of better materials handling systems.
(17) Enhance regulation as regards utilisation factors (efficiency)	Require a minimum load factor for different types of trucks.
(18) Support scale increase in transport units (efficiency)	Allow larger truck sizes and weights. Should be accompanied by city distribution centre at city boundary to prevent larger trucks from entering city centre.
(19) Improve internal logistics decisions (efficiency)	Improve interfaces between logistics, production and marketing. Reduce the need for ad-hoc transport decisions because of better fine-tuning and integral trade-offs between different functions.
(20) Support co-operation among LSPs (efficiency)	Reduce competition among road carriers, thereby reducing the number of carriers who offer cheap but environmentally undesired services. Carriers should co-operate to combine shipments.
(21) Improve logistics efficiency on chain level (efficiency)	Logistics cost-effectiveness should be more predominant in trade-offs between chain members. Emphasise shifts from speed to reliability.
(22) Encourage agreements between wholesalers and retailers about location and payment of stocks (efficiency)	Make retailers more aware of the logistics consequences of their changeable ordering behaviour.
(23) Create better spatial conditions (reduced demand)	Use spatial planning as an instrument to promote chances of alternative transport systems, support closer proximity of suppliers and customers.

E

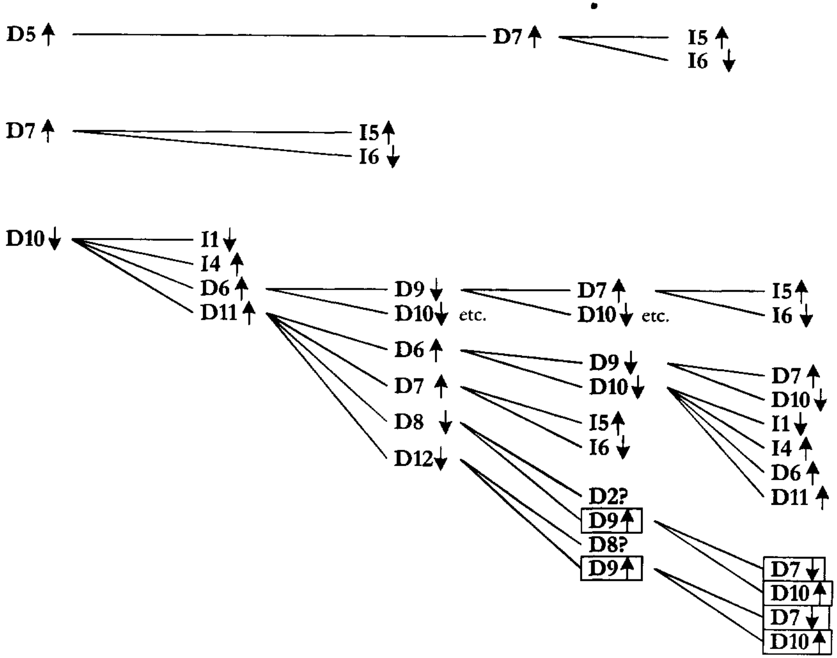
Policy scenarios

POLICY SCENARIO 1: Impose higher charges on road transport

Points of leverage:
D5, D7 and D10

Assumptions

- more DCs (D11) leads to better level of consolidation (D7)
- more night distribution (D5) leads to better level of consolidation (D7)
- offering better services (C9) leads to worse level of consolidation (D7)

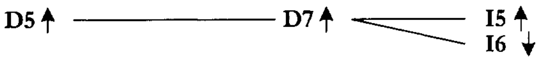


POLICY SCENARIO 2: Extend time windows and promote 24-hour economy

Points of leverage:
D5

Assumptions

- more night distribution (D5) leads to better level of consolidation (D7)

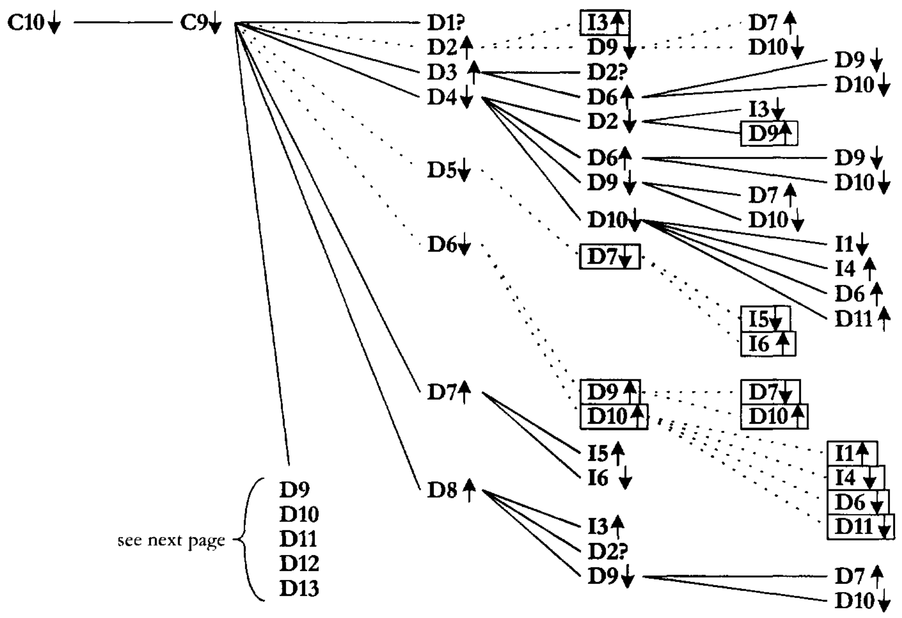


POLICY SCENARIO 3: Promote modal shift - part one

Points of leverage:
C10 and D10 (for effects of D10; see POLICY SCENARIO 1)

Assumptions

- more DCs (D11) leads to better level of consolidation (D7)
- offering faster services (C9) leads to higher inventory levels (D6)
- offering faster services (C9) leads to worse level of consolidation (D7)

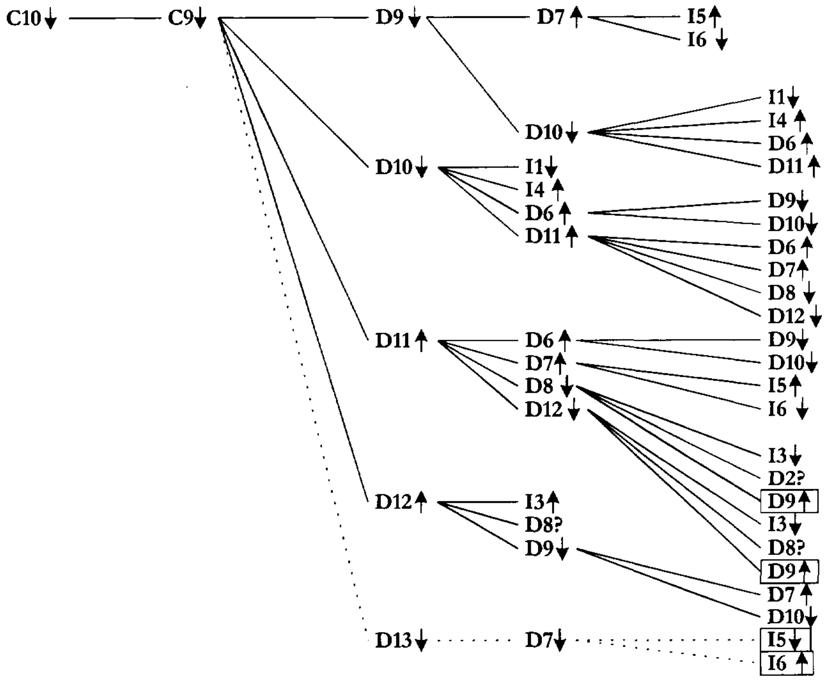


POLICY SCENARIO 3: Promote modal shift - part two

Points of leverage:
C10 and D10

Assumptions

- more DCs (D11) leads to better level of consolidation (D7)

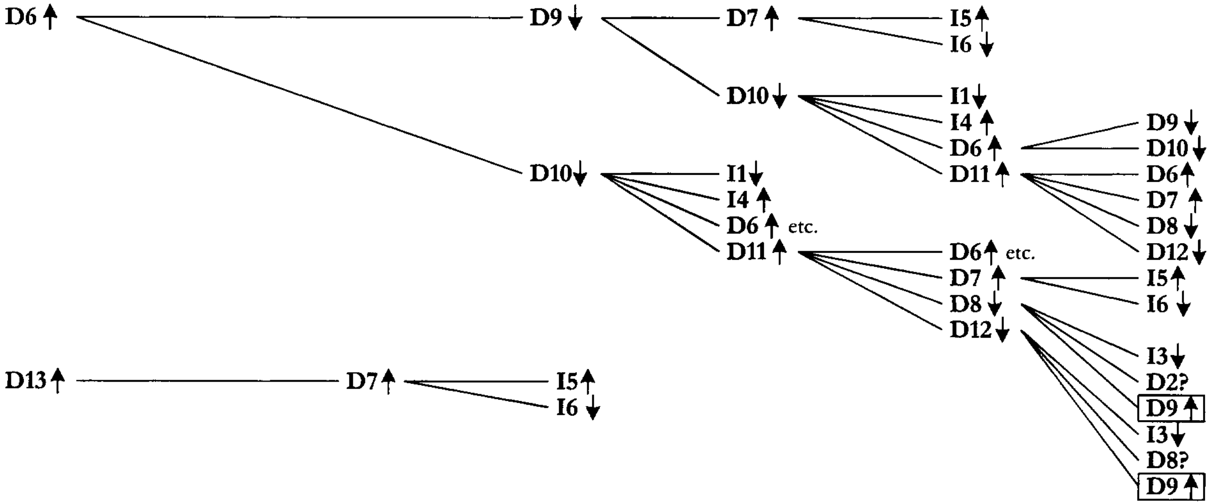


POLICY SCENARIO 4: Promote efficiency

Points of leverage:
C10, D6, D7 and D13 (for effects of C10 see POLICY SCENARIO 3; for effects of D7 see POLICY SCENARIO 1)

Assumptions

- more DCs (D11) leads to better level of consolidation (D7)

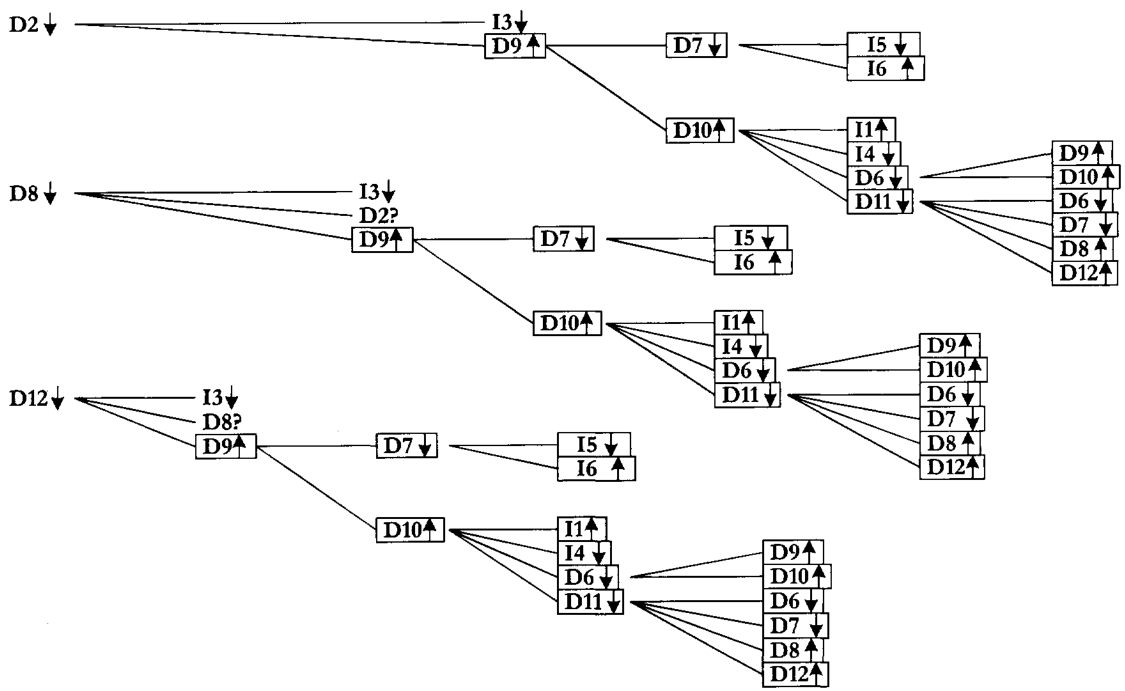


POLICY SCENARIO 5: Spatial adjustments

Points of leverage:
D2, D8 and D12

Assumptions

- more DCs (D11) leads to better level of consolidation (D7)



F

Case study protocol

Short description of the goal of the research

- Gain insight in the logistics developments and trends in your economic sector.
- We are not searching for strategic information, but rather looking for insights in your logistics organisation. We do this by concentrating on a 'typical freight flow' that is suitable to illustrate the way your company has organised its logistics organisation.
- Short description of the interview-elements and an estimation of the time needed.

Agreements

- Interview results will be used confidentially.
- You will be sent a summary report after completion of the interview series.

Company profile

- What are the core activities of your company?
- How many production sites does your company have in the Netherlands?
- What are the three most important product groups produced at this site (measured in turnover)?
- Can the first product group be described as 'typical' for how the remaining products are stored, handled and shipped?

Product characteristics of the most important product

- Could you give a short description of this product (appearance)?
- What is the average shelf life of this product?
- What is the average value density of this product (value per pallet)?

Logistics organisation

- How can the production strategy for this product group be characterised: make-to-stock or make-to-order? **(D4)**
- How many distribution centres are used? **(D11)**
- Where are these distribution centres located? **(D8)**
- What are the most important customers for this product group?
- Where are the distribution centres of these customers located? **(D12)**
- Has the average distance changed in the last three years? **(I3)**
- How many suppliers are used for this product group? **(D1/D3/I2)**
- Where are these suppliers located? **(D2)**
- How would you summarise the logistics strategy of your company? **(C9)**
- What percentage of shipments of this product group is sourced out? **(D13)**
- What is the share of road transport for these shipments? **(D10/I1)**
- What kinds of vehicles are used for these shipments (carrying capacity, e.g. number of pallets)? **(I4)**
- What is the average utilisation rate for these shipments (average number of pallets per shipment)? **(D7/I5)**
- Has this average utilisation rate changed in the last three years?
- Do you acquire return loads? **(I6)**
- At what time of day are these shipments usually carried out? **(D5)**
- What is the average inventory level of this product in your own distribution centre? **(D6)**?
- Has the average inventory level changed in the last three years?
- Do you know of changes in inventory levels at the distribution centre of your customers? **(C6)**

Central question

- What are the most important logistics changes, brought about by the implementation of time-based management concepts such as ECR/JIT?

Preparation of stated-preference analysis

- What are the average transport costs for a shipment (per pallet)?
- What is the average order cycle time (OCT) for each shipment?
- Has the average OCT changed in the last three years?
- What is the average percentage of orders delivered on time?
- Has this average level of reliability changed in the last three years?
- What is the average frequency of shipments per week? **(D9)**
- Has this average frequency changed in the last three years?

Stated-preference task

- For this part of the interview, we will first provide a short explanation.

- Suppose you are looking for a new logistics service provider (LSP) for a shipment of the identified 'typical product' to your most important customer.
- In such a situation, you would probably call for tenders of potential LSPs and compare the different LSPs on a number of characteristics.
- The offers of the LSPs are different from your current logistics organisation in a number of ways: e.g. costs, order cycle time, reliability and frequency of shipments.
- Other characteristics of LSPs that may be important (such as experiences with LSPs, quality of other services), are all considered to be equal to your current logistics organisation, and do not vary between the alternatives.
- We will now present to you nine different offers: these represent LSPs, but could equally represent own-account alternatives.
- In this experiment, you are asked to rate each of these nine alternatives from one (= very unattractive) to ten (= very attractive). The alternatives that you find most attractive should be given the highest marks and the worst alternatives the lowest. Equal ratings are allowed for alternatives that you value similarly. Your ratings are never 'true' or 'false': they should reflect your own opinion.

Follow-up questions:

- What is the most important characteristic for a shipment of the typical product?
- What is the most important trade-off you had to make?
- Why did you rate the alternatives the way you did? (**C**-factors)

Future scenarios

- In the last part of the interview, we would like to see how you would react to four future scenarios. Suppose you are confronted with the following developments with regard to a shipment of the typical product.

Scenario 1: Higher charges on road transport

- Suppose the operation of lorries is made more expensive by (a) a kilometre charge for lorries and vans and (b) a time-dependent toll (between 7 and 9 AM) on the major truck roads in the Randstad. Despite compensation in fixed vehicle taxes, your transport costs rise by 25% compared to the costs of a current shipment. All other transport characteristics remain unchanged: shipments are just as fast and reliable as nowadays.
- What would your reaction, as the logistics manager, be?
- What does this adaptation exactly look like?
- Why don't you already apply this adaptation to your current logistics organisation? (**C**-factors)

Scenario 2: Extended time windows and extension of 24-hour economy

- The National government succeeds in streamlining the municipal regulations as regards time windows for inner cities. Suppose that, under strict conditions of noise reduction, all time window regulations will be abolished. Now, you can deliver your shipment any time you may wish. Your most important customers also open their distribution centres 24 hours per day.

- What would your reaction, as the logistics manager, be?
- What does this adaptation exactly look like?
- Why don't you already apply this adaptation to your current logistics organisation? (**C**-factors)

Scenario 3: Increased road congestion and faster intermodal alternatives

- Suppose the National government decides not to invest in congestion reduction anymore. Traffic jams aggravate dramatically: within five years from now, the average delay of your shipment is twice as long as today. Meanwhile, some logistics service providers succeed in setting up intermodal door-to-door services that are similar to the performance characteristics of your current logistics organisation.
- What would your reaction, as the logistics manager, be?
- What does this adaptation exactly look like?
- Why don't you already apply this adaptation to your current logistics organisation? (**C**-factors)

Scenario 4: Reduced shipment frequency and improved consolidation

- Suppose you succeed in making different business agreements with your customers. Through adjustments of internal business processes (e.g. with the help of information and communication technology), you are able to halve the current frequency of shipments. Your transport costs would be reduced by 25 per cent and these benefits would be shared with your customers.
- What would your reaction, as the logistics manager, be?
- What does this adaptation exactly look like?
- Why don't you already apply this adaptation to your current logistics organisation? (**C**-factors)

G

Introductory letter

[*Company name*]
c/o [*Name of logistics manager*]
[*PO Box number*]
[*ZIP code*] [*City*]

[*Phone number*] [*Date*]

Dear [*Name of logistics manager*],

Logistics concepts such as *just-in-time* (JIT) and *efficient consumer response* (ECR) may sound familiar to you as a logistics manager in the Dutch food industry. Currently, a research project with respect to these concepts is executed by the Delft University of Technology.

Practical experiences cannot be neglected in such a research project. Therefore, I would like to ask for an interview in order to incorporate your practical experiences concerning JIT and ECR into the mentioned research project. The goal of such an interview would be to get a picture of how your logistics operation is organised, and what impacts JIT and ECR have on your organisation.

What's in it for you? After the completion of the interview series, you will be sent a report which summarises the most important logistics trends within the Dutch food industry, and the requirements that will determine the logistics landscape in the next few years. I would like to stress that interview-data will be used confidentially. Within the next two weeks, I will try to contact you by phone, to repeat the above request.

Yours sincerely,

Drs Gert-Jan Muilerman.

H

F-test procedure

We used analysis of variance (ANOVA) to determine whether significant differences exist in the part-worth utilities and the relative importance of each attribute between the samples of food and parts services companies. This comparison was done by carrying out an *F*-test.

The tested null-hypotheses are:

H_0: *there is no significant difference between the food industry and the parts service industry as regards the relative importance of attributes.*

H_0: *there is no significant difference between the food industry and the parts service industry as regards the value of part-worth utilities.*

An F-test was performed to test the difference between the relative importance of the attributes reliability, transport costs and transit time. Furthermore, we tested whether there were systematic differences between all part-worth utilities measured in the food and parts service industry.

The standard ANOVA-table below was used to compute the required F-ratio. The F-ratio is calculated by dividing the explained variance by the unexplained variance, which is then compared with the critical F-value.

Source of variation	**Variation (Sum of Squares, *SS*)**	**Degrees of freedom**	**Variance (Mean Square, *MS*)**
Between column variation	$SS_{cols} = \sum_{i=1}^{c} n_i(\overline{X}_i - \overline{\overline{X}})^2$	$(c-1)$	$MS_{cols} = \frac{SS_{cols}}{(c-1)}$ *explained variance*
Residual variation	$SS_{res} = \sum_{i=1}^{c}\sum_{t=1}^{n_i}(X_{it} - \overline{X}_i)^2$	$\sum_{i=1}^{c}(n_i - 1)$	$MS_{res} = \frac{SS_{res}}{\sum_{i=1}^{c}(n_i - 1)}$ *unexplained variance*

F-ratio: $\frac{MS_{cols}}{MS_{res}}$

Where, X_{it} = the t^{th} observation within the i^{th} sample

$i = 1, 2, \ldots, c$

$t = 1, 2, \ldots, n$

$\overline{X}_i$ = grand mean of all the X_{it}; $\overline{\overline{X}} = \frac{\sum n_i \overline{X}_i}{\sum n_i}$

c = the number of columns to be compared

n_i = the number of cases in the i^{th} sample

The table below shows example calculations for the relative importance of the attribute reliability. In this case, the unexplained variance is much larger than the explained variance, which causes a very small F-ratio, and the failure to reject the null hypothesis.

	Food industry			Parts services		
Respondent	**X_{1t} (Relative importance reliability)**	**Variation**	**Square**	**X_{2t} (Relative importance reliability)**	**Variation**	**Square**
01	35.3	4.7	21.9	72.0	42.0	1764.8
02	50.0	19.4	376.0	45.0	15.0	225.3
03	61.3	30.7	941.3	24.3	-5.7	32.1
04	26.1	-4.5	20.4	34.6	4.6	21.0
05	17.0	-13.6	184.7	13.1	-16.9	284.9
06	35.3	4.6	21.5	64.3	34.3	1176.5
etcetera	...	...	...	...	...	...
Sum	842		6598	293		5041
n_i	27			10		
Industry average	31.2			29.3		
Between column variation (d.f. = 1)	2.8					
Residual variation (d.f. = 35)	11639					
Explained variance (MS_{cols})	2.8					
Unexplained variance (MS_{res})	332.5					
F-ratio (MS_{cols}/MS_{res})	0.008*					
F-critical (at $\alpha = 0.05$)	4.125					

* H_0 cannot be rejected because the F-ratio is smaller than F-critical.

In case of the attribute reliability, H_0 is accepted: there is no significant difference between the food and parts service industry as regards the relative importance of this attribute.

I

Preliminary test of conceptual model

Key:
C = Cause of logistics haste
D = Logistics decision

+ = Confirmation
~~+~~ = Rejection
+ = Undecided
+ = Addition

+ = Positive relationship
- = Negative relationship
+/- = Ambiguous relationship

	C1	C2	C3	C4a	C4b	C4c	C4d	C5	C6a	C6b	C6c	C6d	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
market share/ revenue supplier **C1**																										
logistics costs supplier **C2**																										
market share/ revenue OEM **C3**															-						-					
stockout costs OEM **C4a**														+	-									+		
inventory costs OEM **C4b**														+	-									+		
transport costs OEM **C4c**														+	-									+		
handling costs OEM **C4d**																								+		
market share/ revenue customer **C5**																-										-
stockout costs customer **C6a**																+								+		
inventory costs customer **C6b**																+								+		
transport costs customer **C6c**																								+		
handling costs customer **C6d**																								+		
supplier offering better service to OEM **C7**			~~+~~	-	~~+~~									+												
OEM demanding better service from supplier **C8**													+		+											
OEM offering better service to customer **C9**			+	+				+			+/-	+		~~+~~		+		-								
customer demanding better service from OEM **C10**															+											
# promotions **C11**																			-	+						
inventory level customer **C12**									-	+																
predictability/ stability of demand **C13**				-																						
sales volume per customer **C14**																+										
# SKUs/ introductions **C15**																		+								
shelf-life **C16**					-					-																
value density **C17**					+					+																
product price **C18**			-					-																		
road congestion delays **C19**						+																				
shop opening hours **C20**								+								+										

INTERACTIONS AMONG CAUSES OF TIME-SENSITIVITY

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17
market share/revenue supplier **C1**																	
logistics costs supplier **C2**																	
market share/revenue OEM **C3**																	
stockout costs OEM **C4a**						+											
inventory costs OEM **C4b**				+													
transport costs OEM **C4c**													+	+			
handling costs OEM **C4d**				-											+		
market share/revenue customer **C5**																	
stockout costs customer **C6a**																	
inventory costs customer **C6b**																	
transport costs customer **C6c**																	
handling costs customer **C6d**																	
supplier offering better service to OEM **C7**						-											
OEM demanding better service from supplier **C8**																	
OEM offering better service to customer **C9**	-	-	-	+	+	+/-	+/-	-	+	+	-	-	+			-	+
customer demanding better service from OEM **C10**																	
# promotions **C11**																	
inventory level customer **C12**																	
predictability/stability of demand **C13**						-	+										
sales volume per customer **C14**							+										
# SKUs/introductions **C15**						+	-										
shelf life **C16**																	
value density **C17**																	
product price **C18**																	
road congestion delays **C19**						+											
shop opening hours **C20**																	

RELATIONSHIPS BETWEEN CAUSES AND MICRO-IMPACTS

	C1	C2	C3	C4a	C4b	C4c	C4d	C5	C6a	C6b	C6c	C6d	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
% products contracted out **D1**																										
distance between suppliers and production facility **D2**																										
# suppliers in supply chain **D3**																										
% of products made JIT **D4**																										
% night distribution **D5**						+/-			-																	
inventory level finished goods/materials **D6**				-	+																					
level of consolidation **D7**						-	-																			
distance between OEM and DCs **D8**																										
frequency of delivery **D9**																										
% by road transport **D10**																										
# DCs in supply chain **D11**																										
distance between DCs and customers **D12**																										
% transport contracted out **D13**																										
perform third-party transport **D14**																										
mechanise handling **D15**							-																			
# separate backorders **D16**																										
usage of EDI **D17**																+			+							

FEEDBACK FROM MICRO-IMPACTS TO CAUSES OF TIME-SENSITIVITY

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17
% products contracted out **D1**			■ -														
distance between suppliers and production facility **D2**									■ -								
# suppliers in supply chain **D3**		/+/-				+											
% of products made JIT **D4**		■ -				-			/+	+							
% night distribution **D5**							+/-										
inventory level finished goods/materials **D6**									/-	/-							
level of consolidation **D7**																	
distance between OEM and DCs **D8**		■ -							/-								
frequency of delivery **D9**							+/-			/+							
% by road transport **D10**						■ -					■ -						
# DCs in supply chain **D11**						+	-	■ -				-					
distance between DCs and customers **D12**								■ -	■ -								
% transport contracted out **D13**							+										
perform third-party transport **D14**							▒ +										
mechanise handling **D15**																	
# separate backorders **D16**							▒ -										
usage of EDI **D17**																	

INTERACTIONS AMONG MICRO-IMPACTS

J

Confirmed model factors and relationships

Lower market share/ revenue OEM (C3) causes OEM to offer better service to customer (C9)

Market shares are always under pressure in a mature business sector such as the food industry. Some of the respondents claimed to use time-based competition as a defensive strategy: threatened market shares are combated by providing service levels to customers that are better than or similar to those offered by competitors. We have found that Dutch food manufacturers generally view time-based competition as a way of 'keeping up', rather than as a way of differentiating.

Higher integral costs OEM (C4) causes OEM to demand better service from suppliers (C8)

First, if an OEM is faced with increased stockout costs (C4a), he will be tempted to demand faster, more frequent and more reliable replenishment services from his suppliers. This would result in lower production losses. Second, OEMs who have to deal with increasing inventory costs (C4b) generally opt for 'contracting out' the stock problem as much as possible. A common strategy to offset inventory cost rises, is to transfer some of the inventory to the suppliers and to simultaneously require faster and more reliable replenishment.

Lower market share/ revenue customer (C5) leads to higher service demands customer (C10)

Customers try to improve their own competitive position by increasing their own customer service demands. Higher service standards offered by the OEM could lead to inventory cost reductions for the customer (C6b), which would ultimately create lower product prices (C18) and hence improved market shares and revenues (C5).

Higher stockout costs customer (C6a) lead to higher service demands customer (C10)

If a time-based retailer sees himself confronted with empty shelves and lost sales, he will automatically demand higher service standards from his suppliers: higher frequencies, faster replenishment and more reliable delivery times. These demands would enable him to minimise shelf-space consumption while at the same.time minimising lost sales.

Higher inventory costs customer (C6b) lead to higher service demands customer (C10)

If a retailer faces undesired inventory build-ups, he will try to reduce these by engaging into a closer relationship with a series of 'preferred suppliers'. We have seen *vendor-managed inventory* (VMI) or *co-makership* come into existence, meaning that suppliers are provided with actual demand figures of the retailer and that the supplier is made responsible for controlling the inventory level of his products in the DC of the retailer. The two rules that the supplier has to commit himself to are: (a) never cause stockouts in the shops by failing deliveries and (b) stay within the maximum allocated inventory space. These two rules caused a reduction of the average inventory level in the retailers' DCs.

Better service levels of supplier (C7) lead to lower stockout costs OEM (C4a)

Some respondents claimed that better logistics performance of suppliers indeed results in lower logistics costs: *stockout costs* (C4a) are reduced because of improved supplier performance. A soft-drink producer underlined the importance of trustworthy suppliers:

> *Because we can now rely on our suppliers' delivery schedules, we can eliminate double stocks from our supply chain.*

If suppliers replenish the resources or semi-products more often, it becomes obvious that the risk of running out of these production inputs decreases (C4a).

Higher service demands of OEM (C8) cause supplier to offer better service levels (C7)

This relationship may appear evident in a market-oriented business environment. Nonetheless, as some respondents argued, it is not: whether customer requirements are actually met largely depends on the buying power of the customer. As we have interviewed relatively large food manufacturers, and therefore the relatively more powerful ones, we observed that more stringent customer requirements are generally satisfied by the suppliers of the OEMs. Again, however, just as we encountered in our case study of the pharmaceutical industry, not all suppliers have an interest in providing the best possible service, because the OEMs in the food industry are relatively minor customers.

Higher service levels of OEM (C9) lead to changes in stockout costs of OEM (C4a)

Respondents in the food industry claim that offering higher service levels means an increase in their own *stockout costs* (C4a). For example, if the OEM has to deliver within four hours, the odds for being incapable of fulfilling the order will be higher than in a situation where the required order lead time runs up to three weeks.

Higher service levels of OEM (C9) lead to higher market share/revenue customer (C5)

It is claimed that the higher service achievements accomplished by the OEMs generate higher revenues for the retailers: as products are delivered faster and more frequently, the stores are continually filled with fresh products. Freshness will make or break the business of the full-service supermarkets: the fresher the products, the higher the revenues will be. Furthermore, more frequent store replenishment enables the optimised use of scarce shelf space. Space can instantaneously be made available for 'hot items' without having to get rid off other unsold products that fill up the shelves. Effective category management is therefore often mentioned as a strategy to raise supermarket revenues.

Higher service levels of OEM (C9) lead to lower logistics costs customer (C6)

A general complaint is that the OEMs have had to invest in higher transport and handling costs in order to serve the customers appropriately, while the inventory benefits of the customers are not shared with the OEMs. Many OEMs therefore contend that the retailers' *transport* and *handling costs* (C6c and C6d) have not risen but decreased, despite the higher service levels enjoyed. The simple explanation for this perceived inequality lies in the market power of the retailers.

Retailers however hold an opposite view: they claim not to be interested in half-loaded pallets and unnecessary backdoor congestion at their DCs. Therefore, they would not want to accept inefficient pallet and truck loads, and therefore higher transport and handling costs borne by the OEMs. That this is not just a lip service, is proven by the fact that some retailers (e.g. Albert Heijn) actually force producers of slow-movers to use consolidation services of prescribed LSPs, or 'strongly advice' using backhauling services (i.e. a pick-up service) by the retailer himself.

Higher service levels of OEM (C9) lead to higher service demands from customer (C10)

A better service offer can induce even higher customer service demands: if an OEM offers better performance, customers get the impression that higher service levels are possible. One respondent (a manufacturer of pancakes) claimed to have pampered his customers too much by providing the best possible service performance (originally intended to support marketing targets). Some retailers had grown to believe that there was more in it, and started demanding even higher frequencies of delivery, despite the modest sales volumes involved.

Higher service demands from customer (C10) lead to higher service levels of OEM (C9)

Without an exception, OEMs claim to have improved their service standards owing to higher customer requirements (e.g. frequency of delivery from 3 to 6 times a week, reduced order cycle time from 48 to 8 hours). Almost every respondent mentioned that, under the current market conditions, OEMs do not have any other option but to comply with increasing customer demands. One respondent claimed that only the very large manufacturers of established brands can provide some counterweight in this respect, as a certain segment of shoppers strongly prefer branded articles. This sellers' power has however been eroded by the emergence of own-label products introduced by the retailers themselves. Own-label products often are direct competitors of branded products. Furthermore, the respondents could tell stories of 'power-play' by the retailers: if a manufacturer of branded products did not comply with the service standards of the customer, the retailer would not support product promotions on the shop floor any longer, which of course is an effective threat to those manufacturers whose sales volumes completely depend on the retailing distribution channel.

Higher service levels supplier (C7) lead to lower inventory level OEM (D6)

If the supplier of the OEM delivers faster, more reliably and more often, the OEM can rely on his supplier, and can subsequently reduce his (safety) stock that was previously needed to cushion the impact of unreliable order fulfilment.

Higher service levels of OEM (C9) lead to smaller number of suppliers (D3)

A few respondents had reduced their supplier base under the new time-based regime: limiting the co-operation with a smaller number of preferred suppliers means better opportunities of controlling the required service standards. It is commonly believed that achieving a high level of service reliability can only be realised with a certain group of dedicated suppliers.

Higher service levels of OEM (C9) lead to a larger proportion of products made JIT (D4)

As providing improved service levels could lead to increased inventory levels for the OEM, some respondents adapted their production concept to the new conditions. They moved the order penetration point (OPP; see Chapter 2) upstream, making a larger proportion of products to order, and thereby controlled inventory costs, while at the same time meeting customer service requirements. A manufacturer of meat products heavily invested in the reduction of setup times, so plant efficiency was still guaranteed in the make-to-order process.

Nevertheless, another group of respondents insisted that they were incapable of making production processes more flexible, owing to inherent production lead times or prohibitive setup costs and losses of efficiency. Some products can simply not be produced any faster: e.g. beer has to ferment, cookies should cool down after baking, cheese needs time to ripen on the shelf. Furthermore, some vegetables can only be harvested during certain seasons. In those cases, a make-to-order approach would lead to unacceptable customer lead times. A final objection against the implementation of a JIT production concept lies in the fact that not all retailers are prepared to engage in a co-makership relation: when only a small percentage of the customers share on-line order data with the OEM, the remaining orders still have to be forecast. Production schedules cannot be adjusted to the wishes of a minority of customers, but a certain critical mass is required.

Higher service levels of OEM (C9) lead to a larger proportion of night distribution (D5)

It is generally observed that the higher customer service requirements led to the increased use of night distribution. Since some retailers implement a pull- or sales-based logistics concept such as ECR, opening hours of retailers' DCs have been extended. This is because ECR implies that actual demand figures are continuously tracked and immediately transformed into replenishment orders: products that are sold in the supermarket on the one day, are replenished overnight.

Higher service levels of OEM (C9) lead to higher frequency of delivery (D9)

In theory, continuous replenishment means that actual demand figures are followed and immediately turned into replenishment orders. This does not automatically mean that delivery schedules are intensified, as plummeting markets would require less replenishment shipments. However, the respondents leave no doubt about the general rise in frequency in the last few years. Whereas OEMs used to deliver to Albert Heijn two to three times per week (on average), the same OEMs deliver five to six times per week since the implementation of ECR.

Higher service levels of OEM (C9) lead to larger share of road transport (D10)

It cannot be maintained that the rise of service standards within the food industry has caused a larger share of road transport, simply because the logistics systems used within the Dutch food industry had already been entirely geared towards the use of transport by truck, long before time-based competition came into existence. Nonetheless, it is argued that road transport has become even more attractive with the emergence of time-based logistics strategies. The truck is conceived as the only feasible alternative when it comes to fulfilling the common customer logistics needs. This implies that the truck 'sits firmly in its saddle' in the Dutch food industry, and even more so under the current market conditions.

Higher service levels of OEM (C9) lead to smaller number of DCs in the supply chain (D11)

A few respondents mentioned that higher service standards require a smaller number of DCs to operate from. With a smaller number of DCs, it is found easier to achieve the dual goal of rising service standards and controlling logistics costs: higher levels of consolidation are more easily achieved in a centralised distribution system than in a decentralised logistics structure.

Less suppliers (D3) leads to lower inventory level OEM (D6)

In the limited number of cases where the number of suppliers had actually been reduced, the average inventory level had been reduced as well: the use of less suppliers implies that tighter arrangements are made about deliveries and required quantities. The average safety stock level, needed to guarantee an impeccable production process, can be reduced if the OEM can rely on his smaller group of preferred suppliers.

More products made JIT (D4) leads to lower inventory level OEM (D6)

The upstream shift of the OPP indicates that a smaller proportion of the products are produced to stock, thus reducing average inventory levels. As has been explained under relationship 0, however, not all manufacturers appeared to be capable of materialising this shift towards sales-based production.

More products made JIT (D4) leads to larger share of road transport (D10)

All traffic is already being carried out with road transport, which means that the modal share cannot rise higher than the current level. Increased JIT-production could however strengthen the already dominant position of road transport.

Larger proportion of night distribution (D5) leads to changes in the level of consolidation (D7)

The respondents in the food industry were quite sceptical with regard to the merits of night- or off-peak distribution. Many expect lower levels of consolidation during off-peak hours: current routes would be split up into several smaller consignments, because not all customers would have opened their DCs. Several OEMs stressed that off-peak distribution, but especially night distribution, is a matter of all-or-nothing: either every customer needs to co-operate, or the transport operation becomes too expensive. Despite productivity gains on personnel and transport equipment (*lower transport costs; C4c*), load efficiency would be endangered. Another barrier to the intensification of night distribution would be that combinations of outbound with inbound materials shipments could evaporate as well, owing to the limited opening hours of suppliers. However, as some respondents disliked the idea of internal re-organisation owing to the introduction of off-peak distribution, the 'loss-of-load-efficiency' argument could be a somewhat spurious one. This seems all the more true since others have added that a larger proportion of night distribution would lead to increased outsourcing of the distribution function, which could offset the conceived efficiency losses.

Higher frequency of delivery (D9) leads to lower level of consolidation (D7)

This relationship proved to be a controversial issue in the context of the Dutch food industry. Higher frequencies only lead to lower consolidation levels in case of stable demand figures, because existing full loads are split up into part shipments in those cases. Likewise, higher frequencies may not be a problem at all when product demand is growing and trucks are still fully loaded. A manufacturer of potato products described the following trends:

> *ECR obviously requires higher frequencies, and consequently lower consolidation levels. On the Dutch market we still hold on to the agreement to deliver full-truck shipments only. In the UK, where the ECR-concept is already in full bloom, we are already confronted with half-loaded trucks: shipments have to be split up owing to the immense time pressure. I presume the Netherlands will soon witness the emergence of the ECR-model from across the Channel.*

Another manufacturer (meat products) confirmed that ECR-orders (order cycle time of eight hours, as opposed to the 'normal' order lead time of 48 hours) do not allow for groupage with additional loads. The business segments where part shipments have already come into existence as a consequence of ECR are the slow-moving products (e.g. breakfast products, canned vegetables) and small products (e.g. meat products, sweets and chocolates).

More DCs in the supply chain (D11) lead to higher inventory level OEM (D6)

The main reason behind the rationalisation in the distribution networks of OEMs was to obtain inventory reductions. Every DC normally carries its own safety stock, and aggregate inventory levels can therefore be reduced if the number of DCs is limited.

More DCs in the supply chain (D11) lead to lower level of consolidation (D7)

Many respondents contend that existing shipments would be fragmented by an extended number of DCs. Centralisation of inventory locations improves the integration of freight flows and hence increases in the level of consolidation.

More DCs in the supply chain (D11) lead to shorter distances between DCs and customers (D12)

This relationship is self-evident, as more DCs will generally mean that the average distance between individual customers and the nearest DC is reduced.

Larger proportion transport contracted out (D13) leads to higher level of consolidation (D7)

This is an important relationship mentioned by many OEMs in order to explain why they have opted for increased outsourcing of distribution activities: third-party LSPs produce economies of scale by accumulating part shipments of various OEMs who have to deliver to the same customers. These network advantages translate into cost advantages, and so form the main argument for contracting out distribution activities. However, as one producer of canned vegetables explained, only 'sympathetic' products can be combined in one shipment. For example, heavy goods such as soft-drinks and canned vegetables will soon reach the maximum weight limit. That is why OEMs and their LSPs are constantly searching for 'smart combinations' of products: products that require approximately the same frequency and that can be delivered within the same time windows of the retailers. The LSP of the mentioned OEM combined the heavy canned vegetables with relatively light sweets, candies and crisps. This required the agreement of the retailer involved but eventually resulted in better consolidation levels in terms of both weight and cube-fill.

K

Rejected model factors and relationships

Better service levels of supplier (C7) lead to lower inventory costs OEM (C4b)

There is no direct relationship between these model factors: the intermediate factor D6 (*level of inventory OEM*) determines the relationship.

Better service levels of supplier (C7) lead to higher market share/revenue OEM (C3)

There is no direct relationship between the service performance of suppliers and the OEM's market success. However, as we shall see below, a better supplier performance could contribute to cost reductions and lower product prices for the OEM, which in turn could result in a rise in market share/revenue (C3).

Higher service levels of OEM (C9) lead to higher service demands of OEM to supplier (C8)

This relation is not a direct matter, but is settled through the cost mechanism: if costs rise for the OEM because he has to offer higher service levels himself, he will try to pass on at least part of this cost increase to his own suppliers by demanding a more flexible and faster service. An example of this is provided by a producer of potato products: as soon as the OEM started an ECR-project with his main customer, he also started to involve his supplier and applied the same ECR-physical distribution model of continuous replenishment to the materials management side. The supplier of potatoes was provided with the production schedule of the OEM and was made responsible for controlling the materials inventory.

Higher service levels of OEM (C9) lead to shorter distance between suppliers and OEM (D2)

This relationship does not hold in the case of the Dutch food industry. The prime explanation for the absence of agglomeration effects owing to increasing time-sensitivity is that, in the food industry, suppliers have already been selected mainly at the national level for many years. The well-established distribution structures therefore already satisfy the minimum requirements of 'closeness in lead time' (every supplier can theoretically deliver within two or three hours). Consequently, location patterns in the Dutch food industry have not *changed* as a result of increasing time-sensitivity, but rather, the emergence of time-based strategies was *enabled* by the existing distribution patterns.

Higher service levels of OEM (C9) lead to changes in inventory levels (D6)

There is no direct relationship between these two factors, but a relationship via stockout costs (C4a) exists.

Higher service levels of OEM (C9) lead to changes in the level of consolidation (D7)

This relationship is in fact not a direct relationship: higher service levels do not necessarily produce worse load factors, but depend on the intermediary variable D9 (*frequency of delivery*). Increased frequencies could lead to decreasing levels of consolidation when demand figures are stable, that is, when the same amount of freight is spread over more shipments.

Higher service levels of OEM (C9) lead to shorter distance between production facility and DCs (D8)

Increasing logistics time-sensitivity has not brought about changes in the locational configuration of logistics chains by itself. Rather, service levels are raised within the context of the existing spatial pattern of DCs and production facilities. Additionally, production and distribution facilities of the OEM are often already located on the same site. Therefore, no major locational adjustments resulting from increasing logistics haste are observed.

Higher service levels of OEM (C9) lead to a higher proportion of transport contracted out (D13)

There is no direct relationship between these two model factors. An indirect relationship comes to the surface as soon as OEMs discover that increased service levels cannot be maintained with own-account distribution alone, owing to the rising logistics costs (C4c and C4d) connected with own-account operations: the average level of consolidation decreases when OEMs continue to perform all distribution activities by themselves, while third-party logistics can generally compensate for some of the efficiency losses.

Less suppliers (D3) leads to changes in distance between suppliers and OEM (D2)

Only a few respondents claimed to have reduced their supplier base as a result of increasing time-sensitivity. It was stressed that suppliers are selected first and foremost on the basis of the product quality offered, which is subject to legal restrictions in the food industry (e.g. HACCP regulations). As a result, we found indications that the average distance between suppliers and OEM has not undergone major changes.

More products made JIT (D4) leads to higher frequency of delivery (D9)

Although JIT-manufacturing will generally be accompanied by higher frequencies of outbound shipments, a causal relationship between the two could not be identified. If an OEM produces a large part of his products to order, the frequency of his own deliveries to customers (D9) does not necessarily rise. The root cause of increased frequencies generally stems from the customer and not from the production philosophy of the OEM himself: higher frequencies are only offered if higher customer demands arise.

Higher inventory level OEM (D6) leads to lower frequency of delivery (D9)

This relationship cannot be supported by empirical evidence found in the Dutch food industry. Delivery schedules (and customer demands) remain unaltered, irrespective of the OEM's inventory level. This again illustrates the irreversibility of customer service demands.

Higher inventory level OEM (D6) leads to smaller share of road transport (D10)

The main reason for choosing road transport lie in the functional qualities of road transport: its coverage, its speed, its price etcetera. A change in inventory levels could theoretically open up possibilities for a change in the functional requirements posed on the transport function. However, none of the respondents saw this as a realistic option, since current customer requirements are believed to be dominant.

Longer distance between OEM and DCs (D8) leads to lower frequency of delivery (D9)

One could have expected lower service standards for distant customers (owing to the cost consequences), but as we saw in the above, the distance between OEM and DCs had not changed substantially. Moreover, given the national scale of most trade relations in the Dutch food industry, service standards are equal across the Netherlands. Frequency of delivery (*D9*) is largely determined by the customer service requirements (*C10* and *C9*) and the sales volume per customer (*C14*), not by the distances within the logistics network.

Higher frequency of delivery (D9) leads to larger share of road transport (D10)

Higher frequencies do not influence modal choice, because the modal share of road transport is already at its maximum in the Dutch food industry. The functional requirements that lead to the preference for road transport (including frequency) are considered invariable. Therefore, in the absence of a realistic alternative (according to the respondents) the modal split will remain unchanged.

L

Undecided model factors and relationships

Higher integral costs OEM (C4) lead to reduced service levels of OEM (C9)

It would seem logical to reduce service levels as soon as the costs of maintaining these service levels outweigh the benefits. However, this relation is virtually non-existent according to the majority of logistics managers interviewed: the balance of power between OEMs and their customers (the retailers) works to the advantage of the latter, that is, required service levels provided by the OEMs (C9) are considered irreversible. According to many OEMs, reducing service levels is not negotiable, regardless of the cost increases borne by the OEMs. The 'captive' OEMs see no other alternative but to strive for cost cuts in other areas such as purchasing materials.

There are however exceptions to the above general tendency. One producer of ready-to-eat meals claimed to have reduced his frequency of shipments because his costs (and the retailer's costs) were rising too much. Instead of the usual four shipments per week, the OEM reduced the service level to one weekly shipment. This apparently led to an increase of the proportion of full-pallets from 30 to 70 per cent. Both business partners accordingly reduced their transport and handling costs, and both were prepared to put up with slightly higher inventory levels.

Better service levels of supplier (C7) lead to OEM demanding better service from supplier (C8)

We did not find indications for the existence of this 'rebound effect': none of the OEMs admitted that better service levels offered by their suppliers would automatically invoke a second round of even higher requirements. A similar relationship between service levels offered by the OEMs themselves (C9) and the customer requirements (C10) however illustrates the mechanism of insatiability. This suggests that better service levels *can* indeed be self-reinforcing.

Higher service demands of OEM (C8) lead to OEM offering better service (C9)

We did not encounter any leads to support this hypothesis. Setting high requirements to suppliers does not necessarily mean that one's own performance targets are also on the highest possible level. This suggests that some of the customer requirements that OEMs are confronted with, are actually passed on to their respective suppliers.

Higher service levels of OEM (C9) lead to higher market share/revenue OEM (C3)

It is surprising that none of the respondents in the food industry ever mentioned that providing higher service levels is rewarded by higher market shares or revenues. Time-based competition is merely seen as a way of keeping up. One OEM summarised the situation as follows:

> *Under the current market conditions, we only have the choice between being a co-maker or being a no-maker.*

OEMs either have to comply with the service requirements of the retailer, or they can be considered to be out of business. This implies that the hypothesised relationship may hold in only one direction: given the balance of power in the food sector, *lower* service levels offered by the OEM would invariably lead to the erosion of current market shares.

Higher service levels of OEM (C9) lead to changes in number of products contracted out (D1)

None of the respondents touched upon the issue of making-or-buying in conjunction with increasing time-sensitivity. Apparently there are other, more important, factors that determine whether certain products should be produced in-house, or contracted out. The emergence of time-based strategies is however not one of them.

Higher service levels of OEM (C9) lead to shorter distance between DCs and customer (D12)

No evidence was found for this relationship in the Dutch food industry, due to the same reasons as discussed under relationship 0: location patterns in the Dutch food industry have not changed as a result of increasing time-sensitivity, but rather, the emergence of time-based strategies was *enabled* by the existing short-distance distribution structures.

More products contracted out (D1) leads to a change in the number of suppliers (D3)

We have found no evidence to support this hypothesis, because the respondents did not identify the make-or-buy issue as a relevant question in relation to the emergence of logistics time-sensitivity.

Longer distance between suppliers and OEM (D2) leads to lower frequency of delivery (D9)

The existence of this relationship cannot be confirmed by the empirical findings within the food industry, because the trade relations in the Dutch food industry are primarily oriented towards the national level. Therefore, distances and transit times have always been relatively limited and the same frequencies can be guaranteed wherever the customer is located.

More products made JIT (D4) leads to shorter distance between supplier and OEM (D2)

We found no evidence for the occurrence of these spatial adjustments. Again, the locational choices of a food producing firm are not adapted to the requirements of the production concept, but the relationship works in the opposite direction. The already relatively short distances in the Dutch food industry are a condition for the implementation of JIT-production.

Longer distance between OEM and DCs (D8) leads to changes in distance between suppliers and OEM (D2)

This relationship seems logical, but as the respondents did not draw attention to significant changes in the location of production facility and DCs (caused by increasing time-sensitivity), we cannot draw final conclusions with respect to this hypothesis.

Higher share of road transport (D10) leads to lower inventory level (D6)

This relationship remained unclear, as many respondents already completely relied on road transport since a long time. Therefore, modal shifts have not occurred and impacts on inventory levels could not be observed.

Larger share of road transport (D10) leads to lower inventory level OEM (D6) and less DCs in supply chain (D11)

As the modal split has not undergone significant changes owing to increasing time-sensitivity, we have not been able to identify these causal relationships in the Dutch food industry.

More DCs in the supply chain (D11) lead to shorter distance between OEM and DCs (D8)

This relationship looks evident, but we have not found empirical arguments in support of this thesis, as the distance between OEM and DCs was not mentioned as a relevant topic in relation to increased logistics time-sensitivity.

Longer distance between DCs and customers (D12) leads to changes in distance between OEM and DCs (D8)

There have not been any significant changes in either of these two model factors as a consequence of the implementation of time-based competition. As a result, we have not been able to detect a relationship between the two factors.

Longer distance between DCs and customers (D12) leads to lower frequency of delivery (D9)

As we did not observe large changes in the distance between DCs and customers, we have found no evidence to confirm or disconfirm the existence of this relationship.

M

Added model factors and relationships

Lower market share/revenue OEM (C3) leads to higher number of SKUs and introductions (C15)

OEMs that operate in a stable but contestable market are typically faced with threatened market shares and revenues, as competitors are 'hunting the same pack'. Under such conditions OEMs are constantly on the look-out for ways of improving competitive strengths. One of these ways is to introduce new products to the market and thereby creating customer preferences. This would result in increased market shares and revenues. Many OEMs introduce many products with varying success: the excessive number of introductions are looked at with Argus' eyes by both the retailers and the logistics managers of the OEMs. The retailers are confronted with more products just when shelf-space and stockouts are becoming the main problem on the shop floor. Logistics managers of OEMs generally are not in favour of the seemingly unlimited number of product variations, because of the extra logistics costs involved. One respondent also argued that in the end no customer really requires 15 different types of tomato sauce or any other product. Another logistics manager described the 'introduction-mania' and felt that too many products are leaving the supermarket through the backdoor instead of through the main entrance.

Higher integral logistics costs OEM (C4) lead to higher product price (C18)

The integral logistics costs of food products usually do not amount to more than five per cent of the retail price. However, all cost increases eventually have to be passed on to the customer. The only alternative for this is to compensate cost rises by cost reductions elsewhere. No matter how insignificant logistics costs might seem to be, for low-value products that have to survive in a mature market (e.g. beer), every small price change can have major impacts on the sales revenues.

Lower market share/revenue customer (C5) leads to extended shop opening hours (C20)

Another consequence of the stable and monopolistic character of the Dutch food and retailing market is that opening hours of shops have become a battleground for winning customer preferences. Not only the competition among the retailers themselves, but also the competitive pressure of alternative food channels (e.g. pizza delivery service, snack bars etcetera) meant that retailers saw their sales volume draining away. This formed an incentive to extend opening hours and to keep up with the alternative food channels. These external pressures also led to the strong growth in 'convenience food' (ready-to-eat meals, microwave products etcetera). These are products that are also fast and easy, similar to those offered by pizza couriers or snack bars.

Higher integral logistics costs customer (C6) lead to higher product prices (C18)

Just as higher integral logistics costs for the OEM (the sum of stockout, inventory, transport and handling costs) contribute to the product price, increased logistics costs made by the retailers have to be calculated in the selling prices as well.

Higher service levels offered by OEM (C9) lead to lower inventory levels customer (C12)

Many OEMs have complied with the higher customer demands of retailers by providing faster, more frequent and more reliable services to the customer. Because the retailers can increasingly rely on their suppliers' service performance, they can reduce their inventory levels. Safety or buffer stocks, which were used to absorb delivery irregularities, can now be reduced. Moreover, based on the availability of accurate sales data, the average stock level can decrease because suppliers deliver more exactly what has actually been sold. Figures of retailer inventory reductions caused by the implementation of ECR vary between 25 and 50 per cent, according to estimations by retailers and OEMs. These estimations are confirmed by figures quoted in the business literature [Te Lindert, 2000].

More promotions (C11) lead to lower predictability/stability of demand (C13)

Predicting the success of promotions proves to be an art with a capital A. Whenever advertising campaigns and promotions are initiated, one can never be sure of the logistics impacts they will have: an unexpected success causes stockouts, while a flop means product return flows and a waste of money. In either case, the logistics managers interviewed generally disliked disruptions of the regular freight flows brought about by promotions. They also considered the ECR-model appropriate for handling the idiosyncrasies of promotions: precisely following and tracking demand volumes with accurate and up-to-date sales data, combined with extremely short order cycle times, enables better a command of the art of promotions.

More promotions (C11) lead to higher sales volume per customer (C14)

However difficult promotions may be in terms of logistics control, promotions are believed to be effective in enhancing customer demand. This effect can be temporary or more structural. Rising sales volumes may in any case necessitate higher delivery frequencies, because shelves need to be replenished more often.

Higher inventory level customer (C12) leads to lower stockout costs customer (C6a)

Higher (buffer) stock levels available to the customer guarantee that store orders can be fulfilled more easily than in a situation where there is no such safety stock. The only alternative to keeping more products in stock (and preventing stockouts) would be to establish structural co-makership relationships with suppliers.

Higher inventory level customer (C12) leads to higher inventory costs customer (C6b)

This relationship is self-evident: the higher the amount of products in stock, the higher the capital costs, insurance costs, storage space costs etcetera.

Higher predictability/stability of demand (C13) leads to lower stockout costs OEM (C4a)

More predictable sales volumes simplify the task of a logistics manager. As soon as he (or the marketing manager) can predict future demand volumes reasonably well, he (or the production manager) can adjust production schedules in order to produce the required quantities by the time they are demanded. Likewise, the logistics manager can hold enough reserve inventory in order to facilitate customer demand. In conclusion, the higher the predictability of demand, the lower the risk of unanticipated demand fluctuations and stockouts.

Higher sales volume per customer (C14) leads to higher service demands of customer (C10)

Larger customers wield a greater deal of influence over OEMs. Because OEMs are more dependent on larger retailers than on the smaller ones, they are more keen on pleasing the larger customers. The larger retailers evidently use the power they can exert and consequently demand higher service standards.

More SKUs/introductions (C15) lead to higher inventory level customer (C12)

Just as the OEM is confronted with higher inventory levels in case of more product introductions, the customer also needs to keep more different products in stock in order to prevent stockouts. This leads to higher inventory costs.

Longer shelf-life (C16) leads to lower inventory costs OEM (C4b) and customer (C6b)

As was already explained in Chapter 3 (see Figure 3-4), inventory carrying costs are among others determined by the inventory *risk costs* involved. Risk costs are higher for perishable or fashionable products, because the economic value of these products tends to deteriorate rapidly with time.

Higher value density (C17) leads to higher inventory costs OEM (C4b) and customer (C6b)

Inventory carrying costs are also made up of capital and insurance costs (see Figure 3-4). These two cost components rise as the product becomes more valuable. In case valuable products are stored, more tied-up capital is accumulated and more insurance expenses are made.

Higher product price (C18) leads to lower market share/revenue OEM (C3) and customer (C5)

Higher product prices are believed to form a negative influence on the competitive position of an OEM and retailer. This especially goes for the mature food market, where market shares are defended by offering market-based, that is as low as possible, prices. An exception could be formed by the strong brands, but these OEMs also face increasing competition from own-label brands of the retailers.

More road congestion delays (C19) lead to higher transport costs OEM (C4c)

Several respondents claimed that they increasingly had to deal with delays caused by road congestion. The productivity of both the truck driver and the truck itself is reduced as a consequence of these delays. Consequently, the marginal transport costs increase.

Extended shop opening hours (C20) leads to higher market share/revenue customer (C5)

By extending opening hours, retailers hope to attract more revenue into their shops: if shops would be closed after 18.00 hours, revenue would be lost to pizza couriers, restaurants etcetera. Moreover, openings shops longer than other retailers could enhance market share.

Extended shop opening hours (C20) lead to higher service demands customer (C10)

The extension of opening hours for shops obviously also has impacts on the required opening hours of both the retailers' and OEM's DCs. Shops are opened late at night or even on Sundays. Replenishment of fresh products needs to be guaranteed at those hours as well, in order to avoid stockouts. This calls for the upgrading of service standards upstream the distribution channel: DCs have to be opened during night time and weekends as well. Weekend stockouts are one of the major problems of the current retailing system.

Higher stockout costs (C4a) lead to higher inventory level OEM (D6)

An OEM who is constantly faced with increasing costs of stockouts tends to increase his inventory level of materials in order to avoid further lost sales or production disruptions.

Higher inventory costs OEM (C4b) lead to larger proportion of products made JIT (D4)

Some OEMs that had to deal with increased inventory costs sought the solution in the flexibilisation of production processes. Examples include manufacturers of fish products: fish products are only produced (cutting, cleaning and packaging) when actual orders are received. Consequently, order cycle times are extremely short (e.g. fish products are received by the retailer within four hours after order transmittal). By shifting the OPP upstream, inventory risk costs can be reduced as all (or a larger proportion) of the products are already sold before the production process has even been started off.

Higher transport costs OEM (C4c) lead to larger proportion transport contracted out (D13)

Many respondents expressed this relationship. Transport cost increases form the main reason for contracting out distribution activities to specialised LSPs. The OEMs generally do not see opportunities to calculate transport cost increases in the product price (given the competitive environment) and therefore choose for outsourcing. Almost all interviewed OEMs had contracted out most of their physical distribution activities, while the ones who still perform own-account distribution adjusted their own fleet capacity to the minimum demand volume: the remaining capacity (e.g. in case of sudden upsurges of demand) is hired from third-party LSPs.

Higher transport costs OEM (C4c) lead to performing more own-account transport activities for other OEMs (D14)

Most of the OEMs search for transport cost savings by contracting out distribution activities. Some of the OEMs who engage in own-account transport decided to take up more distribution activities for other OEMs in order to generate the same economies of scale realised by specialised LSPs. By combining different part shipments into full trucks loads, transport cost increases can be compensated for.

Lower handling costs OEM (C4d) lead to higher proportion of products made JIT (D4)

Some of the OEMs interviewed assert that if they succeeded in achieving lower handling costs, they would rise the proportion of JIT-manufacturing. JIT equals the production of small lots and consequently higher handling costs. In theory, no intermediate inventory build-ups are allowed and each production output needs to be stored or transhipped separately instead of combined in one batch. For fear of these cost increases, some of the respondents were restrained from implementing JIT-production techniques.

Higher handling costs OEM (C4d) lead to increased mechanisation of handling (D15)

Mainly the manufacturers of slow-moving products are faced with increasing handling costs due to increasing service demands of customers. The sales volumes of these manufacturers are not sufficient to guarantee fully loaded pallets under a more stringent time regime. Consequently, pallets that are only half-loaded or even worse are delivered to the customers, which is relatively more expensive in terms of handling costs per product. Some respondents indicated that they had invested in technical solutions to overcome this dilemma. Given the fact that personnel costs constitute the larger part of handling costs, mechanised palletising systems enable less-than-pallet-load storage at lower handling costs. Supported by these types of automated handling systems, two OEMs only kept half-loaded pallets in store, in order to provide a strategic answer to the trend of ever smaller order sizes.

Higher service levels OEM (C9) lead to reduction of separate backorders (D16)

Having to provide higher service levels to customers can also be used to the advantage of the OEM himself. Formerly, OEMs had to organise expensive and separate urgency shipments in case an order could not be loaded on the regular shipment. In the new situation of higher customer service standards, the number of regular shipments has been multiplied. Whenever a backorder is required in the new situation, it can usually be shipped along with the next regular shipment, and no separate urgent shipment is required any longer.

Higher service levels OEM (C9) lead to increased usage of EDI (D17)

In order to comply with higher service demands of customers (e.g. in terms of order cycle time), electronic data interchange has become an indispensable tool. Vendor-managed inventory systems are not possible without some form of structured, reliable and fast information and communications system. EDI will undoubtedly be challenged by the rise of the internet and e-commerce, but seems to have come to stay in the Dutch food industry. All the large food manufacturers communicate with their most important customers by means of EDI, although there are still implementation problems to overcome. Some respondents argued that they were ready for EDI (certified by the national EDI Service Centre), as opposed to some retailers: because retailing conglomerates are usually products of mergers and take-overs, retailing organisations are still in the middle of reorganising and standardising communications systems.

Higher predictability/stability of demand (C13) leads to lower inventory level OEM (D6)

If product demand is stable or highly predictable, less safety stock is required to cover demand fluctuations. OEMs are increasingly trying to have a grip on these demand fluctuations by developing demand management, as a part of ECR. Demand management, or category management involves the joint efforts of retailers and OEMs to understand the motives behind of customers' buying behaviour, and thereby improving predictability of demand. Customer purchasing data are increasingly registered through the loyalty cards issued by supermarkets, but OEMs generally complain that retailers do not share these data with them. In the eyes of the OEMs, retailers mainly use these customer data to improve the position of their own-label products.

Higher predictability/stability of demand (C13) leads to higher level of consolidation OEM (D6)

If product demand is stable or highly predictable, shipments can be planned pro-actively. Consequently, there is more time available to generate enough cargo to fill up vehicles.

Higher sales volume per customer (C14) leads to higher level of consolidation (D7)

If one retailer orders more products during a certain a time span, because of sales increases, the OEM will be able to send more products along with the same shipment. Hence, load factors will rise. This relationship provides an important counterbalance for the lower load factors caused by increasing service standards in a stable market. This process of consolidation has been enhanced by the rationalisation trend among retailers. The average sales volume per retailer has increased effectively due to continuous mergers and take-overs.

Higher number of SKUs/introductions (C15) leads to higher inventory levels (D6)

As the number of stock-keeping units rises, the total level of inventory also rises, as each item requires separate inventory locations.

Higher number of SKUs/introductions (C15) leads to lower level of consolidation (D7)

Increasing numbers of SKUs lead to a fragmentation of stocks: each SKU requires room for a full-pallet-equivalent unit, no matter how full it is actually loaded. This not only goes for storage space in DCs, but also for loading space in trucks. Pallets that are only half loaded take up disproportionate amounts of loading space in trucks, since pallets cannot be stacked endlessly.

More road congestion delays (C19) lead to higher inventory levels OEM *(D6)*

Delays cause long and unreliable delivery times. In a logistics system where buffer stocks have progressively been reduced, these delays could lead to production disruptions as a consequence of materials stockouts. As congestion delays and therefore delivery uncertainties increased, some OEMs were forced to raise their average safety stock level to cushion the impact of unreliable lead times.

Higher inventory level OEM *(D6) leads to lower stockout costs* OEM *(C4a)*

When the average inventory level for products is high, the chances of being capable to fulfil orders are higher. Hence, stockout costs decrease.

Higher level of consolidation (D7) leads to lower transport costs OEM *(C4c)*

If an OEM succeeds in organising higher load factors, his transport expenses can be spread over a larger number of products. The transport costs per item thereby decrease.

Performing more own-account transport for other OEMs *(D14) leads to higher level of consolidation (D7)*

For the same reasons why many OEMs have opted for increased outsourcing of distribution activities (D13), namely generating network advantages and subsequently cost advantages, some OEMs have chosen to extend their distribution activities for other OEMs. By combining several part shipments into full loads, the average consolidation rate can be improved.

More separate backorders (D16) leads to lower level of consolidation (D7)

If backorders need to be delivered separately because there is no time to wait for the next regular shipment, the load factor of the truck is bound to be low. We have encountered extreme examples of separate backorders: a salad and a potato product manufacturer occasionally had to deal with accidents in the distribution process. For instance, a tray of salads fell of the fork-lift truck in the distribution centre. Because buffer stocks were not available in the DC, a separate backorder the size of one tray had to replace the lost products. The customer was not prepared to wait for the next regular shipment, owing to the immediate lost sales in the store. Especially the demand for salads can rise very quickly as soon as the weather allows for the organisation of barbecue parties etcetera. One respondent claimed that demand for salad products can explode by 500 per cent within two days, in case weather conditions improve. It is for this reason that retailers cannot afford to wait for late orders.

Higher proportion of night distribution (D5) leads to changes in transport costs OEM (C4c)

The respondents did not agree whether increased night or off-peak distribution leads to a reduction or increase in transport costs. On the one hand, productivity gains (lower delay costs for personnel and trucks) would imply a transport cost reduction, on the other hand salary costs would rise and the level of consolidation might get worse. The respondents' opinions about the balance of these two cost drivers were not uniform.

Higher proportion of night distribution (D5) leads to lower stockout costs customer (C6a)

Under the ECR regime, actual demand patterns are constantly monitored and instantly replenished. Night distribution is a means to this end: stores are also replenished during night hours, so the shelves are already refilled before the first customer enters the supermarket. Therefore, the continuous replenishment process (among others enabled by night and off-peak distribution) leads to the avoidance of stockouts.

Higher inventory level OEM (D6) leads to higher inventory costs OEM (C4b)

This relationship is self-evident: the higher the amount of products in stock, the higher the capital costs, insurance costs, storage space costs etcetera.

Higher level of consolidation (D7) leads to lower transport (C4c) and handling costs OEM (C4d)

If the OEM succeeds in acquiring better load factors, the transport and handling costs of the OEM will decrease per freight unit.

Increased handling mechanisation (D15) leads to lower handling costs OEM (C4d)

It is believed by some manufacturers of slow-moving products that, in the long run, mechanisation of handling activities produces cost reductions, as the larger part of handling costs consist of personnel costs. This relationship holds more and more, since night distribution involves hiring personnel during expensive hours. Replacement of manpower by machines can thereby contribute to lower handling costs.

Increased usage of EDI (D17) leads to higher service demands customer (C10)

Using EDI implies that the OEM and retailer engage in a more open relationship. OEMs receive aggregate sales figures from retailers to determine the required inventory replenishment quantity. Conversely, retailers know exactly what the OEM has in store. In former situations where retailers were not capable of this, OEMs could obscure the real facts and claim that they were incapable of fulfilling the orders on-time because of stockouts. In a co-makership relation, such a game of hide-and-seek is not possible any longer: the retailer knows what the OEM should be able to deliver and therefore becomes less tolerant.

Increased usage of EDI (D17) leads to higher predictability/stability of demand (C13)

The use of EDI enables the retailer to send, and the OEM to receive, orders fast and without errors. Not only the order transmittal process is accelerated, but also order processing and preparation can be sped up. These time gains can be used by the OEMs to extend their planning horizon: they know earlier and more precisely what the actual demand figures look like. Orders are fixed at an earlier point in time and this gives the OEM the opportunity to plan production and shipments.

N

Experts consulted on micro-macro links

Dr B. Kuipers, Assistant Professor and Researcher, Faculty of Technology, Policy and Management, Delft University of Technology.

Drs H.A.C. Runhaar, Researcher, Faculty of Technology, Policy and Management, Delft University of Technology.

Dr Ir L.A. Tavasszy, Logistics Project Leader, TNO-INRO, Delft.

Summary

Introduction

Acceleration of all actions is a prevalent tendency today. This especially goes for business logistics, which is brought into focus in this dissertation. The logistics acceleration trend is exemplified by the emergence of *time-based competitors*: companies that offer greater varieties of products and services, at lower costs and in less time. Business organisations are increasingly applying such strategies as *time-based management*, *lean manufacturing*, *high-speed management*, *cycle-time compression*, *fast cycle time*, *agile manufacturing*, etcetera. Operational examples of time-based strategies include *just-in-time* (JIT) production techniques and *efficient consumer response* (ECR) distribution.

Problem statement

Various studies show what consequences time-based strategies and associated just-in-time concepts could have for the demand for freight transport. Often cited impacts are the decrease of average shipment sizes and an enhanced preference for fast modes of transportation (i.e. road haulage and air transport). These conceivable changes in the demand for transport are contrary to governmental freight transport policy goals that are aimed at a reduction of vehicle-kilometres by road. Time-based strategies may however also lead to reduced demand for freight transport, since these strategies are concentrated on the elimination of all wasteful activities, including superfluous transport (e.g. less backorders, return flows). The described societal problem calls for a scientific approach that enables us to describe and analyse the macro-impacts of changes in logistics choice behaviour.

Research goal

From the different evidence found in the literature, we concluded in **Chapter 1** that it is unclear if and to what extent time-based strategies contribute to a further growth of freight transport volumes. With this dissertation, we therefore try to unravel the above developments by providing a transportation demand analysis: understanding the determinants of the demand and of the manner they interact and affect the evolution of traffic volumes. The specific determinants we concentrate on are changes in logistics choice behaviour and the way these are affected by the implementation of time-based strategies. The research goal for this dissertation was summarised in Chapter 1 as:

Analyse the relevance, causes and micro-impacts of time-based strategies and their macro-impacts on the demand for freight transport, and formulate freight transport policy implications based on the analysis.

This research goal is broken down into five research questions:

Q1. In which business industries does time-based competition appear as an important trend?

Q2. What caused the emergence of time-based competition in these economic sectors?

Q3. What are the micro-impacts of time-based strategies on logistics choice behaviour?

Q4. What macro-impacts do these changes in logistics choice behaviour have?

Q5. If macro-level demand for freight transport increases as a result of the implementation of time-based strategies, what suggestions for freight transport policy can be made?

Research findings

In **Chapter 2**, we started with providing definitions of time-based strategies. Based on the available literature, we found that most of the definitions assign a crucial role to two elements: *responsiveness* to customer needs and *time-sensitivity*. Responsiveness and time-sensitivity are about giving customers *what* they want, *when* they want it. We also positioned time-based strategies in relation to more operational concepts such as JIT and ECR. We continued our exploration of time-based strategies by identifying a series of hypothetical logistics time-reduction alternatives. We carried out this analysis by means of so-called time-space prisms. Five groups of time-reduction alternatives were deduced, each consisting of several different methods:

- Accelerate order shipment (e.g. choose faster modes of transportation).
- Compress inert processes (e.g. reduce order transmittal and order processing time).
- Choose for co-location (e.g. concentrate on nearby customers).
- Eliminate links from the supply chain (e.g. reduce supplier base).

- Replace sequential by parallel processes (e.g. concurrent engineering).

This analysis provided us with the first indications about the conceivable micro-impacts of time-based strategies (Q3).

Chapter 3 starts with a literature overview. This overview examines various business industries in order to determine whether time-based logistics strategies play an important role in these industries (Q1). This desk research was complemented by a series of interviews with five large logistics service providers (LSPs). Since these respondents promote the interests of many different shippers, they were capable of identifying the most time-sensitive business industries and providing explanations for the emergence of time-based strategies in these sectors as well (causes of time-sensitivity; Q2). The results of both the literature review and interviews with LSPs yielded the same 'short list' of time-based business industries: the automotive industry (including spare parts), the consumer electronics industry (especially cellular phones and computers), the food industry and the pharmaceutical industry.

The interviews discussed in Chapter 3 moreover helped to classify different causes of increasing time-sensitivity. We observed three sets of explaining factors for the emergence of logistics acceleration:

- *Causes of increasing time-sensitivity stemming from the interaction between supply chain members*: e.g. powerful customers can be more demanding as regards customer service requirements.
- *Sources of haste originating from the supply chain member himself*: revenue-driven sources of haste mean that offering better logistics services contains competitive advantages or is needed to keep up with competing firms. Cost-driven sources of haste are implied by the move towards inventory reductions, which causes the need for fast replenishment cycles.
- *Technology-driven causes of time-sensitivity*: the new opportunities of speedy transport and communications are exploited to further accelerate logistics processes.

Chapter 3 finally describes the findings of an exploratory case study in the Dutch pharmaceutical industry (eight participating firms). This case study was aimed at gaining more in-depth empirical knowledge about research questions Q1, Q2 and Q3. Time-based strategies appeared to have emerged mainly in the latter part of the pharmaceutical logistics chain, namely from wholesaler to pharmacists/general practitioners. The main logistics micro-impacts created by increasing time-sensitivity turned out to be an increased emphasis on short transit times (road transport had become ever-more indispensable), crossdocking or pre-packaging, electronic data interchange, a pattern of decentral distribution centres and automated order entry and processing systems.

The empirical data gained in Chapter 3 are summarised and conceptualised in a conceptual model in **Chapter 4**. This model contains hypotheses about the interrelations between causes, micro- and macro-impacts of increasing logistics time-sensitivity. In the elaborated conceptual model, the causes of logistics time-sensitivity are connected to the micro-level logistics decisions, which in turn are linked to the hypothesised macro-impacts of increasing time-sensitivity (Q4). The resulting conceptual model allowed us to make propositions for transport policy tactics (Q5). These propositions were both based on the conceptual model and on the results of a workshop with freight transport policy-makers. Ultimately, four policy scenarios were deduced:

- *Policy scenario 1*: Impose higher charges on road transport.
- *Policy scenario 2*: Extend time windows and promote 24-hour economy.
- *Policy scenario 3*: Promote modal shift.
- *Policy scenario 4*: Promote efficiency.

The policy scenarios provided insights into the first- and higher-order effects that policy measures might have. The presented policy scenarios however required further refinement: an exploration of the causality behind model relationships, possible asymmetry of model relationships and overlooked relationships. In addition, the policy scenarios and the underlying hypotheses needed to be tested empirically.

The methods and techniques that can be used to reveal these aspects of refinement are examined in **Chapter 5**. In this chapter the case study methodology, which was used for the external validation of both the conceptual model and the deduced policy scenarios, is presented and underpinned. First, a brief overview of logistics analysis methods is provided (the survey methodology and the multiple case study methodology respectively). Second, the operationalised case study protocol is described (consisting of direct questions, conjoint analysis and stated-adaptation techniques).

The case study protocol was applied during empirical fieldwork in the Dutch food industry (34 participating firms) and the parts service industry (15 firms). **Chapter 6** comprises the selection procedure that was applied to identify the individual case study companies, an introduction into the basic characteristics of the case study sectors, as well as the conjoint analysis results. By means of this technique, the time-sensitivity of companies within the case study sectors is quantified.

Within the food industry, we found that on-time reliability (when measured as a trade-off ratio with costs) is by far the most important time variable, followed by costs. A comparison with the results of similar conjoint analysis studies revealed that our estimations lie within a plausible range. The individual models showed that there is little variation in the preferences among the food manufacturers, while companies in the parts service industry display a greater deal of heterogeneity. This is because food manufacturers have to comply with the dominant logistics demands of a small group of powerful retailers, whereas companies in the parts service industry face a much broader range of clients.

Chapter 7 is made up of the remaining empirical research findings in the food and parts service industry. In this chapter, the initial conceptual model is revised on the basis of the empirical data gathered in the Dutch food and parts service industry. Following this analysis, so-called causal chains are identified. These are robust sequences of variables and relationships that together form important determinants of the logistics system's behaviour. The most important causal chains between the model factors are highlighted in Chapter 7:

- Causes of higher customer demands.
- Micro-impacts of increasing time-sensitivity.
- Cost impacts of increasing time-sensitivity.
- Compensating cost increases.

The causality behind the relationships is explained and illustrated with practical examples.

It appeared that increasing time-sensitivity essentially has contributed to the rise in vehicle-kilometres by road. Mainly in the slow-moving and less-than-truckload segments, higher shipment frequencies have caused lower consolidation levels. This trend towards lower consolidation rates has been exacerbated by the continuous introduction of new products and stock-keeping units. At the macro-level, these logistics trade-offs contribute to a reduction of average utilisation rates and an increase in the number of empty returns. The introduction of time-based competition has also strengthened the position of road transport compared to alternative modes of transportation. This contributes to a rise (or at least a prolongation) of the modal split in favour of road transport. We however realised that it would be too simple to state that increased customer time-sensitivity can directly be translated into lower levels of consolidation and more vehicle-kilometres. We found that some of the transport inefficiencies are indeed compensated by autonomous market trends. The emergence of consolidation services provides an illustration of these self-regulating mechanisms.

Finally, the policy implications of the above are discussed. The policy scenarios were tested in the same series of interviews with logistics managers. The three basic responses to the policy scenarios we have recorded are summarised as:

- *Do nothing*: the intended effects of the policy package are not realised.
- *Involve other supply chain members*: the effectiveness of the policy scenario is often undermined, except when the policy measures have the desired effects on other supply chain members.

- *Make changes to own logistics organisation*: this involves the direct adjustment of the logistics manager's own logistics operations.

We saw in the food industry, that the policy scenarios, which affect the on-time reliability performance of logistics organisations (e.g. a scenario with drastically deteriorating road congestion), offer less 'escape routes' than pricing policies. This confirms the results of the conjoint analysis: logistics managers in the Dutch food industry proved to be more susceptible to on-time reliability than transport costs. In the parts service industry, logistics managers have more opportunities to either do nothing or involve other supply chain members in a solution. This is caused by the relative supply chain power of the service organisations.

In order to achieve a vehicle-kilometre reduction in a business environment that is characterised by increasing time-sensitivity, we found that two elements in our revised conceptual model hold a crucial position: the level of consolidation and the modal share of road transport. All the discussed policy scenarios ultimately attempt to influence these two factors. In the stated-adaptation experiments, we found that the policy initiatives aimed at achieving improved efficiency have better chances than the proposed modal shift policies.

The suggested policy directions of increased efficiency and modal shift imply the use of several policy instruments. Both the policy directions turned out to be hindered by factors such as limited trust among supply chain members, faith in the capabilities of LSPs and intermodal services, and the like. The obvious policy instruments that can and are already used to overcome these barriers involve communication and economic instruments: organising and partly financing demonstration projects to generate critical volumes, break dominant perceptions and show that economic benefits are attainable through increased co-ordination and co-operation. Voluntary covenants that formulate the desired logistics behaviour (e.g. adjusting delivery schedules in order to allow for higher load factors) have however gained ground only to a limited extent.

Finally, the overall conclusions are drawn in **Chapter 8**. The findings for each research question are discussed comprehensively. Moreover, the methodological contributions and implications of this dissertation are examined in the last section. The main scientific contribution of this dissertation is formed by:

- *Extension of empirical knowledge and theory formulation*: a better understanding of logistics choice behaviour in general and under increased time-sensitivity specifically: we have systematised the knowledge and experiences of the logistics managers in different business industries by means of a detailed conceptual model.
- *Ex ante policy evaluation*: with the revised conceptual model, we were able to interpret the reactions of respondents to the policy scenarios and subsequently formulate recommendations for freight transport policy.

The final sections incorporate several recommendations for further research.

Recommendations for further methodological developments

- Future research efforts could be aimed at statistical testing of (part of) the observed causal relationships (e.g. by means of a survey).
- In order to identify possible long-term adjustments, the stated-adaptation experiment could be extended to form a simulation game with realistic cost- and revenue consequences tied to every suggested logistics adaptation.

Recommendations for further empirical research

- Replication of the research activities in internationally operating business sectors could be executed in order to determine whether the same kind or different micro- and macro-impacts are observed at the international level.
- Further research could be aimed at discerning the threshold levels for which observed asymmetries in model relationships are reversed.
- Spill-over effects (e.g. less transport in one part of the logistics chain may cause more transport in other parts) have been discussed implicitly in this dissertation, but may require focused attention in future research efforts.
- Encountered uncertainties in the relation between night distribution and transport efficiency require further research.
- The deduced policy implications are mainly aimed at redirecting existing trends and freight transport flows through efficiency and modal shift measures. Therefore, empirical research that is concentrated on transport prevention policies would be valuable.

Samenvatting

Introductie

Versnelling van activiteiten is een belangrijke hedendaagse ontwikkeling die met name geldt voor de zakelijke logistiek, waar wij ons in deze dissertatie op richten. De logistieke versnellingstrend wordt weergegeven door de opkomst van concurrentie op basis van tijd: bedrijven bieden een steeds groter assortiment van produkten en diensten aan, tegen lagere kosten en in minder tijd. Bedrijven passen in toenemende mate tijdstrategieën toe (aangeduid als *time-based management*, *lean manufacturing*, *high-speed management*, *cycle-time compression*, *fast cycle time*, *agile manufacturing*, etc.). Operationele voorbeelden van dergelijke bedrijfsstrategieën worden gevormd door *just-in-time* (JIT) produktietechnieken en *efficient consumer response* (ECR) distributiemethoden.

Probleemstelling

Verschillende studies laten de mogelijke gevolgen zien van tijdstrategieën voor de vraag naar goederenvervoer. Veelgenoemde gevolgen zijn de afname van de gemiddelde zendingsgrootte en een toegenomen voorkeur voor snelle vervoerswijzen (lucht- en wegvervoer). Deze denkbare veranderingen in de vraag naar goederenvervoer zijn tegengesteld aan de doelstellingen die de overheid heeft gesteld ten aanzien van de ontwikkeling van het goederenvervoer: een reductie van het aantal voertuigkilometers over de weg. Op tijd gebaseerde strategieën kunnen echter ook samengaan met een reductie van de vraag naar goederenvervoer, omdat dergelijke strategieën tevens gericht zijn op het vermijden van overbodige en niet-waardetoevoegende activiteiten (bijv. minder nabestellingen, retourstromen). Deze maatschappelijke probleemstelling roept de wetenschappelijke vraag naar methoden op, die geschikt zijn om mogelijke veranderingen in logistiek keuzegedrag te beschrijven en vervolgens de consequenties op macro-niveau te analyseren.

Onderzoeksdoel

Op basis van de verschillende literatuurbronnen, concludeerden wij in **Hoofdstuk 1**, dat er onduidelijkheid heerst over de vraag of en in welke mate tijdstrategieën bijdragen tot een verdere groei van goederenvervoerstromen. In dit proefschrift trachten we de bovenstaande ontwikkelingen uiteen te leggen door een analyse van de vraag naar goederenvervoer. Deze vraaganalyse is gericht op het begrijpen van de vraagdeterminanten, de manier waarop deze op elkaar inwerken en zodoende de vraag naar goederenvervoer beïnvloeden. De specifieke determinanten waarop wij ons richten zijn veranderingen in logistiek keuzegedrag veroorzaakt door de opkomst van logistieke tijdstrategieën. Het onderzoeksdoel voor deze dissertatie wordt in Hoofdstuk 1 als volgt samengevat:

Analyseer de relevantie, oorzaken en micro-uitwerking van tijdstrategieën en hun invloed op de vraag naar goederenvervoer op het macro-niveau, en formuleer de implicaties voor het goederenvervoerbeleid op basis van de analyse.

Dit onderzoeksdoel is uitgesplitst in vijf onderzoeksvragen:

Q1. In welke economische sectoren zijn tijdstrategieën een belangrijke ontwikkeling?

Q2. Wat veroorzaakte de opkomst van tijdstrategieën in deze sectoren?

Q3. Welke micro-uitwerking hebben tijdstrategieën op logistiek keuzegedrag?

Q4. Welke macro-uitwerking hebben deze veranderingen in logistiek keuzegedrag?

Q5. Wanneer de vraag naar goederenvervoer op macro-niveau toeneemt als gevolg van de opkomst van tijdstrategieën, welke suggesties voor goederenvervoerbeleid kunnen dan nog gemaakt worden?

Onderzoeksresultaten

Hoofdstuk 2 begon met een aantal definities van tijdstrategieën. Op basis van de literatuur bleek dat het reageren op klantenwensen en tijdgevoeligheid terugkerende elementen waren in deze definities. Reactievermogen en tijdgevoeligheid betekenen dat klanten krijgen wat ze willen op het door hen gewenste tijdstip. Tevens werd de positie van tijdstrategieën ten opzichte van meer operationele concepten zoals JIT en ECR duidelijk gemaakt. De verkenning van tijdstrategieën werd vervolgd door het identificeren van een reeks hypothetische logistieke tijd-reductie alternatieven. Deze analyse werd uitgevoerd met behulp van zogenaamde tijd-ruimte prisma's. Vijf verschillende groepen van tijd-reductie, elk bestaand uit verschillende methoden, werden afgeleid:

- Versnel de orderverzending (bijv. kies snelle vervoerswijzen).
- Comprimeer de inerte processen (bijv. reduceer de tijd benodigd voor het overbrengen of verwerken van orders).
- Kies voor nabije lokaties (bijv. concentreer op nabijgelegen klanten).
- Elimineer schakels uit de logistieke keten (bijv. reduceer het aantal toeleveranciers).
- Vervang sequentiële processen door parallelle processen (bijv. parallel schakelen van orderverwerking en transport planning).

Deze tijd-ruimte analyse bracht de eerste indicaties over de micro-uitwerking van tijdstrategieën (Q3).

Hoofdstuk 3 ging eveneens van start met een literatuuroverzicht. In dit overzicht kwamen verschillende economische sectoren aan de orde, waarbij bepaald werd of logistieke tijdstrategieën al dan niet een belangrijke rol spelen in deze sectoren. Dit onderzoek werd aangevuld met gegevens uit een vijftal interviews met grote logistieke dienstverleners. Deze respondenten behartigen de logistieke belangen van een breed scala van verladers, waardoor ze goed in staat waren om de meest tijdgevoelige economische sectoren vast te stellen (Q1). Tevens boden de logistieke dienstverleners inzicht in de oorzaken van toegenomen logistieke versnelling (Q2). Uit de resultaten van zowel de literatuurstudie als de aanvullende interviews bleek dat telkens dezelfde tijdgevoelige sectoren genoemd werden: de automobiel industrie (inclusief reserveonderdelen), de consumentenelectronica industrie (met name mobiele telefoons en computers), de voedingsmiddelen-industrie en de farmaceutische industrie.

De interviews resulteerden verder in een classificatie van oorzaken van toegenomen logistieke haast. We observeerden drie groepen verklarende factoren voor de opkomst van logistieke versnelling:

- *Oorzaken die voortkomen uit de wisselwerking met andere ketenpartijen*: machtige klanten kunnen bijvoorbeeld veeleisender zijn wat betreft hun wensen ten aanzien van logistieke service.
- *Oorzaken die voortkomen uit de ketenpartij zelf*: opbrengst-gerelateerde oorzaken voor haast houden bijvoorbeeld in dat een beter logistiek dienstenpakket een concurrentievoordeel biedt. Kosten-gerelateerde oorzaken komen voort uit de trend naar voorraadverlaging, hetgeen een verhoogde aanvulfrequentie van voorraad teweegbrengt.
- *Oorzaken voortgedreven door technologie*: de nieuwe mogelijkheden van snelle transport- en informatiemiddelen worden aangewend voor een verdere versnelling van logistieke processen.

Hoofdstuk 3 wordt besloten met de resultaten van een verkennende *case study* in de Nederlandse farmaceutische industrie en groothandel (acht deelnemende bedrijven). Deze gevalsanalyse was gericht op het verkrijgen van meer diepgaande empirische inzichten ten aanzien van onderzoeksvragen Q1, Q2 en Q3.

Tijdstrategieën bleken met name een belangrijke rol te spelen in het laatste deel van de farmaceutische keten, namelijk op het traject van groothandel naar apotheek/huisarts. De belangrijkste logistieke micro-uitwerkingen van tijdstrategieën waren een toegenomen nadruk op korte transporttijden (wegvervoer werd steeds meer onontbeerlijk), *cross-docking* (overladen zonder dat goederen in opslag komen) en voorverpakken door de producenten, electronische gegevensuitwisseling (EDI), een distributiepatroon met decentrale distributiecentra en automatische orderinvoer en -verwerking.

De empirische gegevens uit Hoofdstuk 3 werden samengevat en geabstraheerd tot een conceptueel model in **Hoofdstuk 4**. Dit model bevat hypothesen over de onderlinge verbanden tussen oorzaken, micro- en macro-uitwerkingen van toegenomen logistieke tijdgevoeligheid. In het uitgewerkte conceptuele model worden oorzaken verbonden met micro-uitwerkingen, welke op hun beurt gerelateerd worden aan macro-uitwerkingen (Q4). Het resulterende conceptuele model stelde ons in staat een aantal voorstellen voor goederenvervoerbeleid te maken (Q5). Deze voorstellen werden mede gevoed met resultaten uit een interactieve werkbijeenkomst met beleidsmakers van verschillende ministeries en belangengroepen. Uiteindelijk werden hieruit vier verschillende beleidsscenario's afgeleid:

- *Beleidsscenario 1*: Leg hogere financiële lasten op aan het wegvervoer.
- *Beleidsscenario 2*: Verruim tijdsvensters en stimuleer de 24-uurseconomie.
- *Beleidsscenario 3*: Stimuleer een verschuiving naar alternatieve vervoerswijzen.
- *Beleidsscenario 4*: Bevorder de efficiëntie van het wegvervoer.

De uitgewerkte beleidsscenario's gaven inzicht in de eerste-orde en hoger-orde effecten die uit zouden kunnen gaan van de genoemde beleidsrichtingen. De gepresenteerde scenario's behoefden echter verdere verfijning: de veronderstelde causaliteit tussen modelfactoren moest verder verkend worden. Tevens diende aandacht geschonken te worden aan mogelijke asymmetrische modelrelaties en relaties die mogelijkerwijs over het hoofd gezien waren. Bovendien moesten de beleidsscenario's en de onderliggende hypothesen empirisch getoetst worden.

De methoden en technieken die gebruikt kunnen worden om tot een dergelijke verfijning te komen, zijn in **Hoofdstuk 5** behandeld. In dit hoofdstuk werd de *case study* methodologie, welke gebruikt werd voor de externe validatie van zowel het conceptuele model als de afgeleide beleidsscenario's, gepresenteerd en onderbouwd. Ten eerste werd een kort overzicht van verschillende logistieke analysemethoden gegeven (resp. *survey*-methoden en meervoudige *case study*-methoden). Ten tweede werd het geoperationaliseerde *case study* protocol beschreven (bestaande uit directe vragen, conjuncte analyse en zogenaamde 'verklaarde-aanpassingen' (*stated-adaptation*) technieken.

Het *case study* protocol is toegepast tijdens het empirische veldwerk in de Nederlandse voedingsmiddelenindustrie (34 deelnemende bedrijven) en service industrie (distributie van reserveonderdelen; 15 bedrijven). **Hoofdstuk 6** omvatte een beschrijving van de selectieprocedure die gebruikt werd om de individuele *case study* bedrijven te identificeren, een introductie van de beide *case study* sectoren, alsmede de resultaten van de conjuncte analyse. Met behulp van deze techniek werd de tijdgevoeligheid van de *case study* bedrijven gekwantificeerd.

Het kwam vast te staan dat voedingsmiddelenproducenten leverbetrouwbaarheid als verreweg de belangrijkste tijdvariabele beschouwen (wanneer uitgedrukt in een kostenratio), gevolgd door transportkosten. Vergelijking met eerder uitgevoerde conjuncte analyses liet zien dat onze modelschattingen aannemelijke waarden opleverden. De individuele modellen wezen uit dat er relatief weinig variatie in de voorkeuren van de voedingsmiddelenproducenten te ontdekken is, terwijl de bedrijven in de service industrie gekenmerkt worden door een grotere mate van heterogeniteit. Dit is te wijten aan het feit dat voedingsmiddelenproducenten moeten voldoen aan de levereisen van een kleine groep supermarktketens. Bedrijven in de service industrie hebben veelal te maken met een veel grotere variëteit aan klanten.

Hoofdstuk 7 beschreef de overige empirische onderzoeksresultaten uit de voedingsmiddelen- en service industrie. In dit hoofdstuk werd het aanvankelijke conceptuele model herzien op basis van de empirische gegevens die vergaard zijn in de voedingsmiddelen- en service industrie. Vervolgens werden zogenaamde causale ketens onderscheiden; robuuste aaneenschakelingen van variabelen en relaties die samen belangrijke determinanten vormen van het gedrag van het logistieke systeem. De belangrijkste causale ketens zijn naar voren gehaald in Hoofdstuk 7:

- Oorzaken voor toegenomen klantenwensen.
- Micro-uitwerkingen van toegenomen tijdgevoeligheid.
- Kosten repercussies van toegenomen tijdgevoeligheid.
- Mogelijkheden om kostenstijgingen te compenseren.

De causaliteit achter de modelrelaties werd verklaard en geïllustreerd aan de hand van praktische voorbeelden.

Uit de analyse bleek dat toegenomen logistieke tijdgevoeligheid in principe bijdraagt tot een toename in voertuigkilometers over de weg. Hogere zendingsfrequenties hebben met name in de langzaamlopende en deelladingensegmenten geleid tot lagere beladingsgraden. Deze ontwikkeling naar lagere beladingsgraden wordt versterkt door de continue stroom van produktintroducties en produkteenheden. Op het macro-niveau dragen deze logistieke afwegingen bij tot gemiddeld lagere beladingsgraden en een toename van lege retourritten. De opkomst van tijdstrategieën heeft tevens de positie van het wegvervoer ten opzichte van andere vervoerswijzen verstevigd. Dit bevordert (of tenminste prolongeert) het marktaandeel van het wegvervoer. Het zou echter te ver voeren om te stellen dat toegenomen klantenwensen altijd onherroepelijk leiden tot lagere beladingsgraden en meer voertuigkilometers. Sommige inefficiënties in het wegvervoer worden daadwerkelijk gecompenseerd door autonome marktontwikkelingen. De opkomst van bundelingsconcepten is een voorbeeld van deze zelfregulerende mechanismen.

Tenslotte werden de beleidsimplicaties besproken. De beleidsscenario's werden getoetst tijdens de reeds genoemde interviews met logistieke managers. De drie basis-antwoorden op de voorgestelde toekomstscenario's kunnen samengevat worden als:

- *Niets doen*: het bedoelde beleidseffect wordt niet gehaald.
- *Betrek andere ketenpartijen bij het zoeken naar een oplossing*: de effectiviteit van het beleidsscenario wordt vaak ondergraven, behalve wanneer de beleidsmaatregelen het gewenste effect hebben op andere ketenpartijen.
- *Pas de eigen logistieke organisatie aan*: dit betreft de directe aanpassing van de eigen logistieke organisatie om de toekomstscenario's het hoofd te bieden.

We zagen in de voedingsmiddelen-industrie, dat de beleidsscenario's die de leverbetrouwbaarheid negatief beïnvloeden (bijv. sterke toename van files op de wegen) minder uitwijkmogelijkheden bieden dan prijsmaatregelen (minder logistieke managers besluiten niets te doen). Dit bevestigt de resultaten uit de conjuncte meting: logistieke managers in de Nederlandse voedingsmiddelen-industrie zijn meer gevoelig voor leverbetrouwbaarheid dan voor transportkosten. In de onderdelendistributie geldt dat logistieke managers onder beide typen scenario's evenveel mogelijkheden hebben om ofwel niets te doen, ofwel andere ketenpartijen bij een oplossing te betrekken. Dit heeft te maken met de relatieve marktmacht van de service- en reparatiebedrijven ten opzichte van hun klanten.

Twee elementen in het herziene conceptuele model spelen een cruciale rol teneinde een voertuigkilometer-reductie te bewerkstelligen in een zakelijke omgeving die gekenmerkt wordt door toegenomen tijdgevoeligheid: de beladingsgraad en het marktaandeel van het wegvervoer. Alle besproken beleidsscenario's proberen op een of andere wijze deze twee factoren te beïnvloeden. Tijdens de *stated-adaptation* experimenten kwamen we tot de bevinding dat transport-efficiëntie beleidsscenario's betere kansen hebben dan beleid dat zich richt op een verschuiving naar alternatieve vervoerswijzen.

De effectiviteit van beide beleidsrichtingen wordt beperkt door factoren zoals een gebrek aan vertrouwen tussen ketenpartijen onderling, geloof in het kunnen van logistieke dienstverleners en multimodale vervoersdiensten, enzovoort. De voor de hand liggende beleidsinstrumenten die kunnen en worden gebruikt om dergelijke barrières te overwinnen zijn communicatieve en economische instrumenten: het organiseren en gedeeltelijk financieren van demonstratieprojecten die dienen om voldoende kritieke massa te creëren, dominante percepties te doorbreken en te laten zien dat economische voordelen haalbaar zijn door een toename van de coördinatie en samenwerking tussen ketenpartijen. Vrijwillige convenanten die gewenst logistiek gedrag voorschrijven (bijv. aanpassen van leverschema's en zodoende hogere beladingsgraden bereiken) komen echter nog maar moeizaam van de grond.

Tenslotte werden in **Hoofdstuk 8** de algehele conclusies getrokken. Eerst werden de belangrijkste bevindingen samengevat en vervolgens is uitgebreid stilgestaan bij de uitkomsten per onderzoeksvraag. Ten derde zijn de methodologische bijdrage en gevolgtrekkingen van deze dissertatie aan de orde gekomen.

De belangrijkste wetenschappelijke bijdrage van dit proefschrift wordt gevormd door:

- *Vergroting empirische kennis en theorievorming*: een beter begrip van logistiek keuzegedrag in het algemeen en onder toegenomen tijdsdruk in het bijzonder: we hebben de kennis en ervaringen van logistieke managers uit verschillende sectoren daartoe gesystematiseerd in een gedetailleerd conceptueel model.
- *Ex ante beleidsevaluatie*: met behulp van het herziene conceptuele model waren we in staat om de reacties van de respondenten op de beleidsscenario's te interpreteren en vervolgens aanbevelingen voor goederenvervoerbeleid te formuleren.

De laatste paragrafen bevatten aanbevelingen voor vervolgonderzoek.

Aanbevelingen voor verdere methodologische ontwikkeling

- Toekomstige onderzoeksinspanningen zouden gericht kunnen zijn op het statistisch toetsen van (enkele van) de geobserveerde causale relaties (bijv. met behulp van een schriftelijke enquête).
- Teneinde mogelijke lange-termijn aanpassingen in kaart te brengen, zou het *stated-adaptation* experiment uitgebreid kunnen worden tot een simulatiespel met realistische kosten- en opbrengsten-gevolgen voor elke gesuggereerde logistieke aanpassing.

Aanbevelingen voor verder empirisch onderzoek

- Herhaling van het onderzoek in een internationale *setting* zou ondernomen kunnen worden om te bepalen of dezelfde micro- en macro-uitwerkingen ook gelden op het internationale niveau.
- Verder onderzoek zou gericht moeten worden op de drempelwaarden die asymmetrische modelrelaties doen omkeren.
- Overloop effecten (bijv. minder transport in het ene deel van de logistieke keten kan meer transport in een ander deel van de keten veroorzaken) zijn impliciet aan de orde

gekomen in dit proefschrift, maar behoeven speciale aandacht in toekomstig onderzoek.

- Onzekerheden in de relatie tussen nacht- of dalurendistributie en transport-efficiëntie moeten nader onderzocht worden.
- De afgeleide beleidsimplicaties zijn met name gericht op het ombuigen van bestaande logistieke trends en goederenvervoerstromen door middel van vergrote efficiëntie en een verschuiving naar alternatieve vervoerswijzen. Aanvullend onderzoek gericht op transportpreventie is echter van wezenlijk belang.

Subject index

About the author

Gert-Jan Muilerman was born in the town of Markelo (The Netherlands) on the 29th of May 1971. Having graduated at the 'Scholengemeenschap Holten' in 1989, he started studying Human Geography at the University of Groningen. He soon specialised in transport and business logistics subjects.

In 1994 he completed his Master's thesis on the locational choice behaviour of logistics service providers in the Northern Dutch provinces, as part of an internship at the Ministry of Transport. During the final year of his academic studies in Groningen, Gert-Jan was student-assistant at the Institute of Transport Economics. Additionally, he spent four months studying at the University of Reading (UK), Institute of Urban and Regional Studies.

In November 1995 he started to work as a researcher at the Delft University of Technology (Faculty of Technology, Policy and Management), within the Transport Policy and Logistics Organisation Group (TLO). At the same time, Gert-Jan assisted in the transport economics and transport modelling courses at the Faculty of Economics of the University of Amsterdam. In Delft, he was also involved in various applied research projects for the Ministry of Transport and the Port of Rotterdam. He however mainly concentrated on his Ph.D. research project on time-based logistics, for which he conducted case study research in the pharmaceutical, spare parts, food and logistics industry.

Gert-Jan Muilerman currently lives in Vienna (Austria), and works as a logistics consultant.

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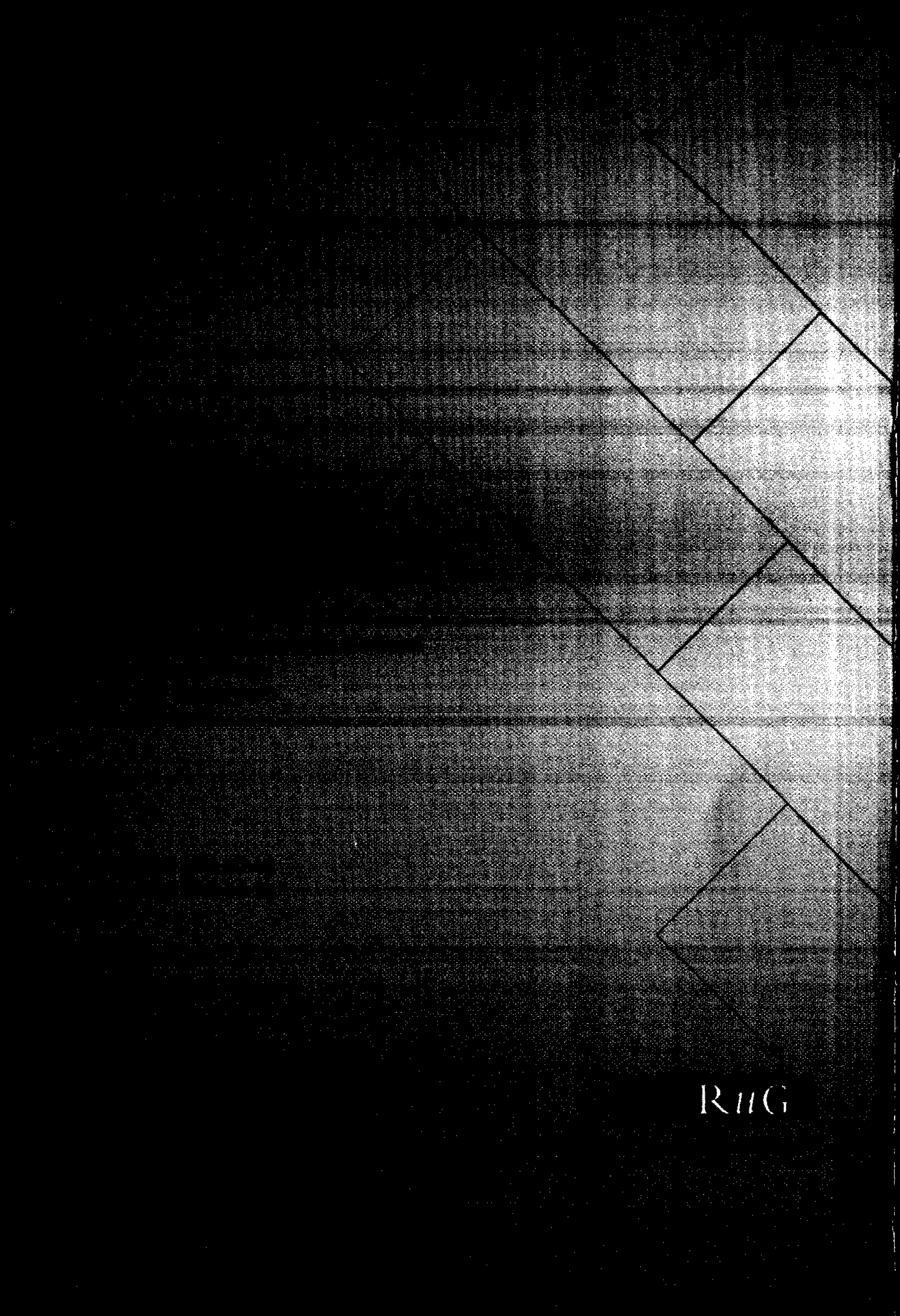

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