

Logistics Concept Development in Multi-Actor Environments

**Aligning stakeholders for successful development of public/private
logistics systems by increased awareness of multi-actor objectives and
perceptions**

Ron van Duin

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logistics systems by increased awareness of multi-actor objectives and
perceptions**

Proefschrift

ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus prof. ir. K.C.A.M. Luyben,
voorzitter van het College voor Promoties
in het openbaar te verdedigen op donderdag 23 oktober 2012 om 12.30 uur

door

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Doctorandus in de (bedrijfs) econometrie
geboren te Rotterdam, Nederland

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ISBN: 978-90-5584-156-1

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Printed in The Netherlands (Nederland)

Preface

*Wat we willen
Momenten
Van helderheid*

*Of beter nog: van grote
Klaarheid*

*Schaars zijn die momenten
En ook nog goed verborgen*

*Zoeken heeft dus
Nauwelijks zin, maar
Vinden wel*

*What we want
Moments
of brightness*

*Or even better of great
Clarity*

*Scarce are these moments
And well hidden*

*Searching makes
little sense, although
Finding does
(Martin Bril†)*

The poem reflects well the romantic longing of writing a PhD. Obviously the author Martin Bril did not have ‘writing a PhD’ in his mind when he wrote this poem, but nevertheless for me it reflects well the internal motivation of a PhD-student. Once you have decided to start a PhD the research issue has to be chosen. For me, as a boy born and raised in Rotterdam, it is almost in my genes that it has something to do with logistics. Inspired by the (un)loading of the large vessels in the Rotterdam harbour I must confess I still feel proud to be a ‘Rotterdammer’ when I watch the logistics activities in ‘our’ harbour.

Mark Twain said once ‘*chance is the main inventor*’. I was lucky to work for a period with Mark van Twist as my roommate. ‘Myriapod’ Mark met ‘Myriapod’ Pieter Bots and they had interesting stories about multi-actor-analysis. Inspired by their conversations I became aware of the power relations, strategic behaviours, the power of metaphors, and hidden agendas. This was an interesting new world for a simple econometrist as me, whose research world relied mostly on self-made models. It was even more interesting for me when Pieter Bots chose to formalise the actor analysis. After several sessions and discussions the DANA (Dynamic Actor Network Analysis) –tool was developed and this inspired my interest in

multi-actor situations. Therefore I thank Mark and Pieter for their inspiration and the good discussions we had.

As master thesis supervisor I was able to coach students on a couple of projects which were helpful to work out some of my ideas. Therefore I want to thank especially my students Johan Kneyber, Dennis Kuiper, Jouke Dessens, Mels van der Voet, Bin Wang and Alexander Kloppers. It was nice working together and I noticed the same enthusiasm for research.

For their critical reading and thinking I must thank my co-authors (and many times became close friends) Eiichi Taniguchi, Hans Quak, Jesús Muñozuri, Harry Geerlings, Lori Tavasszy and Bert van Wee. The writing-process with you provided a good synergetic quality for the articles.

Of course, many more colleagues should be credited as they have contributed to a pleasant and inspiring working atmosphere, not forgetting the laughs. Some of these inspiring colleagues are Maarten Kroesen, Nilesh Anand, JanAnne Annema, Caspar Chorus, Marcel Ludema, Eric Molin, Vincent Marchau, John Baggen, Jan-Willem van der Pas, Bart Wiegmans, Ekki Kreutzberger, and Marisa de Brito.

Special thanks go to Akos Wetters, Bert van Wee, Lori Tavasszy, and our Dean Theo Toonen for their effort to support me by organising a lecturing-free period in which I was able to concentrate fully on finishing my dissertation despite the severe budget cuts at our faculty. To Rachel Heap who corrected my summary and chapters 1, 7 and 8 into proper English. To Conchita van der Stelt who supported me with the book format. To Lori, my promoter, you were able to structure my thoughts and smoothly streamline my writing. Symbolically you were Polonius in Shakespeare's Hamlet *'there is a method in the madness'*.

To Rob, my promoter, I must confess that I should have been listening more to Nietzsche: *'One repays a teacher badly if one always remains but a pupil'*. A long time ago I started with the idea of writing a dissertation. I thank you for your unending patience and the confidence you showed in my ability to finish it. Most of all I thank you for understanding that there are sometimes incidents in a personal life which are much more important than writing a PhD.

Therefore I end this preface with by thanking the most important people in my life. My children Lara, Rik, Luuk and Tim for claiming the computer and being socially abandoned at moments when they wanted to chat with their friends or to play games with their friends. My parents Co and Ali, my sister Corinne and many close friends to whom I have had to explain many times why the progress of my dissertation was lagging behind or had stalled completely. Last but not least my wife Marjolein, who always gave me wise advice to focus on one goal instead of being tempted by other challenges, to remain more selfish and just to focus on finishing my dissertation. As the Dalai Lama says: *'Devotion is the essence of the path'*.

Finally, I dedicate this thesis to two important people in my life who passed away far too young: Nelleke Huijsdens, the mother of my children, who was the first one who supported me in beginning with a PhD and Gerard Kuypers, a close college friend who introduced me into the scientific philosophical world and gave me scientific inspiration during long nights which lasted until the sun rose.

Ron van Duin

Millingen a/d Rijn, June 2012

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1 Logistics on the move

*'There is nothing more difficult to take in hand
more perilous to conduct, or more uncertain in its success,
than to take the lead in the introduction of
a new order of things'*
(Niccolo Machiavelli, 1513)

1.1 Introduction

Logistics has become a field of growing societal importance over the last decades. Every product we buy has been the subject of production and distribution activities controlled by a concept of logistical management. In this thesis a logistical concept is defined as a way of managing and controlling a series of activities by one or more organisations in order to generate a product or a service for a specific economic market. Based on the philosophy of logistical concepts such as 'just in time' or 'Kanban' (Ohno, 1988, pp. 25-28), the societal production and consumption behaviour basically triggers the whole supply chain of logistics activities. A necessary condition of survival in the current markets for businesses is therefore a continual re-consideration of logistics structures. The variety in product and service specifications, fluctuations in volumes, changes in markets, shorter product lifecycles and new sustainability requirements, motivate businesses to continually update and improve the design of the logistics concepts they apply. They constantly have to ask themselves questions such as: Which suppliers can satisfy our requirements with regard to product quality, quality of delivery and price? Which distributors can fulfil the customer needs best in terms of order-quantities and delivery times?

The parties involved with logistics have a lot of effects on society. First of all, logistics activities generate employment and economic value for regions and states. For instance, 6 percent of the Dutch Gross National Product (29.9 billion Euros) is directly derived from freight transport and logistics business, of which 36% is directly related to transport and

transshipment activities, 14% is related to warehousing activities, 39% is related to value-added-logistics & services and 11% is related to supply chain control activities (Van Wijk et. al., 2011). This economic performance makes freight transport and logistics a 'basic good' (Saitua, 1993). On the other hand, logistics activities also produce negative effects, reducing the quality of the living environment. The transportation of products for instance, dominated by road transport, contributes to the traffic congestion on roads and causes environmental effects such as noise and air pollution. Another example is the packaging processes which often uses non-decomposable plastic materials to seal products. A third example of a negative side effect is the growth in the space needed for warehousing and freight handling in old and newly constructed industrial areas.

These impacts have led to increasing demands by society for a more explicit influence by governmental policies is more and more stressed by society, ranging from the local level to Europe and even wider to the global level. Participation by governmental organisations can be seen in the introduction of specific laws and steering regulations, for example the Driving Times Decree (i.e. maximum number of hours a truck driver is allowed to drive without a break) or at a local level by the rules for access to urban areas for trucks. The government can also intervene to enable new logistics activities or supply new transport infrastructure. The construction of a hinterland connection from the port of Rotterdam to a hinterland terminal nearby the border of Germany for freight transport ('The Betuwelijn') is an example of a national intervention by the Dutch government. The application of road pricing (see e.g. the Maut-system for freight transport in Germany) is another example of intervention at state level. At the local scale many municipalities develop logistics business parks to increase employment or to try to influence the behaviour of logistics service providers with time window regulations for entering the inner city. Besides the interferences of government many interest groups participate in the discussions concerning the construction of new infrastructure, the setting of environmental criteria or the establishment of new business activities.

This development shows that the growing importance of transition and innovation in logistics concepts has moved away from its traditional boundaries. Logistics concepts nowadays have to serve multiple values (social, economic, environmental) of the different interests of the stakeholders and thus the development of logistics becomes a social engagement for all the stakeholders involved. This also inherently includes an important challenge for the methodologies/analytical approaches that are used to support multiple actor decision making on the introduction of new or fundamental changes in existing logistics concepts. This study is triggered by the observation that the presently applied analytical approaches and methodologies do not sufficiently match the requirements following the aforementioned described development regarding the societal involvement in logistics concept transition. Therefore, for this thesis the following hypothesis is chosen:

'If the methodologies for designing and analysing (future) logistics concepts do not pay sufficient attention to the preferences of various stakeholders, the concept will not be implemented as planned, effects will be different from those expected and the expected results will not be achieved.'

An illustrative example of this thought concerns the development of the innovative, underground freight transport concept OLS-ASH (Ondergronds Logistiek Systeem Aalsmeer

Schiphol Hoofddorp) in the Netherlands in the period 1995-1996. Several aspects of this innovative concept were researched in detail and many research reports on various aspects have been published (Brouwer *et al.*, 1997; van Binsbergen & Visser, 2001; de Vreede *et al.*, 2000; Pielage, 2005). However, at the end of the day, the lack of support from the private sector appeared to be the main reason why political decision-makers discontinued the project (Visser *et al.*, 2008). Another example illustrating the difficulties with traditional approaches for logistics service development is the innovative project Distrivaart. In this project an automatic pallet-sorter and transshipment system was developed to operate on board an inland barge, aiming to transport pallets quickly and efficiently between production plants and retail outlets. The service with the specially constructed ship 'Riverhopper' had an operating schedule of less than one year. Main users were beer brewers and retailers wanting their products distributed. The technical feasibility had been proven. The economic feasibility study indicated a required demand of at least 650 pallets per week. (Groothedde, 2005). In practice this business requirement was never met because of incomplete implementation of the service. Moreover, the main problem in this competitive market turned out to be the fact that transport by road was actually still cheaper for the beer producers¹.

Van Binsbergen and Visser (2001) executed a quick-scan of 13 innovative logistics projects. In terms of content it appears that the innovation projects analysed regularly meet similar challenges or issues. These issues are who does the initial investment, inaccurate allocation of the benefits and costs, ignoring the effects on existing market concepts and power relations and the mistrust in the actual reliability and efficiency of new technologies. Identical findings are mentioned in the BESTUFS II study (Allen *et al.*, 2007). Most of the city logistics schemes have failed. The main reasons for these 'failures' were that the profitability of such approaches were overestimated, allocation of benefits and costs was not done properly and the critical mass on consignments to be bundled for city distribution was never reached.

Summarizing, in this thesis we argue that the introduction of logistics concepts asks for an improved approach. From the early design phase till the moment of finalising the logistics concept (product or service) all its main impacts should be made more transparent to all the stakeholders involved. The elements of improvement should be evident and convincing and the design should take into account elements that are likely to encounter foreseeable opposition. To overcome some of the (often organisational) pitfalls mentioned of traditional approaches to logistics concepts change, this study focuses on the development of a novel approach for analysing and designing logistics concepts, emphasising and including the interests of the stakeholders involved.

The remainder of this chapter gives an introduction to the study. The next section deals with the evolution of logistics. The significant changes in logistics thinking through time are discussed from internal logistics up to public logistics with their related characteristics. Section 1.3 gives insight into the shortcomings of current logistics thinking and its design methodology and is a starting point for rethinking the design approach. Section 1.4 specifies the research scope and objectives. Section 1.5 discusses the chosen research approach. The last section 1.6 of this chapter presents the research outline and describes the structure of this book.

¹According to one of the project advisors Walter Kusters, at the VLM-meeting Veenendaal (17 Augustus 2007), one of the partners stepped out the project and the operators of the service didn't have the flexibility to promote their services to other parties.

1.2 The evolution of logistics systems thinking: public & private concerns

Thinking about logistics systems actually started in defence organisations. The material supply of the forces proved to be an essential element of strategic warfare. The word 'logistics' was used for the first time by the French Swiss military theoretician de Jomini in 1869. He defined the function of a high staff member responsible for co-ordination of accommodation, transport and provisioning as 'Marechal de Logis'.

Logistics as a discipline developed mainly by thinking over defence operations. The strategic movements of transport (Coakley, 1968), the supply structure of foods and ammunition, the maintenance of equipment were logistics issues which were the subjects of professional studies. The notion of 'logistics' already existed but didn't play a managerial role in the way that it does nowadays. To meet the requirements of steady economic growth after World War II mass production was introduced as a way of meeting the demands of the consumers. Production firms became vertically organised from the purchasing of raw materials to the distribution of final products, using bureaucratic, hierarchical management control systems based on traditional management doctrines (Taylor, 1911). Scientific research was mainly focussed on the development and application of operational research methods for specific logistics operations (de Schepper 1991). For example statistical inventory control systems (Wagner & Within, 1958; Silver, 1976) found broad application in practice as well as in more scientific research. Another example is Forrester (Forrester, 1961), who investigated logistics processes with such control systems and demonstrated how demand variations are amplified when the ordering information is transmitted along autonomous links in a production process or distribution system.

Internal Integrated co-ordination

In the 1970s companies began to embrace and implement the concept of integrated distribution (Londe *et al.*, 1970; De Schepper, 1991). The elements of co-ordination were incorporated as the essential part of business logistics (Ballou, 1987). Bowersox *et al.* (1986) defined logistics as: 'the process of managing all activities required to strategically move raw materials, parts, and finished inventory from vendors, between enterprise, facility and to customers'. Daskin (1985) added aspects of engineering and timing to the controlling process. 'Logistics is the design and operation of the physical, managerial and informational systems needed to allow goods to overcome space and time'. The business-financial aspect was emphasised by Christopher (1985). Many businesses failed to recognise the financial consequences for performance of implementing improvements in logistics management, i.e. that without logistics management there could be no cost reductions. Logistics became an essential part of the business strategy (Heskett, 1977). Progressive firms began to realise that a well-designed and operated logistics system could create strategic added value among competitors (Bowersox *et al.*, 1986).

Supply chain management

Based on these insights, stressing the importance of an adequate logistics concept and control system, many firms sought logistics control by internally developing and performing as many essential activities as possible in the beginning of the 1980s. This internal controlling drive led to private warehouses, own account transportation and in-company information processing. Huge capital investments were required to finance the control of logistics

operations. However, shareholders were mainly focused on the profitability of the firms and the high investments led to a serious decrease in profitability. In response logistics managers started reducing invested capital by outsourcing a wide range of logistics activities not directly related to their core business. Selection of logistics partners was managed carefully and only a few suppliers were selected as preferred partner. Consequently, logistics co-operation (Cappellin, 1992) led to a reduction in the number of parties involved. The importance of the remaining parties grew and the communication between these parties intensified, also because the requirements from the consumption markets changed. Considering the demands and wishes of the chain partners, lead-time reductions and lead-time reliability had to be realized (Ploos van Amstel *et al.*, 1996). Operations had to run smoothly and unnecessary interfaces between entities in the supply chain were to be avoided, because each interface point within a logistics system represented a potential source of disturbance (Bowersox *et al.*, 1986). Forrester (1961) had, for example, already demonstrated the possibility of the extreme stock positions in a chain of one by one interrelated warehouses.

Global logistics

In the early 1990s some companies in Europe began to integrate operations across national boundaries. The removal of trade barriers, one of the main policy aims of the EU, increasingly enabled the cross-border geographical integration of markets and thus logistics operations could also cross country borders, creating economies of scale (Bowersox *et al.*, 1996). In order to sustain economic growth, for many companies it became necessary to develop new markets outside their home countries. New manufacturing plants and distribution centres were built e.g. in low labour costs countries. Not only the market conditions seemed to be favourable but also the manufacturing conditions. The main motives for these companies to invest in such facilities were low wages, sufficient labour forces and expansion opportunities. As a result relocation and re-allocation of existing manufacturing activities took place (Vos, 1993). This global shift of manufacturing activities created pressure to change distribution structures. To satisfy delivery requirements the organisation of excellent distribution channels became extremely important. To guarantee the speed and the price of delivery, as well as the flexibility of demand (peak variations), new logistics concepts were developed and implemented to structure and support these distribution channels. Related activities such as transshipment, (sub) assembly, packaging and pricing also became important links that added value to the distribution channel.

Nowadays, the trend towards global logistics influences the wider context of logistics. While the domestic and global logistics principles tend to remain the same as those that are applied to accommodate global logistics the operating environment has become more complex and cost-expensive. These increases in costs and complexity are reflected in the changes in distance, management of documents, diversity in culture and public administration, (inter)national governmental intervention, customer demand and the growing importance of the requirements for sustainability.

- *Distances* are becoming longer (although recently new ideas about local-for-local logistics have been launched) and therefore the role of transportation is still of increasing importance in logistics concepts. The shortening of lead-times stimulates the demand for transportation. The unpleasant side effects of transportation such as congested roads, noise

and air pollution are generally known nowadays. In order to maintain growth and to reduce these negative side effects, new logistics concepts are being considered. Concepts for multimodal transportation, underground freight transport, and urban consolidation centres illustrate this search for new means of simultaneously accommodating logistics concepts and reducing the negative effects of related transport flows. The logistics concepts influence the environment and this in turn stimulates the search for changes in the logistics concepts.

- With average transportation distances becoming longer, there is an urgent need to monitor product flows, resulting in ‘knowing where’ and status *documentation*. For controlling and safety reasons the documentation process is becoming more intensive, using new technologies such as sensing, RFID and geofencing. In order to perform just-in-time deliveries and to protect against the threats from potential terrorist attacks, the state and position of the goods to be transported has to be continuously monitored. Every irregularity in transportation has to be registered, because it might lead to a severe delay. In reaction for example, many organisations in the Rotterdam harbour have tried to make their administrative processes more manageable, efficient and safe by using ICT (see e.g. Den Hengst-Bruggeling, 1999; Tan, 2011). Here we can also see a greater involvement of governmental authorities in formulating security requirements, and customs and port-authorities in the control and exchange of information.
- *Demand variation* in products and logistics services is necessary to satisfy cultural *differences*. Many (inter-)national companies apply the concept of postponed manufacturing in their distribution channels (Feitzinger & Lee, 1996; Kramarz & Kramarz, 2011), where the product is produced tailor-made to the customer, in other words produced as late as possible or as near as possible to the customer. The final delivery to the customer (last mile logistics) however faces specific regulations set by public and local authorities such as for instance low emission zones, or specific attention with respect to a product (for instance in the situation where the product is a dangerous good).
- *Institutional complexity* is caused by the amount of regulation at various governmental levels in the functioning of economic markets, environmental protection, urban development, labour, etcetera. The complexity in cross-border transport is for example caused by the differences and fragmentation in national laws, infrastructures and regulations in the EU and non-EU-countries, regarding factors such as labour, environmental protection, infrastructure use or market regulation. The European rail freight transport market is one example of institutional complexity (Walker *et al.*, 2004; Zhang *et al.*, 2009). At the European scale there is a fragmentation which refers to the various forms of divergence in the system of the rail freight transport operations, which impedes the cross-border operation from being seamless, resulting in longer transit time, lower reliability, and higher operational costs. In general, fragmentation is presented in the operational, technical, pricing, administrative, and market systems of the rail freight operation. In an attempt to remove such fragmentation the EU decision makers introduced standardisation and harmonisation in the sub rail systems, primarily by introducing Community regulations and directives that were to be transposed into national decrees and

implemented in all member states. Nevertheless, the extent to which the EU laws and directives are transposed and implemented, the divergence in political and economic interests and the degree to which the EU interest is shared among the national states, varies enormously (Zhang *et al.*, 2009).

Towards public logistics

Crum and Poist (2011) conclude in their overview and retrospective analysis on the 40th anniversary of the International Journal of Physical Distribution & Logistics Management, that there is a strong interest among logistics researchers in addressing the challenges and issues associated with managing “outside the walls” of the organisation. According to Crum and Poist (2011), a key emerging research area for logistics and SCM is the discipline’s contributions to addressing important societal issues. The dynamics and manifestation of societal issues are influenced by incentives from industry as well as public governments.

Governmental organisations have various *policy instruments* which influence/facilitate logistics structures either directly or indirectly. The government can make investments in the development of transport networks, i.e. terminal development and the connecting infrastructure. Encouraging investment in public private partnerships for infrastructure development has recently become common practice in the Netherlands. Examples of these partnerships are the developments of multimodal terminals such as the one in Born and the planned multi transport centre in Valburg (Dijkhuizen, 2011).

Besides investments, the government also has *regulation and pricing instruments*. A real-life example of regulation is the introduction of time-window constraints in cities, where freight trucks are not allowed to enter the inner city during specific time periods. Also the lobbying of municipalities to provide industrial or logistics zones (ECMT, 1997) for regional economic welfare makes businesses reconsider their location policy and their distribution structure. Another real-life example is environmental zoning in cities. This governmental measure based on the environmental performance of vehicles aims to create incentives to use less polluting vehicles or even to renew the vehicle fleet or forbid polluting vehicles entering specific zones in a town (Russo and Comi, 2010).

We should also mention the instrument of encouraging knowledge development and dissemination in which public authorities can play a significant role. In the Netherlands we have seen important initiatives in this area with the Centre for Transport Technology (1996-1999), Connekt (1999–now), the Transumo programme (Transition to sustainable mobility) and the most recent knowledge integration organisation Dutch Institute for Advanced Logistics (Dinalog (2010–now)). These initiatives are all based on public-private partnerships between private organisations and knowledge institutes in the field of transport and logistics. The conclusion is that the logistics concepts can be greatly influenced by policy measures and can lead to adjustments of logistics concepts.

Governmental bodies at various administrative levels are major players in the field of policy making. There is a long scientific tradition of theorizing on and studying the processes of policy making. The literature on policy making has traditionally concentrated on processes of defining the content of policy problems and on designing and evaluating alternative policies. Walker (2000) summarizes this tradition by indicating that policymaking, in essence, concerns making choices regarding a system in order to change the system outcomes in a desired way. In the old tradition of policy making, reference is made to the general interest of society, known by and protected by public authorities. In this context much attention is paid

to supportive methodologies. The dominating methodology applied has strong roots in operations research and applied systems analysis (Miser & Quade, 1985; Walker, 2000).

In the general debate on policy making support, policy scientists criticise policy analysts using these methodologies for being too narrowly focused on means-end rationality, referring to the observable key roles of other types of rationality (political, procedural). Other factors in policy making, such as power, personal interests and relations, strategic behaviour and the strategic use of information (Lindblom, 1959; Wildavsky, 1993) are according to this criticism too often neglected. Following this criticism, Lindblom & Cohen (1979) argued that the scientific challenge is to provide the actors involved in the policy field with analyses and information suited to their particular roles and interests, instead of merely referring to the general interest as if that is clear for all.

The awareness has grown recently that policymaking has the potential to become a controlling process of actors continuously involved in choices to change the system outcomes. Initiatives to control the policy process have been developed. For example, Eden and Ackerman (1998) propose a so-called 'Journey making model'² that provides an answer to Lindblom and Cohen's idea. The journey has a facilitator and the journey the main goal is to achieve consensus on formulating the strategy. Others (e.g. Walker, 2000; Marchau *et al.*, 2008; Hermans & Thissen, 2009), following the controlling paradigms (Shewhart, 1939; Deming, 1986), suggest ideas to enable policymakers to cope with the uncertainties of specifying policies. These uncertainties relate to e.g. long term changes in the system, lack of insights in causalities, insufficient data, and so on. These authors advocate provisions for learning, e.g. based on the use of scenario-techniques as well as the implementation of system-monitoring systems.

These general developments in the field of policy analysis and theory on policy making are also reflected in the developments in the field of logistics. As argued, we can observe a change of scope in decision making on logistics from a mono-actor or company perspective towards a multi-actor perspective in which governmental policy making actors are more involved. Policymaking for logistics therefore requires an integrated view with respect to the various alternative options, their possible consequences for the transport system performance, and societal conditions for implementation (Bertolini *et al.*, 2008). Moreover we observe that policy making cycles interact dynamically (Walker, 2000). This growing interaction between public policy and logistics management cycles is shown in Figure 1.1 (= grey colouring), which refers to the idea that the management of logistics concepts is frequently shaped by a process of continuous improvement of the overall logistics performance (Deming, 1986). The process operates in controlling circles such as pictured here (Deming, 1986) with the steps plan-do-check-act, the so-called 'Deming-wheels'. Nowadays many businesses shape their logistics processes by principles derived from 'this process of continuous improvement' (Goldratt & Cox, 1984).

² They make use of tools like Decision Explorer <http://www.solari.co.uk> and Group Explorer <http://www.prontis.com>

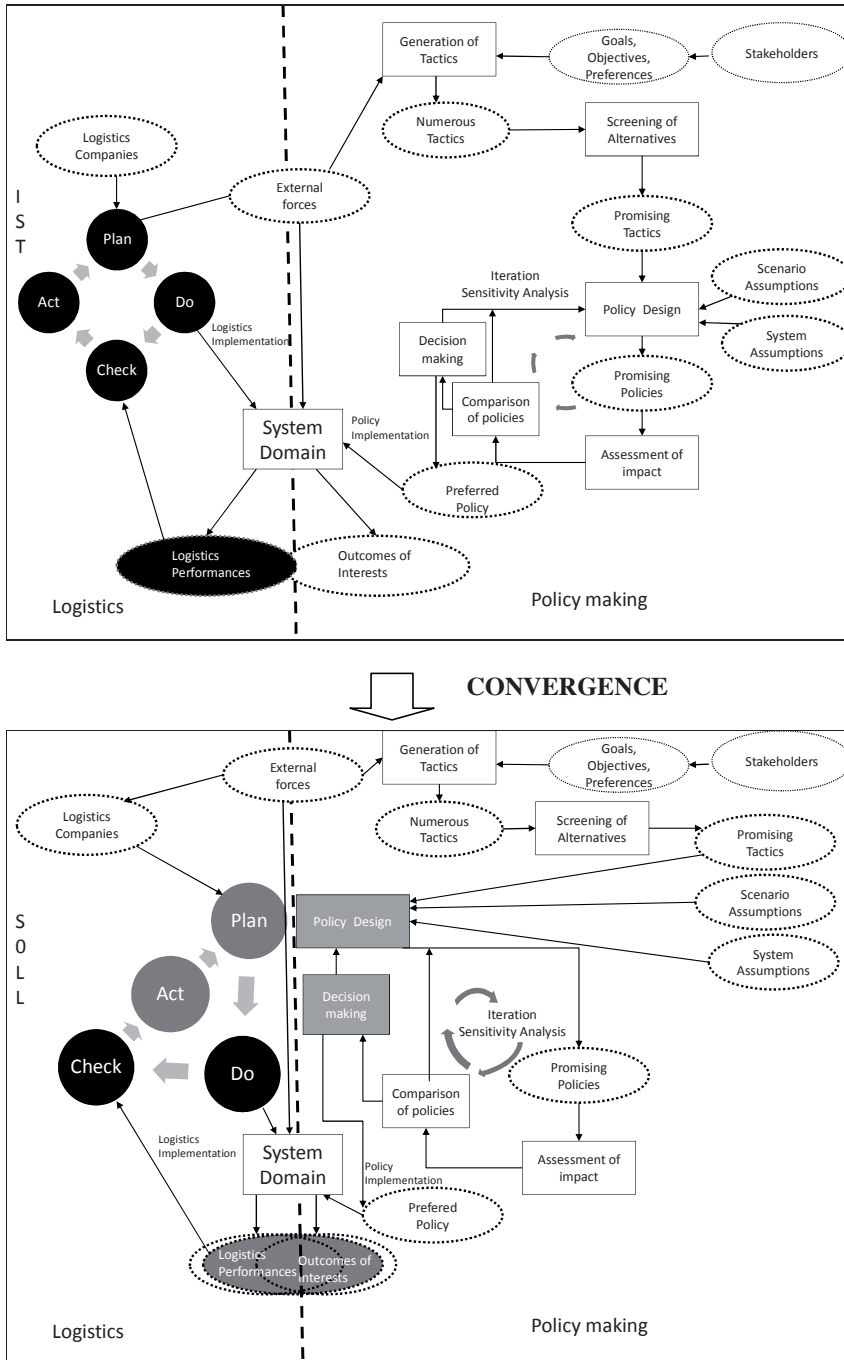


Figure 1.1: Growing integration of outcomes and performances, planning and policy making between logistics management circles (Deming,1986) and policy making cycles (Walker, 1987)

By analogy with the trend in Figure 1.1, Craig et al. (2011) show that the field of sustainable supply chain management has evolved from a perspective of isolated research in specific social and environmental areas, through a corporate social responsibility perspective, to convergence of perspectives based on environmental, social, and economic performances (see Elkington, 1998). In this view, there is a growing consensus for both the need to address the generators of freight traffic in order to optimize logistics activities and a general consensus on the need to ensure a rational and effective connection between the industrial areas and the regional transport and logistics infrastructural backbone, implicating for example policymaking in the Netherlands (van Wijk *et al.*, 2011). Similar thoughts have been formulated by Rodrigue and Notteboom (2010) who illustrate that international supply chains have become more complex and the pressure on gateway logistics is increasing, not just in terms of infrastructure and capacity, but more importantly because of the need to match regional demand which leads to the setup of more efficient regional freight distribution strategies. Most market players have responded by providing new value-added services in an integrated package, through a vertical integration along the supply chain. Entire freight distribution systems including gateways, corridors and inland centres are adapting to these new realities. In spite of powerful converging forces, namely containerization, information technologies and globalization, the geographical, political and cultural characteristics tend to convey a significant regional differentiation of freight services in practice. This regionalism leads again to increased interaction with local governments and illustrates that also the level of decision making has moved from a mono-scale level (company/supply-chain perspective) towards a multi-level decision-making process.

The conclusion is that the regional mix of cultural, political and socio-economic aspects, the dynamic interaction of the controlling cycles in policy and logistics management have led to such significant changes in logistics that we need a new definition and a different approach of logistics concept development and implementation. The original definition of logistics, e.g. the definition stemming from the council of logistics management (Bramel & Simchi-Levi, 1997): ‘Logistics is the process of planning, implementing and controlling the efficient and cost-effective flow and storage of raw materials, in-process inventory, finished goods and related information from point of origin to point of consumption for the purpose of primary satisfy customer requirements’ emphasizes the handling of product flows. We add the idea of ‘contextual embeddedness’ to the definition of public logistics:

Definition:

Public logistics is logistics embedded in an environment where public and private actors take mutually dependent decisions, and consequently broaden the scope of requirements on logistics concepts.

The essential difference with the original definition of company logistics is the embeddedness in an environment with intensive interactions between public and private stakeholders. In this context a stakeholder is an organisation, a group or a set of individuals, or a combination of both, having a relationship with or an impact on the entire process of planning, implementation or control. All the stakeholders participate in networks. Some actors have close relations with each other while they have direct responsibilities for some part of the logistics process. Other actors, like governmental bodies, can influence a logistics concept without participating actively.

The consequence of adopting this view on logistics is that logistics problems can by definition, no longer be considered as isolated and static entities which can be researched independently from their context; they are parts of a more comprehensive system of problems (such as urban accessibility, regional economic performance, efficient infrastructure use, globalization, local environmental deterioration, etcetera), best described as messes (Ackoff, 1981, pp. 4-5) or wicked problems of organised complexity (Mason & Mitroff, 1981, p. 12). Solutions to problems become obsolete even when the problems to which they are addressed do not. Moreover, problems are mutually linked. Opportunities for change through action in one area frequently affects the intensity and importance of problems in other areas as a side effect. For instance, the application of stock-reducing concepts can cause more transportation, which generates more costs and extra emissions. The problems can rarely be distinguished into independent, discrete, and mutually exclusive parts (Dunn, 1981, pp. 99-100). Every wicked problem can be considered as a symptom of another problem. At the same time there is no identifiable root cause. Since curing symptoms does not cure problems, one is never sure the problem is being attacked at the proper level. Wicked problems have no definitive solution³.

It is also important to realise that solving such problems may require commitments from many stakeholders that may result in high costs and, to a large degree, might be irreversible. There is, in other words, often not much room for trial and error. Once a solution is attempted, it is very difficult to undo what has already been done. Consequently, the probability of failure is greater, because the probability of solving the wrong problem is often larger than of the probability of finding the wrong solution to the right problem. Or as Mason and Mitroff (1981, p.26) put it: "In a first course in statistics the student learns that he must constantly balance between making an error of the first kind (that is, rejecting the null hypothesis when it is true) and an error of the second kind (that is, accepting the null hypothesis when it is false). Practitioners all too often make errors of the third kind: 'solving the wrong problem'". It is therefore important to know the perceptions of all the stakeholders involved and to understand the actors' behaviour in their strategical, tactical and operational thinking.

Applying this idea of public logistics as a wicked problem according to László et. al. (2008) there is a strong need for stronger cooperation in policy making between institutional bodies - responsible for public policy making, financing and infrastructure investment decisions- and manufacturing companies, logistics providers, transport operators, transport & logistics node managers, whose decisions and supply chain strategies strongly affect the spatial pattern and the modal split of freight transport. In order to achieve sustainable logistics solutions at a local, regional and national level, logistics criteria should be adopted in spatial planning, in the planning and set up of industrial areas and in the choice of the companies to be located in production areas.

Summarising this section, the evolution of logistics systems thinking, we can observe the following trend in views on logistics (Table 1.1).

³ See as an illustration of 'The Goal, a process of ongoing Improvement' by Eli Goldratt (1984)

Table 1.1: Views on logistics systems thinking

Years	Logistics	Main Focus	Aim
1970s	Internal	Internal integration	the traditional integration of the basic logistics elements procurement, production, sales and distribution
1980s	Supply chain	Channel integration	the integration of firms as part of the supply chain in order to meet the final customer service
1990s	Global	Geographical integration	the global reallocation of production and distribution firms in order to meet economies of scale and to penetrate new market-areas
2000s	Public	Public integration	the integration of actors' attitudes into new logistics concepts in order to improve quality and public acceptance of the concepts.

1.3 Towards a multi-stakeholders oriented concept design

Now we have discussed the evolution of logistics systems thinking, it is important to have a closer look at the set of available methodologies. In particular the following two developments can be observed.

Quantitative approach

Methodologies for the design and implementation of logistics concepts have a traditionally strong basis in quantitative research methods. Logistic reasoning and design strongly rely on mathematical techniques rooted in Operations Research, using computational power to solve often NP-hard combinatory problems (Bramel & Simchi-Levi, 1997). Inventory control (Silver, 1976), production (job-) scheduling (Rinnooy Kan, 1976), transportation routing, location allocation models (Aikens, 1985) have already proven their value in understanding logistics. The quantitative dependencies and interrelations between operational logistics issues within and between companies are strong. Adjustments in these logistics issues require a complex trade-off analysis between various cost elements and usually also a vast range of non-quantifiable factors. The high number of possible combinations of management-controllable parameters and control policy structures add to the managerial complexity (Mourits, 1995), which has its consequences for modelling tasks. From this perspective, the available techniques are absolutely valuable.

Growing awareness of the multi-stakeholder environment in logistics practice

As has been argued, the major change in analytical requirements deduced from the concept of public logistics stems from the fact that many stakeholders are involved in the design of logistics concepts. The role, impact, and participation of these stakeholders vary during the design process. It is likely that stakeholders' decisions on strategic logistics issues are influenced by differences in interests, means, skewness of information, intuitions and common (gut-) feelings. Decisions are not necessarily based on a well-considered evaluation of well-defined performance indicators (Sijbrands, 1993), as is often assumed in the above mentioned quantitative analytical approaches. Vidal and Goetschalckx (1997) mentioned in their critical review of supply chain models, that research into developing more comprehensive supply chain concepts should also focus on modelling of alliances and multi-

company network configurations. This matches the trend we discussed earlier. The mismatch between available methods in logistics analysis and the requirements arising from the need to support public logistics implies that we need to seek for a new approach to analyse logistical concept development against a background of a variety of stakeholders, aspects and interactions in order to reduce the risk of failure for a logistics concept and to obtain multiple values for the stakeholders involved.

Multi-stakeholder research in logistics (private actors)

Attention for strategic alliances between organisations within supply chains can be found in the literature under the label of 'governance' in logistics. Many definitions of such forms of governance (Rhodes, 1997; Pierre, 2000) can be found. These can be summarised as the design of the process approach of how the management of the logistics concept will be directed and how the laws and customs (rules) apply to that way of directing. Governance in logistics includes the relationships among all the stakeholders involved (for example: shareholders, managers, employees, customers, banks, and regulators). These governance studies focus on alliance design issues to understand performance differences for this purpose. In relation to this issue of governance, for the field of logistics Omta *et al.* (2001) and Diederer and Jonkers (2001) have defined a new interdisciplinary called 'Chain and Network Studies'. Diederer and Jonkers (2001) argue that: 'Better understanding of all system principles underlying successful actor-networking and effective network governance is the main challenge to be tackled and forms a mission of paramount significance for multidisciplinary research and knowledge transfer'. The knowledge created in the domain of Chain and Network Studies is related to the analysis, construction and validation of productive networks and chains. Issues such as partner selection (Parkhe, 1993; Geringer, 1991), ownership (of resources, buildings and equipment) and control (Beamish, 1987; Geringer & Herbert, 1989) have been investigated to explain alliance performance. Ziggers *et al.* (2005) developed an alliance performance model by empirically testing whether partner firm's alliance capabilities, effective management of alliances and relational capital like trust, friendship and respect (Coleman, 1990) can lead to improved performance. To summarise these studies confirm that the management of the multi-stakeholder network is an important factor in the success or failure of the final logistics concept. The theories and concepts used in these studies can be positioned in the right part of the diamond in Figure 1.2 which is based on the distinction between four dimensions: the involvement of theory, the involvement of practice, the public nature of the actor or the private nature of the actor. The combination of these dimensions results in a field with four corners: public actors that are strongly involved in theory development (analysis and method development) versus public actors that strongly participate in practice (implementing and facilitating logistics concepts). These two ends of one axis represent completely different types of involvement by these public actors. In contrast, the same holds for private companies/actors. The involvement in theory or practice constitute two ends of another axis. The diamond in the middle of the playing field represents the present dominating practice of logistics (which implies a relatively strong involvement of private actors in both theory development and practice, and a relatively low involvement of involvement of public actors). In public logistics, a balanced involvement of public and private actors is pursued in theory (analysis and method development) as well as in practice (implementing and facilitating new logistics concepts). The figure therefore indicates the two major gaps to be filled to reach this balanced situation. These gaps will be explained further.

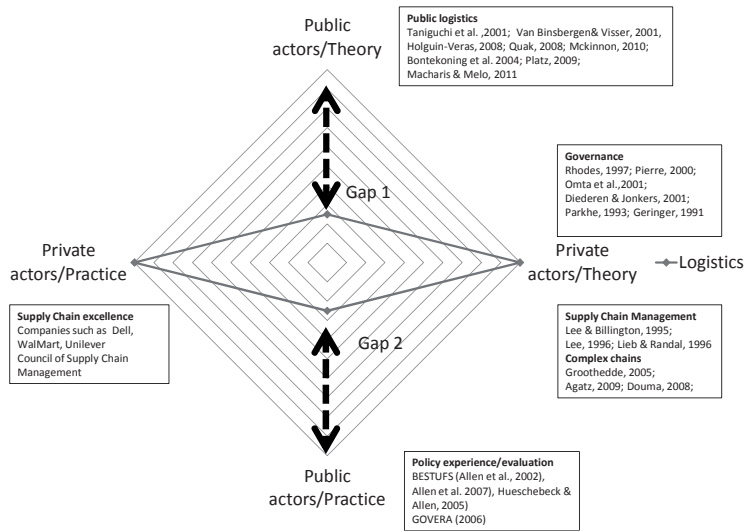


Figure 1.2: Positioning of logistics

Translating theory to practice for private actors

As mentioned above, most of the governance literature in logistics focuses on the horizontal (supply-chain) cooperation between logistics companies. The organisational structures and companies' attitudes have changed as a result of supply chain thinking and current logistics practice shows that many organisations are involved in logistics management. The most important reason for this involvement is the outsourcing of logistics activities to other companies (Razzaque & Sheng, 1998). Public warehousing may be the oldest form of outsourcing in logistics (Goldsmith, 1989). Richardson (1992) added marketing, packaging, transportation, distribution, import and export to the list. The delivery and working relations between organisations have been intensified in order to meet the customer service requirements. To obtain supply-chain integration Simatupang and Sridharan (2002) distinguish three types of collaboration: vertical, horizontal and lateral cooperation. Horizontal cooperation refers to concerted practices to share private information, facilities or resources to reduce costs or improve the service between companies. Vertical collaboration is defined as collaboration between the parties that succeed each other in a particular generation process. Lateral cooperation is a combination of vertical and horizontal cooperation. Nowadays many third-party logistics companies offer dedicated services such as logistics information, shipment consolidation, warehouse management/operation, carrier selection, rate negotiations, fleet management/operations, product returns, order fulfilment, spare parts services, vendor selection and purchasing (Lieb & Randall, 1996) which operate within horizontal and vertical cooperation.

The literature which translates the theoretical concepts of a large group of private actors into practice is quite mature. Most of the research can be found in the literature of supply chain management in which Hau Lee (Lee & Billington, 1995; Lee, 1996) is seen as a founding father of supply chain management. More sophisticated contributions with complex private-

actor relationships in logistics can be found in the project Distrivaart (Grootthedde, 2005), project www.albert.nl (Agatz, 2009) and the game-planning tool for aligning the operations of barges and terminals (Douma, 2008). The theories and concepts treated in these studies can be positioned in the left part of the diamond in Figure 1.2.

Involvement of public actors

The *netchain* concept from the interdisciplinary Chain and Network Studies was originally defined (Lazzarini *et al.* 2001) in terms of linking the two terms network and (supply) chain. The authors define a netchain as ‘a set of networks comprised of horizontal ties between firms within a particular industry or group, which are sequentially arranged based on vertical ties between firms in different layers’. We add another dimension to this netchain definition: the stakeholders involved in the logistics concept should cooperate with external parties such as the governmental bodies and local communities (the public actors), both in practice and in theory. We also still observe a lack of attention for the influences, positions and perceptions of all the stakeholders involved. Here we can identify the two research gaps in the field of logistics and call them the **theoretical and practice public-stakeholder-gaps** (see Figure 1.2, Gap 1 and Gap 2).

Some specific fields in logistics like green logistics (Mckinnon *et al.*, 2010), City Logistics (Taniguchi *et al.*, 2001; van Binsbergen & Visser, 2001; Holguín-Veras, 2008; Quak, 2008; Macharis & Melo, 2011) and Intermodal freight networks (Bontekoning *et al.*, 2004; Platz, 2009) certainly have the focus to integrate sustainable elements and their related actors’ behaviours in their search for solutions and concepts.

The awareness of stakeholder involvement is particularly dominant in the field of city logistics. Taniguchi *et al.* (2001) identified four stakeholder groups (shopkeepers, retailers, municipalities and carriers). The importance of a dynamic actor network analysis became clear and van Binsbergen and Visser (2001), for example made a first attempt to introduce some factors of the actor perceptions into their city logistics concepts. Holguín-Veras (2008) doubted whether pricing is an effective policy instrument to organize freight transport to achieve a more balanced use of the limited infrastructure. Quak (2008) made a quantitative evaluation of specific actor groups as the increase in costs for the retailers was proven to be a consequence of the introduction of time-window policies by the municipalities. Macharis and Melo (2011) provide a thorough evaluation of city distribution and urban freight transport, highlighting the importance of developing methodologies that reflect and integrate stakeholder perceptions.

Most of these contributions have shown the importance of public and private actor involvement and the potential influence on the success of the logistics concept. However, none of the contributions has developed an approach for the integration of different stakeholder perceptions in a logistics concepts design that fits one framework.

In practice we frequently observe unknown dyadic relationships between policy makers working at different policy levels and the operating field of retailers, logistics service providers and transport companies (see for example Quak (2008) who showed that the influence of strict time-window-policies leads to an increase in retailer cost and above all, contrary to the municipality’s expectations, to an increase in CO₂-emissions). On the one hand, in practice the public actors are not fully satisfied with the outcomes of the research initiatives since their societal goals are not met, i.e. the practice public actors gap (see Figure 1.2, Gap 2). On the other hand the private actors in practice find themselves restricted by the

rules and policy measures and also have their complaints about the facilitating role of the government (see Figure 1.2, Gap 2). This gap is in line with van Woensel (2012) who addresses the critical impact of governmental policies on the success or failure of logistics concepts. In many cases, policymaking has been counterproductive to the efforts to strengthen logistics performance. Since policy measures have a significant impact on the costs of the logistics activities of companies, the private sector is directly affected. The gaps mentioned are exactly the important societal issues mentioned by Crum and Poist (2011) as a key emerging research area for logistics and SCM (Supply Chain Management).

1.4 Research questions

This thesis focuses on a stronger methodological integration of stakeholder perceptions and attitudes in the logistics concept design in such a way that the final logistics concept is sufficiently tuned to the perceptions of different stakeholders to create the support for successful implementation. Based on this research scope, the central research objective is formulated as such:

‘To develop an improved approach to support the analysis of new logistics concepts in multi-stakeholder context’

When actors start thinking about implementing a new logistics concept, they are triggered by the results of a reflection on the current situation. Their attitudes and perceptions are formed and strategies are considered which aim to meet their own private goals for the new logistics situation. Therefore, we need insight into the societal complexity reflected by the (changing) perceptions of the actors. This relates to Gap 1 in Figure 1.2, i.e. the theoretical public-stakeholder-gap. Accordingly the first research question can be formulated as:

(1) *‘In what way can we identify mutual critical influences of public and private actors on a logistics concept?’*

In the field of logistics decision making it is common practice that decision making on logistics problems is based on objectively measurable conditions. The existence of these conditions may be established by simply determining the ‘facts’ in a given case: *What is the total throughput? What are the costs of the processes? What is the ‘bottleneck’?* For logistics consultancy these questions might be appropriate as far as it concerns the physical logistics processes, analysed from the eye of the beholder or problem owner (Dunn, 1981, p.97). But even then, one sometimes fails to recognise that the same facts can and often will be interpreted in markedly different ways by the various actors involved. The same relevant information can (and will most often) result in conflicting definitions and explanations of a ‘problem’. The external conditions that give rise to a logistics problem are selectively perceived, classified and evaluated. Furthermore, the solution takes a different form, depending on which explanation one chooses. Mason and Mitroff (1981, pp 10-12) say that ‘understanding the problem is synonymous with solving it’. In other words, every formulation of the problem corresponds to a statement of solution and vice versa. Hence, the actors involved may disagree on the definition and explanation of a problem, and even when there is consensus about this, they may yet disagree on its scope, severity, and importance.

To sum up: there is actually no single correct view; problem definitions depend on the actors' specific characteristics, loyalties, past experience, and even incidental circumstances of involvement. Problems are therefore largely socially constructed, maintained and changed. For our research it implies that we should consider all the individual perspectives of the actors involved, because that is the way they perceive the development of a new logistics concept, instead of one overall perception designed by the analyst/scientist.

This has consequences for the application of methods and techniques. The analyst should not pursue the construction of the ultimate model of a situation, but should be able to handle a rich set of models that as a whole is able to reflect the diversity in actor perceptions. The soundness of the model set is determined not by the degree of correspondence with reality, but by the accuracy with which it mirrors the assumptions the actors make about this reality, or more precisely 'their reality'. So if we want to develop logistics concepts, we need to understand the dynamics of the logistics field entirely, both in its processes and in its actors' perceptions. Therefore the complexity of a logistics concept is not only due to the procedural complexity of the planning and management processes necessary for the implementation of the concept, but also due to the diverging attitudes and goals of the actors involved. In particular the factors they consider to be important, their instruments of control to influence the concept, their mutual relationships and their dynamic behaviours are relevant in this context. Facing the earlier mentioned problems (Mulvey, 1994) the next research question is therefore:

- (2) *'What modelling techniques do we need for analysing the complexity of a logistics concept to support the joint decision making process between public and private actors?'*

From one perspective, generally the problem-owner's perspective, we believe that the dynamic behaviour of logistics processes of a logistics concept can be well analysed by operations research techniques through the development of mathematical models. However, the models developed as a part of a methodology must be understood (Sijbrands, 1993) by more than one stakeholder and should somehow reflect the perceptions of the stakeholders. This leads us to the next research question:

- (3) *Will the suggested methodology lead to the improved implementation of a logistics concept and a greater probability of acceptance by the multi-stakeholders involved?*

The answer to this question is an attempt to fill the earlier described Gap 2 (see Figure 1.2), the practice public-stakeholder-gap. In order to evaluate whether the developed approach will provide an enriched insight for an improved design, we will rely on the following evaluation criteria:

- *Analytic criteria* (Geurts & Vennix, 1989);
The approach should leave space for many perspectives. The relevant arguments for logistics concept development should be deduced from a broad, holistic systems approach. The models and techniques applied must be flexible and hybrid (Nutt, 1982). The hybridity of the approach refers to a combination of techniques derived from the hard,

formal sciences and the soft, cognitive sciences and should contribute to transparency in the applied methods.

- *A quality improvement of the logistics concept;*

This criterion implies that the approach should provide transparency with respect to the causal relationships of the logistics concept and its operating environment for all the stakeholders involved. The quality improvement can be obtained by a mutual understanding of the stakeholders' relationships to the logistics concept.

- *Trust/belief (Rousseau et al., 1998; Hofstede, 2002)*

It is assumed that both aforementioned criteria contribute to the trust and confidence in the developed approach. Recently the notion of trust and belief has gained importance in actors' networks (Hofstede, 2002). Trust (Rousseau et al. 1998) is a psychological state compromising the intention to accept vulnerability based upon positive expectations of the intentions of behaviour of another. The approach should contribute to gaining the trust of the involved actors/partners.

Geurts and Vennix (1989) also address the importance of process criteria such as the quality of the logistics decision-making process. They argue that the approach should allow for pluriform participation by the stakeholders involved. Each individual contribution of a participant should be included as a part of the approach. In our research the process of real world decision making will not be taken into account, but we will evaluate the perceptions of stakeholders regarding the evaluation of the outcomes of the design process.

1.5 Research approach

Research into logistics is complex as the empirical domain includes a variety of business functions and strategic decisions. New and Payne (1995) stressed a fundamental problem of the process of logistics research which is actually socially constructed. They argued that the scientific progress in this field is technical, incremental, and in accordance with Kuhnian 'normal science' (Koningsveld, 1982). They found this approach to be insufficient for understanding the sector.

New and Payne (1995) specify a trade-off between two approaches: One can study artificial and abstract problems with the rigour necessary to create proper research, or one can study more interesting and real issues, but risk getting lost in the extraordinary complexity and ambiguity of the real world. The broader the question and issues involved, the more difficult rigorous research becomes. This research on public logistics attempts to bring these approaches closer together, focusing on real-life complexity and real-life problems. Considering the research objective, a case study approach is an adequate research strategy. The cases provide the opportunity for the development and application of a tailor-made approach for designing and analysing logistics concepts. Yin (1994) gives a definition of case study research which is related to the scope of the case studies and the intrinsic value of the case study domain combined knowledge acquisition. The definition of the case study is 'an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident'.

This relates to the preferred empirical approach suggested by New and Payne (1995). Yin (1994) further specifies the nature of case studies as follows: ‘the case study inquiry

- copes with the technically distinctive situation in which there will be many more variables of interest than data points,
- relies on multiple sources of evidence with data needing to converge in a triangulating fashion,
- benefits from the prior development of theoretical propositions to guide data collection and analysis.’

This description of case study research connects well to various perspectives of the actors involved. The research itself focuses on the most dominant issues deduced from the actor perceptions and the technical aspects of the logistics processes.

An often-mentioned disadvantage of case study research is the lack of generalisability. A first step to counter with this criticism is the ‘analytic generalisation’ (Yin, 1994, p31). Taking into account that every method has its limitations, the development of a theory is based on and determined by the supply of multiple cases. Eisenhardt (1989) also takes this stance, where the analysis of different cases gradually hones and clarifies the theory. Multiple cases should never be used for statistical generalisation, the statistical inferences based on empirical data (Flyberg, 2006). Instead the cases are used to formulate a template of a theory, developed earlier in the research process with which the empirical results of the individual cases can be compared. If it is demonstrated that two or more cases support the same theory, replication may be claimed. Yin (1994) also argues that it may be more worthwhile using the empirical results from two or more cases to evaluate the developed theory alongside a rival theory. The empirical results may be considered more likely if two or more cases support the developed theory and do not support an equally plausible, rival theory or if the outcomes of the applied research are compared with real-world data.

A second step to improve the plausibility of the case study research strategy is to build in the four validity tests common to all social science methods (Kidder & Judd, 1986, pp. 26-29; Hutjes & van Buuren, 1992):

- *Construct validity*

The empirical data should be collected by proper operational measurement. The empirical phenomenon ought to be measured precisely. The elimination of subjectivity towards the observations can be obtained by:

- the use of multiple sources of evidence;
- the establishment of a chain of evidence;
- the review of key informants which could be colleague researchers and participants in the case area (i.e. so called ‘member check’).

- *Analytical validity*

Analytical validity or validity of causal interpretation (Molin, 1999) refers to assumed causal relations in the case studies between the variables. New and Payne (1995) report about the lessons learned from their research experiences in the field of logistics. They have doubts about the viability of naive causal connections between performance, practice, and the environment. In their empirical research they search for

a causal model which defines a more subtle relationship between the environment and practice. Molin (1999, p. 101) also underlines that empirical statistical correlations (i.e. correlation, significance) cannot automatically be interpreted in terms of causality. Whether this is allowed mainly depends on the possibility of the research design to eliminate alternative explanations or spurious relationships (see for example (Levitt & Dubner, 2005)). If empirical data are available, pattern-matching techniques can be applied to validate (test) the assumed causalities, for example modelling results versus observations.

- *External validity*

External validity deals with the earlier mentioned problem of generalisability (Cook & Campbell, 1979). Swaborn (1994) distinguishes external validity to population validity and ecological validity within external validity. Population validity refers to the generalisability of the results for larger or different populations. The central issue in the ecological/external validity refers to the generalisability for different situations and environments. In order to prove this type of validity the assumptions made and conditions imposed on a case need to be studied carefully before any generalisation of the developed knowledge is suggested. Applying replication logic on other cases is reported to be a satisfactory method to support the argumentation of generalisation.

- *Reliability;*

The last type of validation is the reliability of working procedures. Another researcher, following the working procedures, should arrive at the same findings and conclusions. A case study protocol and a case study database should provide the necessary documentation to cope with this problem.

We are now able to construct a research plan which incorporates the abovementioned validation tests. Following the idea of analytic generalisation (Yin, 1994) we have selected the cases on the following criteria:

- each case representing a logistics concept offers a unique situation;
- every case has its unique pattern of interaction with society, and
- the overall collection of cases necessary shows a near completeness to the levels of scale since the selected cases have a societal impact at national, regional and/or city level.

Based on the general function of the case studies for achieving our research objectives, relevant cases could be selected. In our search for the development of an adapted, innovative, approach we follow the suggestion of de Bruijn & Herder (2009) who argue that an actor perspective and a system perspective should be applied simultaneously and interactively. It implies that during the design and analysis of public logistics concept we are able to switch perspectives continuously and are able to apply both perspectives in a fruitful manner. The analysis of the 5 selected cases try to integrate the actor perspective gradually more intensive into the system perspective. Here we follow the systems design approach based on the basic steps of problem analysis, conceptual design, basic design, detail design, and implementation (Dym & Little, 2004).

In this study 5 cases were selected. The case selection shows a growing complexity in terms of the number of stakeholders, the number of factors to be considered, and the policy levels involved (Table 1.2). The cases will be briefly described in the next section.

Table 1.2: Case complexity

Case	Number of stakeholders	Number of factors	Geographic level	Case type
<i>Case 1</i> <i>E-auction as a concept of UCC (van Duin et al., 2007)</i>	2 private actors, 1 public actor	Many factors	City level	Laboratory Experiment
<i>Case 2</i> <i>CO₂-emissions at terminals (van Duin & Geerlings, 2011)</i>	1 private actor, 1 public actor	1 external factor	City level	Real case
<i>Case 3</i> <i>Noise-emissions at terminal Tilburg (van Duin & van der Heijden, 2012)</i>	1 private actor, 2 public actors	1 external factor	City level	Real case
<i>Case 4</i> <i>Urban consolidation centre in The Hague (van Duin et al., 2010)</i>	Many private actors, 2 public actors	Many factors	City level	Real case
<i>Case 5</i> <i>Policy making on intermodal transport (van Duin & van Wee, 2007)</i>	Many private actors, many public actors	Many factors	National, regional, & city level	Real case

Summarising we assume that the case study research is the most appropriate way to answer our research questions. It enables a description of precisely 'how' a new logistics concept can be designed. The four validity tests will be carried out per case with respect to the research methodology in order to provide insights into how the acquired knowledge can be generalised.

1.6 Research outline

This thesis consists of a collection of peer-reviewed and published research papers on the issues of logistics systems, policy making and the societal complexity of logistics concepts reflected by the perceptions of actors. Each paper has a unique research focus, although all the contributions are interrelated through the research approach sketched in the previous sections. We discuss the positioning of these cases within our own research framework in more detail

below, by locating them in the problem field diamond presented in Figure 1.3 and discussed in this section. The cases are bundled in three parts of this thesis.

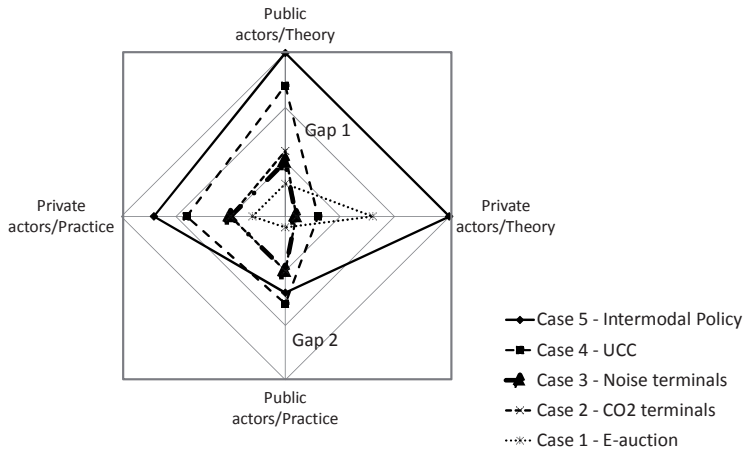


Figure 1.3: Case positioning

Part 1: E-auction: a new freight bundling concept for urban freight transport (van Duin et al., 2007)

Case 1 deals with the introduction of an alternative concept for urban freight consolidation, i.e. a real time auction for hybrid freight markets, based on the experiences with city distribution centres. More precisely the ex-ante feasibility of a hybrid system of contracting freight carrying services is determined. The effectiveness and efficiency of this contracting system is tested by means of a simultaneous, real time simulation of the execution of planned tours, the auctioning process and the re-scheduling of tours. The model provides us with new insights into the dynamics of bidding behaviour on the side of carriers and shippers (Figure 1.3, i.e. Gap 1 & 2). For the municipality the reduction of vehicle kilometres is essential; the applied approach enables a thorough analysis in this respect.

The public logistics character of this case is based on the fact that E-auctions for urban freight transport face a growing interest of municipalities. However, municipalities don't know whether this is an appropriate manner to reduce transport kilometres and to create a fair transport market. Based on this missing insight municipal authorities are also not decisive about promoting or financially supporting these developments. In addition, the case has a strong multi-actor character, as it revolves around negotiations between freight actors. The private actors, such as carriers and shippers, are hesitant with respect to this concept since they don't know whether it contributes to the reduction of costs. This case was selected to explore whether it is possible to incorporate some of the behavioural characteristics into the modelling part to provide insight in the performance of the logistics concepts for all the actors involved.

Part 2: External factors on the logistics performances (van Duin & Geerlings, 2011; van Duin & van der Heijden, 2012)

Case 2 focuses on the elaboration of a first step towards a approach to analyse the CO₂-emissions from container terminals and to gain a better understanding of the CO₂-emissions by container terminals in port areas (Figure 1.3, i.e. Gap 1). A better understanding of the CO₂-emissions enables identification of more effective solutions to reduce CO₂-emissions by container terminals (Figure 1.3, i.e. Gap 2). The study provides insight into the processes of container handling and transshipment at the terminals and assesses the contribution of these processes to the CO₂-emissions (or carbon-footprint) of the container terminals. Using these insights, potential solutions reducing the CO₂ at the terminals can be identified (Figure 1.3, i.e. Gap 2).

The public logistics character of this case is defined by the fact that government wants to know the CO₂-emissions at terminals and wants to obtain insight what can be effective solutions to reduce the CO₂-emissions. The private actors, in this case terminal operators, seldom know how to measure the CO₂-footprint. Some operators are also hesitant to provide this information since the CO₂-footprint can be competition sensitive.

The paper describing Case 3 focuses on a case study of the design of a new barge terminal that offers high operational performance without exceeding the environmental standards for protecting the adjacent urban living area. The research strives to find a balance between the operational issues and the environmental effects of the designs of the new terminal and to evaluate them on logistics performances and noise emission (Figure 1.3, i.e. Gap 2).

The public logistics character of this case stems from the fact that the terminal operator intends to operate the terminal activities in such a way that noise emissions might easily violate the limits allowed. The municipality has a mixed role in showing high willingness to develop a new terminal initiative on the one hand for local economic reasons. On the other hand the municipality is also protecting the environment for the inhabitants.

These two cases were selected to explore whether we are indeed able to translate the insights obtained by our modelling step to shape the design solution space in such a way that it significantly adds to the mutual understanding of the positions of the actors involved.

Part 3: Logistics cases with multi-actor perspectives (van Duin et al., 2010; van Duin & van Wee, 2007)

Case 4 concerns the application of multi-actor perspectives on a city-distribution case in The Hague. In this paper a few European projects of urban consolidation centres were studied as instructive cases in understanding the critical factors of implementing an urban consolidation centres. Combining these insights with experiences from other cases, the real case in the city of the Hague was studied by applying parts of a Cost Benefit Analysis (CBA) in order to analyse the pre-feasibility of an urban consolidation centre (Figure 1.3, i.e. Gap 1) to find out whether a consolidation centre could be a good solution for many actors, such as retailers, consignees, transport companies, the municipality, inhabitants and the UCC-operator (Figure 1.3, i.e. Gap 2).

The public logistics character of this case results from the fact that the municipality is seriously interested in developing an urban consolidation centre (UCC). The municipality wants to know under what conditions the urban consolidation centre can operate viably an how much it will contribute to a reduction of the total vehicle kilometres in the inner city.

Inhabitants and shopkeepers also show interest in the number of deliveries per day and the flexibility of the concept. A company is interested to operate the UCC, but is hesitant in starting a UCC due to the failing past performance of other UCCs.

This case was analyzed to follow all the steps of our approach for a relatively well demarcated logistics concept. In this case study the number of actors involved is relatively small and the logistics concept is relatively simple. However the importance of obtaining deep insight is high for all the actors involved and crucial for the choice whether to implement this concept, or not.

Case 5 deals with the development of intermodal freight networks in the Netherlands. In their plan ‘Trans European Networks’ ministers of transport from the European Committee tried to co-ordinate the development of intermodal transportation networks at macro level. At the national level the Dutch Ministry of Transport chose the planning of terminal locations to such an extent that the added values of the terminals greatly contribute to the National Product. Both plans are based on a traditional approach assuming major logistics changes due to infrastructure development. In contrast to both plans the practice of terminal development and intermodal transportation initiatives seem to develop more whimsically (Figure 1.3, i.e. Gap 2). The application of our approach (Figure 1.3, i.e. Gap 1) led to an improved insight into the perceptions of shippers, carriers and terminal operators. The advised propositions of terminal network extensions is more directly related associated with transport demand in practice (Figure 1.3, i.e. diminishing Gap 2).

The public logistics character can be found in (and within) all the geographical levels. European and national governments tend to develop large intermodal networks. Moreover, they sometimes provide subsidies for the start of new terminal locations. Large shippers try to optimise their own transport networks and increasingly ask for intermodal services to reduce their transport costs. At regional level municipalities initiatives are taken to develop new terminal services assuming that this is good for attracting large companies. At the local level terminal managers want to attract transport volumes for their services whereas local authorities cooperate by increasing accessibility, granting permits, et cetera.

This case was selected to follow all the steps for decision making on a complex logistics concept at different geographical levels involving many different actors. For shaping the solution space, as well as the modelling part, this case will teach us how to cope with the multi-level governance nature of a logistics concept.

1.7 Research contents

The remainder of this thesis is split into four parts (*see Figure 1.4*): Part 1, including Chapter 2 focuses on a new freight bundling concept based on an laboratory experiment with urban freight data; Part 2, including Chapter 3 and 4, focuses on one specific external factor showing the impacts on the logistics performances and the consequences of policy making in the broader perspective. Part 3, including Chapters 5 and 6, focuses on logistics cases with multi-actor perspectives at different policy levels; and Part 4, containing Chapter 7 concerns the main research findings and the setup for a new approach, Chapter 8 provides the conclusions and recommendations of this thesis and reflects on the hypotheses and the research objective. Chapter 9 provides an epilogue.

Chapter 2 A future perspective on city distribution (Real time simulation of auctioning and re-scheduling processes in hybrid freight markets)	Part 1
Chapter 3 CO ₂ -emission (Estimating CO ₂ -footprints of container terminal port-operations)	
Chapter 4 Noise (The influence of noise at a new barge terminal in a residential area: the case of Tilburg)	Part 2
Chapter 5 Multi-actor policymaking in urban freight networks (New challenges for urban consolidation centres: the case The Hague)	
Chapter 6 Multi-actor policymaking in intermodal transport networks (Modeling terminal locations using a three -spatial scales framework)	Part 3
Chapter 7 Synthesis, research findings and methodology	
Chapter 8 Conclusions & recommendations	Part 4
Chapter 9 Epilogue	





-  = Laboratory experiment, city level
-  = Real case, external influence, city level
-  = Real case, many factors, city level
-  = Real case, many factors, city/regional/national level

Figure 1.4: Research contents

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2 Real time simulation of auctioning and re-scheduling processes in hybrid freight markets

'More than the past, I am interested in the future, because in it I intend to live'
(Albert Einstein)

Duin, J.H.R. van, Tavasszy, L.A., & Taniguchi, E. (2007). Real time simulation of auctioning and rescheduling processes in hybrid freight markets. In *Transportation Research Part B (41)*, 1050-1066.

Abstract

In the freight logistics business, supply chains are under strong pressure to provide customized goods and services. Individualized product deliveries, modifications in product specification, late orders and volume changes need to be accommodated within strict delivery time frames. This uncertainty in demand can only be accommodated by allowing for slack capacity and time in trip planning. As this overbooking creates substantial costs, however, firms will attempt to minimize these costs by further optimizing and re-organizing their distribution channels. In this paper we look at the feasibility of one such solution, a hybrid system of contracting freight carrying services. Here, part of the services are provided by various carriers using contracts for a fixed base volume of freight, which results in planned delivery tours. Additional to these volumes, peaks resulting from additional shipments are accommodated by one or more of these carriers within an auction setting based on price and quality of service. The additional freight is won by the carrier that has the most flexible trip planning in terms of capacity, service quality and costs. We test the effectiveness and efficiency of this contracting system by means of a simultaneous, real time simulation of the execution of planned tours, the auctioning process and the rescheduling of tours. The model provides us with new insights on the dynamics of bidding behaviour on the side of carriers and shippers.

Keywords: Freight, Logistics; Auctions; Shipper behaviour; Carrier behaviour

2.1 Introduction

In the freight logistics business, industry and service providers are under strong pressure of increasingly individualized and dynamic consumer demands. More and more, firms need to employ advanced supply chain management and supply chain operations to cater for customized products and to be responsive to changes in customer needs. The trend of increasing customization implies ever thinner flows, down to the level of flexible manufacturing, built-to-order distribution and individual packaging. This growing fragmentation of flows creates losses in scale of logistics activities and hence additional costs. From a logistics point of view consolidation is a key concept towards gaining efficiencies in logistics chains. Consolidation is the combining of many less-than-volume shipments into one large shipment that the carrier can transport economically (Coyle et al., 2003). The increased responsiveness drive creates additional challenges to supply chain efficiency. Sudden changes in product specification, late orders and order volume changes need to be accommodated within strict delivery time frames. The uncertainty in demand can only be accommodated by allowing for slack capacity and time in trip planning. As this overbooking creates substantial costs, however, firms will attempt to minimise these costs by further optimizing and re-organizing their distribution channels.

Our research addresses the potential of new information technology and new co-operation mechanisms between shippers and carriers to improve urban freight transportation. In urban freight transport, advanced information systems can be used to optimise the use of trucks and the commodity flows within one company, which could be called an intra-organisational approach. Information technology can also be used inter-organisationally, which can be done by facilitating the trade and negotiation between shippers and carriers. More specifically, in this paper we look at the feasibility of a hybrid system of contracting freight carrying services. Here, part of the services are provided by various carriers using contracts for a fixed base volume of freight, which results in planned delivery tours. Additional to these volumes, peaks resulting from additional shipments are accommodated by one or more of these carriers within a spot market, after negotiations with the shipper on price and quality of service. The additional freight is won by the carrier that has the most flexible trip planning in terms of capacity, service quality and costs. Such a contracting system offers the ability to shippers and carriers to communicate and to trade in an innovative way. Matching systems are set up for various reasons, like a better use of the available resources and a decrease of the transport costs. In branches other than transport, matching systems already exists; on the level of city logistics not much research has been done yet on the effects of these systems. The potential of auction systems to improve the efficiency of freight transport services, however, seems to be substantial. Research shows that auctions can achieve gross savings ranging from 5 to 40% (Tully, 2000), with a typical average of 15–20% of costs (Cohn et al., 2000). Besides the cost saving, auctions provide several other benefits, such as a rapid matching of demand and supply, expanding the scope of potential market for business enterprises, improving the information flow and enhancing supply chain integration. In order to investigate the potential of auctions for transport and supply chain management, researchers have conducted several studies (see e.g. Kambil & van Heck (1998), Bapna et al. (2000), Walsh et al.(2000), Jin & Wu (2000), Liao & Hwang (2001), Babaioff & Nisan (2001), Kambil & van Heck (2002), Koppius & van Heck (2002)). This literature shows, however, that most research focuses on the development of the architecture of auctions and auction algorithms. Combinatorial

auctions have been topic of active research during recent years. Song & Regan (2005) investigated the bidding problem in combinatorial auctions from a carrier perspective. The impact of auction mechanisms upon freight transport in urban areas is studied thoroughly by Figliozzi et al. (2004, 2005) and Figliozzi et al. (2006). A framework to study transportation marketplaces is described in this research. Smart routing with looking ahead one-step (load) further based on knowing the shipment arrival and other characteristics distributions show beneficial performances (Figliozzi et al., 2004). Learning strategies of carriers have been investigated in Figliozzi et al. (2005). Likewise Hoen & La Poutré (2004) demonstrate their strategy of decommitment of the loads in order to postpone the loads and sometimes even break load agreements to create more efficient combinatorial routes. Based on the findings in these researches we try to analyse different bidding behaviours of the carriers. In this paper we will try to study whether it is profitable for a carrier to announce low bids (even lower than marginal costs) when a schedule is still empty or almost empty for a truck in order to obtain more loads and to realise more combinatorial possibilities for truck routes with lower overall costs. On time delivery can also be an important selective argument of shippers when Just-In-Time (deliveries) are demanded. Therefore it is interesting to investigate the relationship between both reliability and bidding price on the profitability of the carrier and the obtained performances to the shipper. The structure of research of our research experiment is similar to Hoen & La Poutré (2004) – as La Poutré (2004) stresses in his inaugural speech, an analysis based on detailed simulations models, prototypes and pilots is most appropriate to study applications in reality.

Therefore, we have developed a simulation model of auctioning and route/delivery rescheduling in ‘hybrid’ freight markets. The market is hybrid inasmuch as ‘fixed’ orders originating from long-term contracts are scheduled by carriers at the start of a time-horizon while subsequent, ‘auctioned orders,’ obtained through successful bidding in an ongoing auction, are scheduled as and when they are won by the respective carriers. We test the effectiveness and efficiency of such a new contracting system by means of a real time simulation of the execution of tours, the auctioning process and trip re-scheduling. The paper is organized as follows. In the section 2.1 we introduce the subject and summarize the literature in this area. Section 2.2 describes the freight contracting system, the agents and the auctioning protocol. Section 2.3 describes the experimental, computational setting in which we have tested the performance of this contracting system. We also describe the various scenarios for carrier bidding behaviour. Section 2.4 provides the results of the tests and their interpretation. Section 2.5 concludes with a summary of the main findings and some recommendations for further R&D and applications.

2.2 The freight contract system

As a framework our research we designed a hybrid freight contracting system to connect shippers, the owners of freight who demand transportation services, and carriers, who offer and supply these services (Figure 2.1). The system is called hybrid as there are two types of contract that are at work simultaneously. The long term contracts are agreements between shippers and carriers on a repetitive service over a fixed period of time (e.g. a month, or a year), for a known set of origins and destinations, under largely predetermined performance conditions. Volumes are known beforehand, within certain bounds. In contrast, on the spot market, all these are not known beforehand and the demand for services only arises at a very

late stage. Shippers must ensure that conditions for services to move these shipments are either included in the long-term contracts, or, when uncertainties are too high, additional deals are closed. Information is exchanged at the moment that (1) the immediate demands of the shipper are clear and (2) the carriers have already planned their tours based on the longer term contracts. This results in new contracts and a rescheduling of services. Central to this scheme is the auctioning protocol by which services of various carriers can be matched with the shippers' demands. Below we describe our choice for the type of auction to simulate the matching system. In the real world there are different types of auctions and different circumstances dictate different answers (see e.g. Reynolds (1996), Bulow & Klemperer (1996), Jap & Sandy (2000, 2002)). A brief classification of auctions is given in Table 2.1.

Table 2.1: Auction classification (Beam & Segev (1998))

Traditional auction type	Brief description of rules
English	Continuous ascending auction; bidders can see high bid and possibly other bidders' bids and comment, and can update their bids during the auction. Winner is highest bidder and pays the price bid.
First price sealed bid	Bidders email in secret bids for item; bids are opened simultaneously and highest is declared the winner. No chance to update a bid once submitted, and winner pays the price bid.
Dutch	Continuous descending auction; bidders can see current price and must decide if they wish to purchase at that price or wait until it drops. Winner is first bidder at the current price.
Continuous double auction	Similar to NASDAQ. Buyers and sellers continuously view market and prices, make real time offers, which clear at market price.
Sealed double auction	Buyers and sellers simultaneously submit secret sealed offers to buy and sell. Auctioneer opens offers and clears market. The auction repeats several times to give a continuous market price.
Vickrey	Similar to first price sealed bid auction; winner is highest bidder. However, winner only pays amount of second highest bid.

These auctions have mainly been used for sales auctions, selling unique products, i.e. agriculture products, whose price is difficult to estimate or there are high fluctuations with their demand and supply (Smith, 1989). Different from selling products to potential buyers in sales auction, sellers in reverse auctions, on the contrary, bid for the demand of a buyer. The bidder, who offers the lowest bid price, will win the freight order. Such a reverse auction is the most applicable auction type for our case. We have chosen to implement a sealed multiple

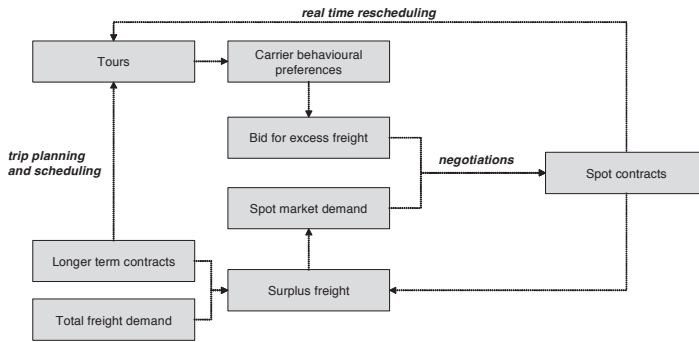


Figure 2.1: Sketch of the hybrid freight contracting system

auction setting. Mei et al. (2003) argue that the auction mechanisms for sales auctions are also suitable for reverse auctions. The reverse auctions are usually multi dimensional in nature, however; buyers’ demand orders are often described as service level and price. A recent inventory of websites for information sharing between carriers and shippers on urban freight (Yoshimoto, 2004) found that price is not often a defining factor but quality of service and dependability are both determinants too. Service quality therefore needs to be included in an auction framework. Koppius et al. (2000) provides a useful multi-dimensional procurement model for our purposes. In this model, a buyer’s request has K attributes. These attributes can be any combination of monetary unit or non-monetary unit, i.e. price and supplier’s reputation. In addition, a K-dimensional constraints vector is added for each demand order. Corresponding to buyer’s demand, any bidder’s bid is denoted as a K-dimensional vector. Each dimension of a bid must follow the demand constraints. We used this approach to include both price and quality attributes in a reverse auction setting. We assumed the following protocol for the exchange of information between shippers and carriers. For a load to be announced the following information flows can be distinguished in chronological order (see Figure 2.2):

- (1) A shipper announces a load for the auction.
- (2) The carriers receive information about this load.
- (3) The carriers send their bids on this load to the matching system.
- (4) The shipper receives these bids and chooses the best bid.
- (5) The shipper announces which bid in his opinion is the best.
- (6) This information is sent to the carriers.

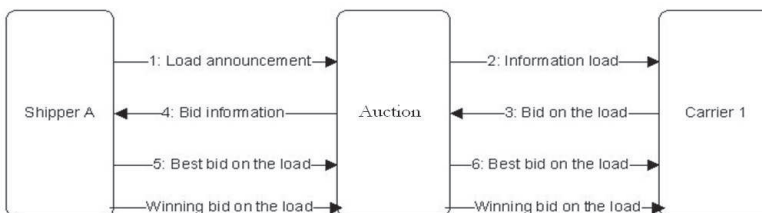


Figure 2.2: Information flows between the actors and the auction

The carriers can make a new, improved bid on a load if they want to. These new bids are sent to the shipper, who again evaluates them. Our protocol is based on the ECNP Protocol described by Fischer et al. (1996). The cycle of process 3–6 continues, either until no carrier makes a new bid anymore or until a certain amount of time has gone by. The auction can be interpreted as an intermediate actor, agent or website providing the facilities for auctioning. In our auction the shipper pays the price equals to the winning bid. English auction shows higher efficiency than sealed bid auctions (Kagel, 1995). However, more transparency can be observed for an optimal bidding strategy. We have chosen to implement an iterative version of the sealed-bid procurement auction in which bidding would proceed in rounds.

Time	Procedure	LoadNumber	Who
307	EvaluateBid	9	Shipper1
308	AnnounceLoad	17	Shipper1
312	LoadAccepted	2	Shipper1
317	AcceptAuctionLoad	6	Carrier3
318	DetermineBid	14	Carrier1
320	EvaluateBid	10	Shipper1
324	LoadAccepted	3	Shipper1
330	AcceptAuctionLoad	7	Carrier3

Figure 2.3: Example of the user-interface during simulation

In our simulation model, the negotiations take place as in a real auction: each carrier can make a bid; the shipper chooses the best bid, after which the carriers can decide to make a new bid (see Figure. 2.3). Other factors influencing a carrier's demand price can be the profit to be made, the number of transport orders (or income) already won, or the preference gain transport within a certain region. In the simulation each carrier can apply their own discount-table based on the income won. This table reflects actually the greediness (responsiveness) of the carrier to obtain a full schedule as soon as possible. This table shows by which percentage transport costs should be raised or decreased. This table shows the carrier will lower his price if he only has a small income secured for that time period. If the schedules of their trucks are far from full, the carrier is probably greedy to attract new loads. The expectation is that the losses accepted now (for instance -15%) can be compensated with obtained loads with better price conditions later due to a larger (obtained) combinatory solution space. So if the carrier already has gained a lot of income, he probably has a smaller incentive to win even more loads, so his price might be higher than the transport costs. These effects will be stronger if the announcement time until transport of the load is shorter. Long before the transport, the carrier expects he is capable to win more orders, so he will not change his price much. How big the effects exactly are, depends on the individual carrier's behaviour. An example of such a table is shown in Table 2.2.

Table 2.2: Example of a discount-table for a carrier

Income already won	Time until transport			
	< ½ day	½ - 1 day	1-2 days	>2 days
<1000	-15%	-10%	-8%	-6%
1000-2000	-10%	-7%	-5%	-3%
2000-3000	0	0	-2%	-2%
3000-5000	+2%	+0%	0	-1%
>5000	+5%	+2%	0	0

The fourth step in defining the bid is the determination of the profit-bonus. This bonus represents the percentage of profit the carrier wants to make. The transport costs will be raised by this percentage to get the final bid-price. The input for this profit-bonus calculation is:

A general profit-characteristic of the carrier: some carriers want to get more profit per load than other carriers. How many bids the carrier has made on this load: it is assumed that carriers will lower their bid during the auction, so for the first bid on a load, the bonus will be larger than for the second or third bid. An example of such a table is shown in Table 2.3.

Table 2.3: Example profit-bonus table

# bid on this load	profit-bonus
1	10%
2	8%
3	7%
>3	5%

Beside costs, a shipper might also use other criteria, like possible pick up time, responsiveness, transport speed, and the punctuality and reliability of a carrier. Their appreciation is expressed as a weighted function of the price differences between bid prices and their own prices, as well as the time differences between the time asked for and the time provided by the carriers.

2.3 Experimental setting to evaluate the matching system

In order to evaluate the auction, an experimental setting was specified that includes the following elements and behavioural assumptions, which are described in more detail in this section:

- transport cost and penalty functions,
- a list of freight loads that is dynamically updated,
- a physical network with origins and destinations,
- carriers and shippers with realistic demands and capacities,
- test scenarios and performance indicators.

The model uses realistic cost functions that depend on the driven distance (fuel costs), travel time (costs of the driver) and fixed truck costs. In addition, we have included penalty costs: if

a truck arrives at the customer before or after the time window, then the truck is given a penalty. Arriving too late results in a higher penalty costs than arriving too early (see Figure 2.4).

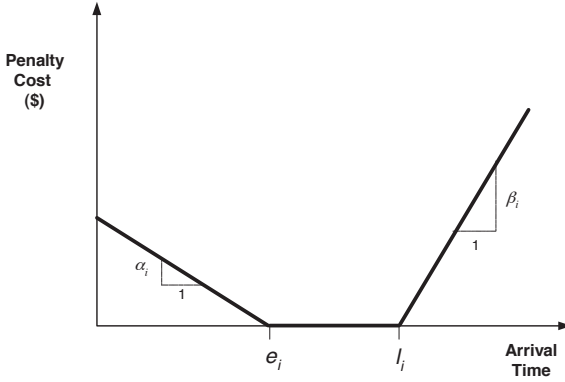


Figure 2.4: Penalty cost function

A VRP-TW model is used for each carrier and determines the optimal solution by minimising the total costs. The total costs are composed of three components; (a) the fixed cost of vehicles, (b) vehicle operating costs that are proportional to the time travelled, and (c) early arrival and delay penalties for designated pickup/delivery time at customers. The model can be formulated as follows:

Minimise

$$C(t_0, \mathbf{X}) = \sum_{l=1}^m c_{f,l} \cdot \delta_l(\mathbf{x}_l) + \sum_{l=1}^m C_{t,l}(t_{l,0}, \mathbf{x}_l) + \sum_{l=1}^m C_{p,l}(t_{l,0}, \mathbf{x}_l) \quad (1)$$

where,

$$C_{t,l}(t_{l,0}, \mathbf{x}_l) = c_{t,l} \sum_{i=0}^{N_l} \{T(t_{l,n(i)}, n(i), n(i+1)) + t_{c,n(i+1)}\} \quad (2)$$

$$C_{p,l}(t_{l,0}, \mathbf{x}_l) = \sum_{i=0}^{N_l} \{c_{d,n(i)}(t) + c_{e,n(i)}(t)\}(t_{l,0}, t, \mathbf{x}_l) \quad (3)$$

Subject to

$$n_0 \geq 2 \quad (4)$$

$$\prod_{l=1}^m \prod_{i=1}^{N_l} \{n(i) - k\} = 0 \quad \forall k = 1, 2, \dots, N_l \quad (5)$$

$$\sum_{l=1}^m N_l = N \quad (6)$$

$$\sum_{n(i) \in \mathbf{x}_l} D(n(i)) = W_l(\mathbf{x}_l) \quad (7)$$

$$W_l(\mathbf{x}_l) \leq W_{c,l} \quad (8)$$

$$t_s \leq t_{l,0} \quad (9)$$

$$t'_{l,0} \leq t_e \quad (10)$$

where

$$t'_{l,0} = t_{l,0} + \sum_{i=0}^{N_l} \left\{ T(t_{l,n(i)}, n(i), n(i+1)) + t_{c,n(i+1)} \right\} \quad (11)$$

- $C(t_0, \mathbf{X})$: total cost (yen)
- t_0 : departure time vector for all vehicles at the depot $t_0 = \{t_{l,0} | l=1, m\}$
- \mathbf{X} : assignment and order of visiting customers for all vehicles $\mathbf{X} = \{\mathbf{x}_l | l=1, m\}$
- \mathbf{x}_l : assignment and order of visiting customers for vehicle l $\mathbf{x}_l = \{n(i) | i=1, N_l\}$
- $n(i)$: node number of i th customer visited by a vehicle
- $d(j)$: number of depot (= 0)
- N_l : total number of customers visited by vehicle l
- n_0 : total number of $d(j)$ in \mathbf{x}_l
- m : maximum number of vehicles available
- $c_{f,l}$: fixed cost for vehicle l (yen /vehicle)
- $\delta_l(\mathbf{x}_l) = 1$; if vehicle l is used, = 0; otherwise
- $C_{r,l}(t_{l,0}, \mathbf{x}_l)$: operating cost for vehicle l (yen)
- $C_{p,l}(t_{l,0}, \mathbf{x}_l)$: penalty cost for vehicle l (yen)
- $c_{t,l}$: operating cost per minute for vehicle l (yen /min)
- $t_{l,n(i)}$: departure time of vehicle l at customer $n(i)$
- $T(t_{l,n(i)}, n(i), n(i+1))$:
travel time of vehicle l between customer $n(i)$ and $n(i+1)$ at time $t_{l,n(i)}$
- $t_{c,n(i)}$: loading/unloading time at customer $n(i)$
- $c_{d,n(i)}(t)$: delay penalty cost per minute at customer $n(i)$ (yen/min)
- $c_{e,n(i)}(t)$: early arrival penalty cost per minute at customer $n(i)$ (yen/min)
- N : total number of customers
- $D(n(i))$: demand of customer $n(i)$ (kg)
- $t'_{l,0}$: last arrival time of vehicle l at the depot
- t_s : starting of possible operation time of trucks
- t_e : end of possible operation time of trucks
- $W_l(\mathbf{x}_l)$: load of vehicle l (kg)
- $W_{c,l}$: capacity of vehicle l (kg).

The problem specified by equations (1) – (11) involves determining the variable \mathbf{X} , that is, the assignment of vehicles and the visiting order of customers and the variable t_0 , the departure time of vehicles from the depot. Note, that $n(0)$ and $n(N_l + 1)$ represent the depot in equations (2) and (3).

To simulate the tours, we used a grid network with 25 nodes and 80 links with a size of the area assumed to be 400 km² (20x20 km), representing a part of a city (see Figure 2.5). This road network is comprised of two types of roads: trunk roads with free running speed of 40 km/h and streets with 30 km/h. These roads have two lanes with a traffic jam density of 120 vehicles/km/lane. This test-network was applied in previous city logistics studies (Taniguchi et al., 1998; Jagtman, 1999; Taniguchi et al., 1999; Taniguchi et al., 2002; Yamada et al., 2004; Taniguchi & Shimamoto, 2004).

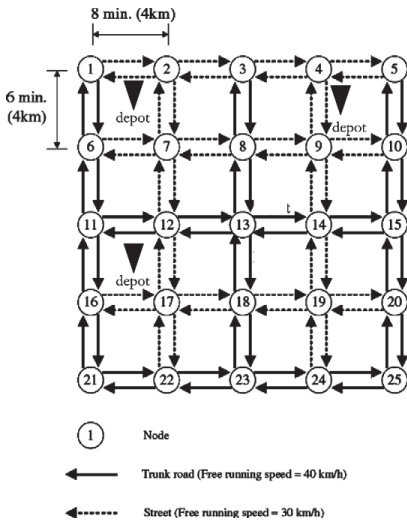


Figure 2.5: The test network

In our model three carriers are simulated, operating daily from a depot with randomly chosen location, which is the starting and ending point for the routes of the trucks. Each carrier has four trucks available to execute the transport. Each of these trucks has a capacity of 40 tons. The run-length of the simulation is 1 week (10,080 min). This period is assumed to be long enough to give accurate results. At the beginning of the simulation the fixed orders for each carrier and truck are determined. For each truck this is done by putting 46 loads into their schedule. These loads all have a random amount, a random location and a random time window attached to these nodes. The arrival time between these loads is Poisson distributed. During the actual simulation, a new auction load is announced on average every 17 min. This means that during the simulation of 10080 min, about 600 loads are available on the auction. The preferred pick up time varies between 6 and 12 hours after the current time. For each load/truck combination a new transport schedule is determined. The load of customer will be assigned to the carrier whose total distribution costs for the new schedule are the lowest in case of cost minimisation of the shipper. In other words, the carrier with the smallest difference between the total costs of the old schedule (fixed customers only) and the total costs of the new schedule (fixed customers and the new customer) will win the bid. In case of high importance (weight) to reliability by the shipper, the carrier with the smallest time difference will get to execute the transport of the new customer. With help of a Tabu-search method (Gendreau, 2002) for several situations (locations and time windows of fixed and new

customers and locations of carriers) the optimal schedule is searched and the load is given to the ‘best’ company. In the comparison with the current best approaches the Tabu-search heuristics are clearly among the best techniques to tackle the vehicle routing problem (Braysy & Gendreau, 2002). The validation of our scheduling algorithm was based on the Solomon VRPTW C101 problem instance (Solomon, 1987). This problem has hard time windows. However, our problem has soft-windows. Only for validation purposes the penalty cost function had been set with an extremely high penalty. Our test results provided us quickly (after ± 50 TABU-iterations) with good solutions. This seemed to be satisfactory to perform the real-time planning within the simulation (see Table 2.4).

Table 2.4: Solving VRPTW C101 with TABU-search

Iteration number	Objective value(total cost)	Objective value
0 (init solution)	528.327	0%
1	449.714	-14.89%
10	404.786	-23.38%
20	394.759	-25.28%
40	352.089	-33.35%
50	352.061	-33.36%
100	352.061	-33.36%
200	352.061	-33.36%
300	352.061	-33.36%

2.3.1 Performance indicators

Several performance indicators were defined to analyse and compare the results of the simulations. These performance indicators will be discussed per actor.

For the *carrier*, the number of orders won is of course very important owing to its relationship with the profit. Another characteristic is the number of bids the carrier makes. This indicator can be specified into the number of times the carrier bids one or more times on a load. It has also a direct link to the profit gained by the application of the profit-bonus table. The characteristics of the bids themselves are analysed in terms of: what is the average bid price and what is the average punctuality of a bid. The punctuality is the difference between the preferred pick up time of the shipper and the pickup time the carrier offers in his bid. For the trucks the total time used per carrier on the different activities (driving, waiting, loading and unloading) is calculated. Figure 2.6 represents the interfaces (schedules and bids) for a carrier during the simulation.

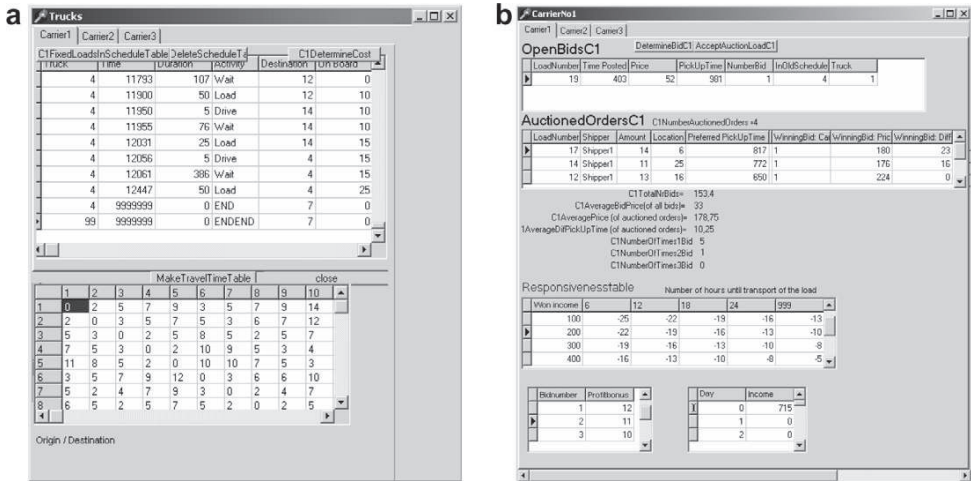


Figure 2.6: (a) Carrier form schedules and (b) Carrier form bids.

For the shipper the costs of transportation are calculated. Both the total costs and the average costs per order are calculated in the model. Also the total sum punctuality of the orders and the average punctuality per executed load are analysed. Finally, the total number of loads announced and the percentage actually auctioned orders are calculated (see Figure 2.7).

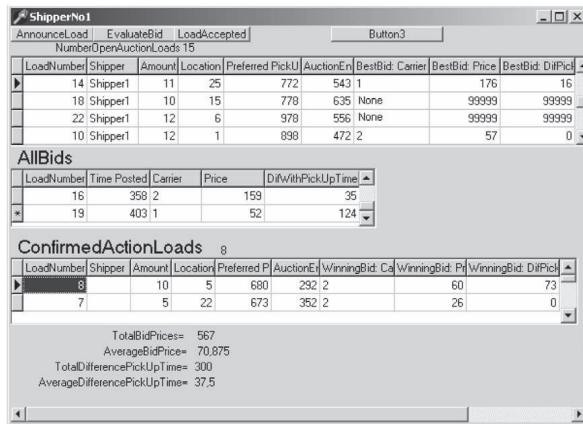


Figure 2.7: Shipper form

For society we used the amount of time used in the simulation per activity and the total number of truck kilometres driven to execute the transport.

2.3.2 Behaviour scenarios in the simulations

In order to gain insight in the effects of using the auctions we have changed the responsive bidding behaviour of the carriers. Each scenario has been setup with 3 or 4 variants. For each

variant 20 simulation runs were carried out with random seeds. Therefore all results are based upon $(1 + 3 + 4 + 3) * 20$ simulation runs.

- *Scenario 0. The first scenario can be interpreted as a reference case*
In this case we have specified the three carriers with the same characteristics. They all have identical cost-time functions and they apply the same responsiveness table. The simulation has about 600 transport orders and about 350 orders have been accepted by the auction. The average number of bids was about 1100. The total incomes for the three carriers have been analysed.
- *Scenario 1. Carrier behaviour – price and time accuracy*
The bid price and offered timing accuracy are changed in this scenario for each carrier. The hypothesis to be tested is that in the scenarios in which the price is increased and/or the punctuality of carriers' bids is decreased, less orders will be won by these carriers. Not only will the absolute effect of price and punctuality be investigated; also the effects of a price increase will be compared with the effects of a punctuality decrease.
- *Scenario 2. Carrier behaviour – responsiveness*
In scenario 2 the responsiveness of the carriers is changed. The responsiveness has a direct influence on the price of a bid via the discount-table. Four different attitudes are defined:
 - The carriers are equally nervous.
 - The responsiveness increases when the time until transport is shorter.
 - The responsiveness decreases when the income already won is higher.
 - A combination of options 2 and 3: when the time until transport is shorter, the responsiveness increases, when the income already won is low, the responsiveness is higher.
- *Scenario 3. Carrier behaviour – cost-time-functions*
In scenario 3 the slopes (combinations with values -0.5, -2 and -8) of the cost-time functions of the different carriers are changed. Experiments have been carried out with carriers who presume that price is more important and experiments with carriers who presume that punctuality is more important to the customer.

2.4 Results of the experiments

In this section the results from the scenarios are summarised from the perspectives of different actors (shippers, carriers and society at large), in order to judge whether the expectations as to possible advantages really could be met. A detailed description of the simulation results (140 runs) is given in Kneyber (2002).

2.4.1 Carriers

Carriers try to maximise their profit. They try to achieve this by maximising their turnover and minimizing their costs. Turnover can be increased by raising a higher price per order or

by winning a larger number of orders with more dedication to meet the demands of the shippers. The costs can be decreased by a fuller schedule, a lower number of vehicle kilometres and by lower search and negotiation costs. The simulation shows that average bid price is lower than the average expected price and that the average price per auctioned order is lower than average bid price (see Table 2.5). One should remind that the average price per auctioned order is calculated as the total average of 20 different replications, each individual price based on the application of the discount-table, the profit-bonus table and the current status of truck routes at a specific moment (see Example 1).

Table 2.5: Simulation results scenario 0

Simulation results	Carrier1	Carrier2	Carrier3
TotalNrBids	375.1	362.4	388.0
AuctionedOrders	119.5	112.7	117.6
AverageBidPrice (all bids)	88.6	87.6	90.1
Average Punctuality Difference(all bids)	40.8	41.9	42.9
AveragePrice (auctioned orders)	71.6	65.8	70.7
Average Punctuality Difference (auctioned orders)	29.5	29.2	30.8
NrTimes1Bid	303.1	298.4	313.0
NrTimes2Bid	65.8	59.6	68.9
NrTimes3Bid	5.7	4.1	5.8
Revenues	8495	7449	8110

Example 1. The following calculation shows that average price in scenario 0 that might be expected based on the input data is 92. The average cost price is equal to the average loading costs plus the average driving costs plus the average unloading costs. Because the average ordering amount is 10, the average cost price is $10 * 5 + (5 + 2) + 10 * 5 = 107$. To get the bid price the discount-bonus and the profit-bonus are applied to this cost price. The average discount-bonus is about -22% (when the income already won ≥ 300 and the time until transport is smaller than 6 h). The average profit-bonus is 10% (for the first bid). The average bid price is therefore $107 * (100 - 22%) * (100 + 10%) = 92$.

The results indicate that the reverse auction has a price decreasing effect and supports the general findings on price decreasing effects of auctions by Tully (2000) and Cohn et al. (2000). For each carrier the revenues increased by 30% which allowed them to lower their prices. The average Punctuality Difference (=difference between requested delivery time and realised delivery time) per auctioned order is lower than the average Punctuality Difference per bid, which indicates that the auction also has a positive effect on reliability. A carrier wins fewer orders if its price is higher. Remarkably, the total income of carrier 2 is significantly lower than the incomes of the other carriers. This is caused by the lower average price of the orders won by this carrier, as can be seen in Table 2.5.

Scenario 1

Table 2.6 shows the results of scenario 1, a rather extreme scenario: the bid price of carrier 2 is doubled, the bid price of carrier 3 is ten times higher (the bid price of carrier 1 remained unchanged). Because of these extreme changes, the results for the carrier are quite different from those of scenario 0. Table 2.6 shows that the price increases for carrier 2 and carrier 3

result in a reduction of the Punctuality Difference for these carriers. It also shows that for every carrier the average price and Punctuality Difference of the orders won is higher than the average price and Punctuality Difference of all bids. Despite the larger price increase, carrier 3 still wins 49 orders. These are probably orders that only can be executed by this carrier, so the shipper has no choice than to accept the (very high) bid of this carrier. Carrier 1 profits most from the high prices of the other carriers and wins 49% more orders than in scenario 0. Carrier 1 can also ask a higher price than in scenario 0, because there is less competition on price from the other carriers. Carrier 1 can make less bids than in scenario 0, again because the competition is smaller. Not only does he make 25% less bids in total, he also bids 42% less often twice on the same load and 69% less often three times on a load. Carrier 3 on the other hand bids more often and also bids more often two or three times on the same load. The cause of this is that carrier 3 lowers his price for a second bid, because his income has decreased. The total income per carrier for scenario 1, compared to the total income in scenario 0, show an increase of the total income for all the carriers: the income of carrier 1 is almost 70% higher, the income of carrier 2 is 181% higher and carrier 3 receives 442% more income. When maximisation of profits is the main goal, a strategy with a very high price seems to be favourable for the carrier in the simulations. Clearly, a low transport price only can be realised if enough carriers participate in the auction and if the participating carriers have significant 'free space' in their schedules. When few carriers participate, there is not enough competition to speak of a real market price. The simulation has also shown that a smaller punctuality difference also means that the average price increases. The negative effects of a larger punctuality difference are smaller than the negative effects of a high price. A higher price or smaller punctuality difference almost always results in more driving-time.

Table 2.6: Results scenario 1: carriers with extreme price settings

Carrier	Average			Difference with Scenario 0		
	price*1	price*2	price*10	price*1	price*2	price*10
TotalNrBids	279.7	374.2	435.5	-25%	0%	17%
AuctionedOrders	172.7	132.5	48.7	49%	14%	-58%
AverageBidPrice (all bids)	93.5	179.3	888.7	5%	101%	897%
Average Punctuality Difference (all bids)	46.0	41.2	39.2	10%	-2%	-7%
AveragePrice (auctioned orders)	83.0	156.5	908.8	20%	126%	1210%
Average Punctuality Difference (auctioned orders)	36.5	36.7	45.8	21%	21%	52%
NrTimes1Bid	241.0	307.0	341.3	-21%	1%	12%
NrTimes2Bid	37.2	63.7	87.8	-42%	-1%	36%
NrTimes3Bid	1.5	3.5	5.8	-69%	-29%	17%

Scenario 2

Table 2.7 shows that the various discount-tables do not result in big differences with scenario 0. Carrier 2, the carrier whose responsiveness decreases when he has won more income, seems to win slightly more orders than in scenario 0. This appears to be caused by the preferred pickup time the order gets when it is announced by the shipper. This preferred pickup-time is at most twelve hours after the announcement is made. If the carrier makes a bid, the time until transport is therefore always shorter than twelve hours, which means that in the responsiveness-table only the values in column 1 (shorter than 6 h) or column 2 (shorter

than 12 h) are used. In case of longer time between the announcement of a load and the preferred pick up time of this load, more bids and more auctioned orders result. If the responsiveness depends on the income already won, then the carrier more often bids twice or three times on the same load.

Table 2.7: Results scenario 2: carriers

	Average			Differences with scenario 0		
	C1	C2	C3	C1	C2	C3
TotalNrBids	387.8	358.8	373.2	4.2%	-1.6%	-2.9%
AuctionedOrders	117.6	122	111.4	-0.2%	6.6%	-4.4%
AverageBidPrice (all bids)	86.4	82.6	88.8	-3.6%	-6.1%	-1.1%
Average Punctuality Difference (all bids)	41	42.6	42.6	0.0%	3.1%	-1.6%
AveragePrice (auctioned orders)	66	62.4	68.6	-9.3%	-4.6%	-2.1%
Average Punctuality Difference (auctioned orders)	30	29	29.8	0.3%	-6.8%	0.3%
NrTimes1Bid	306	294.2	301.6	1.6%	-1.2%	-3.5%
NrTimes2Bid	73	58.8	65.4	12.1%	-4.1%	-2.7%
NrTimes3Bid	8.2	5.6	5.6	54.7%	12.0%	24.4%

When the responsiveness depends on the time until transport, the carrier needs the most time for driving, loading and unloading. When the responsiveness depends on both the time until transport and the income already won, the carrier needs the least time for driving and unloading (see Table 2.8). The results of the schedules executed by each carrier are shown in Table 2.8. In the initial schedule, each carrier has 184 loads to transport. In the schedule after simulation, carrier 1 transports on average 119.5 additional loads, carrier 2 has additional 112.7 loads, and carrier 3 has 117.6 additional loads. For the Average Punctuality Difference, only these extra loads are used to calculate the average time used for each activity per auctioned load. The table 2.8 shows that the orders won in the auction take more driving time than the fixed orders.

Table 2.8: Results scenario 2: schedules (in minutes)

Average	Initial					After simulation (Initial + auction)				
	Drive	Wait	Load	Unload	Total	Drive	Wait	Load	Unload	Total
Carrier 1	1155	31838	8715	8145	49853	2404	19615	14202	10092	46313
Carrier 2	1165	28837	8975	8410	47387	2273	20479	14082	9361	46195
Carrier 3	1155	30388	8550	8240	48333	2235	21095	13793	9701	46823

Average	Difference (absolute)					Difference (relative)				
	Drive	Wait	Load	Unload	Total	Drive	Wait	Load	Unload	Total
Carrier 1	1249	-12223	5487	1947	-3540	108%	-38%	63%	24%	-7%
Carrier 2	1108	-8358	5107	951	-1192	95%	-29%	57%	11%	-3%
Carrier 3	1080	-9293	5243	1461	-1510	93%	-31%	61%	18%	-3%

The effects on the planning of the loads are very clear: the driving time almost doubles, the waiting times decreases about 1/3, the total loading time increases by 60% and the time for unloading increases with 12%. For the doubling of driving times a logical explanation can be

found. In practice, one can observe schedules with an initial average load factor of 36.8% (for trips shorter than 50 km and trucks with loading capacity of 3.5 until 7 tonnes, see Dings et al. (1999)). In other words, usually there is still enough capacity available to be used more efficiently. The enormous reduction in waiting times can be explained by a better planning towards the time-windows. In our model each customer can have its own random time-window. This is realistic as in practice every municipality has its own set of time-window regulations (van Duin, 2005). When responsiveness of the carrier is always high (independent of both the time until transport and the income already won) the reduction in waiting-time is the greatest. The carrier can fill his schedule quickly. When the responsiveness depends on the income already won, the carrier needs the least waiting-time. Eagerness will be rewarded.

Scenario 3

In scenario 3 carrier 1 uses a slope of -0.5 in the cost time-function, carrier 2 uses a slope of -2 and carrier 3 a slope of -8. The carrier with the steepest slope of the cost–time-function is most punctual. Table 2.9 shows the results of this scenario for the carriers.

Table 2.9: Results scenario 3:carriers

	Average			Difference with scenario 0		
	C1	C2	C3	C1	C2	C3
TotalNrBids	371.4	356.2	359.4	-0.2%	-2.3%	-6.5%
AuctionedOrders	111.4	110.6	122.8	-5.4%	-3.4%	5.4%
AverageBidPrice (all bids)	90.4	88	87.6	0.9%	0.0%	-2.4%
Average Punctuality Difference (all bids)	46.4	44	43	13.2%	6.5%	-0.7%
AveragePrice (auctioned orders)	71.4	67.6	67.8	-1.9%	3.4%	-3.3%
Average Punctuality Difference (auctioned orders)	32	29.8	27.4	7.0%	-4.2%	-7.7%
NrTimes1Bid	304.8	293.4	305.8	1.2%	-1.5%	-2.2%
NrTimes2Bid	62.4	57	68.6	-4.1%	-7.0%	2.1%
NrTimes3Bid	4.2	5.4	4.8	-20.8%	8.0%	6.7%

These results show that carrier 3, the carrier with the steepest slope wins 5% more orders than in scenario 0. Carrier 1, who considers costs as the most important, wins 5% less orders. The better performance of carrier 3 can probably explained by the greater competition between the carriers on price than on punctuality. The punctuality depends on the schedules of the carriers and cannot directly be influenced by the carriers. Because of the very negative slope of -8, the punctuality of carrier 3 has the biggest influence on his price: every minute not on time causes a decrease in price of 8. This results in a lower bid for carrier 3 and therefore wins more orders.

The carrier whose applies the lowest value of time, carrier 1, now has a 13% higher average punctuality difference in his bids and a 7% higher average punctuality difference in the orders won. The carrier who values time the most, carrier 3, now has a 8% lower average punctuality difference in the orders won. A higher priority for Punctuality causes a carrier to win more orders. A high priority for costs causes a carrier to win fewer orders. This can be explained by the greater competition between the carriers on price rather than on punctuality.

2.4.2 Shippers

As already mentioned, the simulation shows that the auction causes the price and the punctuality difference to decrease, both favourable conditions for a shipper. However only half the orders available on the auction are actually auctioned. This could be a warning for the shippers, not to be too much dependent of the auction system. The shipper cannot be sure that his load will be transported by a carrier found via the auction system, so he should be able to find a carrier in an alternative way.

In the model, a shipper is not able to refuse a bid made on his load: a shipper has to choose the carrier that makes the best bid, even if this bid means a very high price and/or a bad punctuality performance. To prevent this, before the auction begins it has to be agreed that the shipper can also decide not to accept any of the bids made by the carriers. A longer time between the announcement of a load and its preferred pick up time causes the number of auctioned orders to rise significantly. The conclusion can be drawn that this period has to be long enough for the carriers to schedule the load, to make several bids and to complete the auction correctly.

Less competition on price and/or punctuality difference results in a longer time necessary per order for driving, loading and unloading together. We found in every scenario in which carriers have a higher price and/or higher Punctuality difference means more driving-time, less waiting-time, more loading time and more unloading time is needed compared to the results in scenario 0.

2.4.3 Society

Taniguchi et al. (2001) defined City Logistics as the process for totally optimising the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy. From this, one important objective is to reduce total driving-time and the number of truck kilometres driven. A more general goal is to have a fair market for shippers and carriers: the market needs to be open and transparent for all parties involved. As already mentioned, a higher price almost always means more driving-time and loading-time. A higher Punctuality difference always means more driving-time and almost always means more loading-time and less waiting-time. The carrier with the highest priority for Punctuality difference needs less time for these activities. The extra focus being on time makes the scheduling more efficient by attracting more orders and making a more efficient clustering possible.

2.5 Conclusions

Auctions can help to create more transparent, effective and efficient freight markets, as shippers have more information on (potential) carriers and the other way around. Through the real time and simultaneous simulation of auctioning and re-scheduling, presented in this paper, we were able to study in some detail the dynamics of bidding behaviour of both carriers and shippers. The inclusion of realistic criteria for shippers and carriers has shown that with simple means a rich picture can be obtained of the effects of freight auction systems. The model proved useful to obtain quantitative measures of efficiency improvements for both shippers and carriers. In addition, it provided guidance on the influence of the various auction rules on the performance of the freight transport system. Like Song & Regan (2003) and

Figliozzi et al. (2006) we confirm that an auction system can contribute to a higher degree of consolidation by an improved clustering of routes. Here we also show that benefits accrue to both carriers and shippers. For the carrier the auction can be seen as an opportunity to improve the occupancy rate of transport vehicles. Shippers can obtain better responsiveness rates or price conditions. We note that not all transport orders auctioned will have favourable conditions compared to planned tours or can be added easily to existing schedules. Therefore, shippers should strive to maintain long term relationships with their main carriers.

An interesting area of innovation involves extended experimentation with this system, to study shipper and carrier behaviour in even more detail and with increased realism. Assumptions in the model that remain to be refined are, as in Figliozzi et al. (2006), that (1) vehicles and loads are compatible, (2) implementation and transaction costs can be neglected, (3) behaviour of shippers and carriers is static (i.e. no learning during the auction) and (4) adoption behaviour towards auction systems is not considered. Yoshimoto (2004) finds that shippers associate auctioning with extra risk which comes from using untested/unknown transportation providers. Shippers or carriers may have reserves or strategies that inhibit their participation or their efficiency of trading. Future research, therefore, will need to extend towards more sophisticated actor behaviour, e.g. by developing a gaming environment based on agent-based modelling for the auctioning and planning of transport orders to learn more of the effects of these electronic marketplaces on the one hand, and on the other hand to serve as a training tool to overcome the major hesitations of shippers and carriers to use these systems.

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3 Estimating CO₂-Footprints of container terminal port-operations

‘Non minima negotii pars est adeundi negotii viam nosse’
(It is not the least important part of a task to know how you tackle)
Erasmus

This chapter is based on:

J.H.R. van Duin, H. Geerlings, (2011). Estimating CO₂-footprints of container terminal port-operations. *International Journal of Sustainable Development and Planning*, 6(4), 459-473.

Abstract

At present there is increasing pressure on governments and industries to come forward with initiatives to reduce CO₂-emissions. This is particular relevant for the transport sector, as the share of transportation is still increasing, while other sectors are reducing their CO₂-footprints.

The main purpose of this paper is to present a method to analyse the CO₂-emissions from container terminals and gain a better understanding of the CO₂-emissions by container terminals in port areas. With a better understanding of the CO₂-emissions, more effective solutions to reduce CO₂-emissions by container terminals can be identified. The study provides insight into the processes of container handling and transshipment at the terminals and calculates the contribution of these processes to the CO₂-emissions (or carbon-footprint) of the container terminals. The model was validated by application on 95% of all sea and inland container terminals in the Netherlands.

Keywords: Container Terminal, CO₂-emissions, Carbon-Footprint, Modelling

3.1 Introduction

In the mid-1990s we observe a first recognition of policy initiatives reducing CO₂-emissions. From that moment on there is an acceleration in new policy initiatives, e.g. international arrangements under the supervision of the United Nations, such as the Kyoto Agreement (U.N. Intergovernmental Panel on Climate Change, 1998); supra-national agreements, such as the Biomass Action plan by the European Commission (2005); and, see for an extended inventory of European initiatives (Geerlings & Sluis-van Meieren, 2008), and multilateral agreements, such as the Clear Skies and Global Climate Change Initiative initiated by the Bush Administration in 2002 (U.S. National Oceanic and Atmospheric Administration, 2002; U.S. Environmental Protection Agency (EPA), 2005).

At the same time there are numerous policy initiatives on the national level dealing with the stabilisation and reduction of CO₂-emissions and other greenhouse gases, mostly addressed in national policy plans. Consequently, there is increasing pressure on industries as well to come forward with (more) climate-friendly strategies. The recognition of this new challenge requires new approaches that include a reconsideration of existing production and consumption processes, new policy initiatives and instruments, new data, and new supportive research activities. Aberdeen Group (Shecterle, 2008) shows in their research on the Supply Chain Executive's Strategic Agenda 2008, that the recent interest in green supply chain initiatives is robust and growing. Their study explored the main green drivers among 400 companies, and has identified specific areas of opportunity in each individual company in relation to energy usage reduction, supply chain network design and logistics optimization, and green supplier initiatives. All these elements effect the carbon-footprint of a company.

From a sectoral perspective it is noted that transport systems have significant impacts on climate change, accounting for between 20 and 25 per cent of world energy consumption and CO₂-emissions (World Energy Council, 2007). Greenhouse gas emissions from transport are increasing at a faster rate than any other energy using sector (UN-Intergovernmental Panel on Climate Change, 2007). In particular, the container sector is currently the fastest growing industry (despite the last two crises years). Especially in the Netherlands over the last ten years container handling has experienced an explosive growth in the Netherlands. Due to the rapidly growing flow of containers from Asia, mainly from China, and the development of a new port extension in the Rotterdam area called Maasvlakte 2, it is expected that this growth will accelerate, as it is expected that the number of container handlings will rise from 11 million per year in 2008 to 33 million per year in 2033. This growth will account for a significant increase in the contribution of CO₂-emissions caused by container handling both for deep-sea terminals as well as hinterland inland terminals.

Analysing the policies announced both at national and regional level (RCI, 2007) we observe a lack of a clear plan, related instruments, and actions that focus on the reduction of the CO₂-emissions of this sector. There is a serious knowledge gap since there is almost no understanding and knowledge of the CO₂-production of this sector. Especially terminal operators do not have any idea how to perform a CO₂-footprint. Therefore for policymakers it is even more difficult to address proper policies which might reduce the CO₂-emissions since they don't know what the most polluting factors in this sector are. However, there is a strong pressure on the sector to become (more) sustainable. As a first step both for policy makers and

terminal operators it is therefore important to understand the total quantity of CO₂-emissions of the different terminal configurations, at the managerial/policy level.

Therefore, in this paper the research goal is how to develop a method which can predict the total CO₂-emissions at terminals. This article presents a quick bottom-up method to estimate the CO₂-emissions from container port terminals based on fuel and energy-consumption. The study provides insight into the processes of container handling and container transshipment at the terminals and calculates the contribution of these processes to the CO₂-emissions. The estimates are validated for sea and inland container terminals in the Netherlands. Based on these insights and the identification of potential solutions to reduce CO₂ at the terminals, policy proposals can be made for the terminal operators and governments.

3.2 Literature overview

There is extensive research related to decision making in container terminals. As Murty et al. (2005) stated in their work, all the decisions to be made at terminals are related to the berth allocation of vessels. No contributions can be found with respect to the emissions of terminals. Considering our audience of policymakers and terminal managers our method should provide good estimates of the emissions and the applied method, as a consequence, needs to be very simple and interpretable instead of a method based on difficult mathematical equations. In this respect, we have been able to develop a simple model which can provide for understandable, reliable predictions of CO₂-emissions and energy-consumption at terminals.

In literature the next contributions can be found related to transport and environmental performance. The audience of Hickman & Banister (2007) consists also policy makers who want to look at a future horizon of 20 years regarding transport and CO₂-emissions. Their back-casting method can be a helpful for policy makers who wish to reduce the CO₂-emissions to a certain desired levels. However, their method does not explain how realistic the paths to these wanted emission-levels are, and how likely it is this can be achieved. Like other studies, such as Liao et al. (2009), Lodewijks & Wellink (2009) and Notteboom & Verminnen (2009), they do not calculate the environmental performance of the transshipment activities, but they focus only on the environmental performance of the individual transport modes. In this paper we have made a start to develop a new bottom-up method to estimate the environmental performance of different terminal configurations. As Ariztegui et al. (2004) make clear, one has to tackle several problems to collect real data regarding the (terminal) traffic at different hours and days, to accurately estimate the emissions, to estimate the composition of the fleet, and to estimate the mileage driven by the fleet. The new model presented here will be estimated in such a way that environmental footprints easily can be obtained from terminal operations.

This study builds on research by Medin & Mo (2005), van Zeebroeck (2005) and Oonk (2006). Medin & Mo (2005) have calculated the emissions from road transport on the basis of a selection of relevant vehicles, the type of fuel and fuel consumption. By using a GIS-system for several transport routes, distances are determined, and hence the emissions can be calculated (based on vehicle performance and distance). The same approach was used in a research project by Transport & Mobility Leuven (van Zeebroeck, 2005). The applied method was used in a project that concentrated on the emissions from “non-road mobile vehicle”.

Most of these research contributions share the same modelling paradigm based on activity-based emission modelling (Beckx et al., 2009). We have applied this modelling paradigm to develop a method for the calculation of emissions caused by the container terminals, i.e. terminal-equipment. This has resulted in a new combined and more generic model. This model includes a bottom-up calculation of the amount of work supplied by equipment, not using the amount of fuel as input, but as the result of the model. Oonk (2006) also uses a similar method in a study by the Dutch research institute TNO to assess the emission of harmful gases by terminal operator ECT (European Combined Terminals) at the Delta terminal on the Maasvlakte. This includes a study of the environmental performance of an automated terminal, called the Delta terminal, compared with a more traditional manned terminal. Different from the study of Oonk (2006), which can be seen as an advantage, our model uses macro-level data such as the number of transshipments at the terminal and the deployment of various types of equipment, each with a different energy-consumption pattern, coupled with standard routes with average distances, and average energy consumption (see Figure 3.1). A disadvantage of the model could be too rough estimates of the energy consumptions and related environmental performance. However, the quality of the estimations by our method will be validated on the real energy consumption figures of the selected terminals.

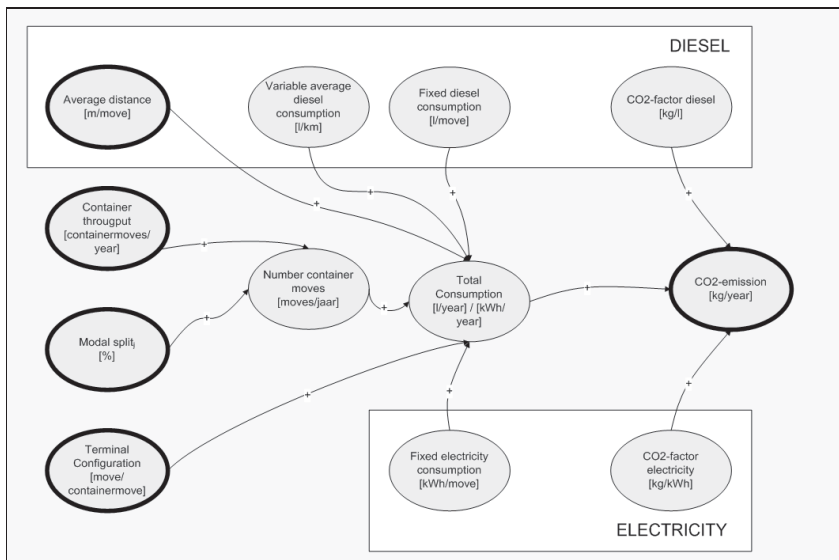


Figure 3.1: The conceptual model for calculating CO₂-emissions at terminals

This study is therefore based on a quantitative analysis of the energy consumption of terminal processes and the related CO₂-emissions. The CO₂-emissions are a direct consequence of the burning of fossil fuels to generate the energy needed to operate terminal processes. The transshipment of containers takes place with the different types of equipment that are used by the terminals. The type of equipment and the use of this equipment determine the energy consumption, and consequently the amount of CO₂-emissions. The quantity of fuel directly

determines the emissions, which is different for different energy sources: for example, the burning of a litre of diesel produces around 2.65 kg of CO₂ (based on the calorific value of diesel with a density of 0.835 kg/dm³) (ECN, 2008).

3.3 The model

Current emissions caused by the transhipments at container terminals are mapped using an emission model per terminal. Since CO₂-emissions are the direct consequence of energy used by the transhipment processes, it is important to obtain an idea of the factors in the transhipment processes that consume energy. These factors include the equipment used by each sub-process, the energy-consumption pattern of various types of equipment, the deployment of the equipment in each sub-process, and the average distance within a sub-process.

3.3.1 Input variables

The aim of this research is to obtain a quick understanding of the CO₂-emissions of a container terminal at macro level. For a quick understanding, it is important that appropriate data is freely available and easy to obtain. Therefore the following data is needed as input for the calculation of emissions (see Figure 3.1):

- *The overall transhipment performance by means of the total container throughput at a terminal in one year*
Yearly reports of container terminals are easy to obtain. In the model the overall transhipment performance expressed in containers is dealt with, or, if it is not expressed in TEUs, making a recalculation to estimate the number of containers based on the 40ft and 45ft containers.
- *Modal split: the breakdown of the transhipment to the various forms of pre-and post – transport*
The modal split is important for its share in total container throughput to the various modalities. For each type of modality the handling processes and routes of the containers are different (see also next point).
- *Terminal configuration: deployment of equipment per sub-process*
The various transhipment processes at the terminal can vary by each type of modality. The way the processes are laid out, what type of equipment is used, and to what modalities is transhipped, are all part of the terminal configuration. Container terminals can use the following equipment (Oonk, 2006):
 - Quay cranes (QCs) are used to (un)load different types of ships. These electric cranes pick up a container directly on a tractor or automatic guided vehicle, or make the container ready for subsequent transfer to a straddle carrier.
 - Barge cranes (BCs) have a smaller ‘reach’ (range) than the above mentioned quay cranes and are suitable for (un)loading barges.

- Rail cranes (RCs) or gantry cranes, can run over one or more rail-tracks. The gantry cranes can directly transfer containers at a terminal, or this can be done by a Multi-tractor trailer system next to the track.
 - Automated Stacking Cranes (ASCs) are unmanned-cranes that put a container into the stacking area or pick up a container from the stacking area at an AGV (see below) or prepare them for a straddle-carrier. ASCs are electrically-driven.
 - Rail-mounted Stacking Cranes (RSCs) or gantry cranes, are placed on rails and can move around on or off the stack to pick up or position containers.
 - Automated guided vehicles (AGVs) are designed for the horizontal transport terminals. AGVs are unmanned vehicles and have been seen at terminals since the 1990s. Currently, most AGVs are diesel-powered hydraulic-driven.
 - ReachStackers (RS) are the most flexible handling solutions since they are able to transport a container in short distances very quickly and pile them in various rows depending on its access.
- *Terminal layout: average distances of equipment to sub-processes.*

The energy-consumption of the equipment also depends on the distances travelled to and from the various sub-processes. The layout of the container terminal will determine these distances. Each terminal has its own design and related distances between the various locations within the terminal. The energy consumption is calculated using an average distance by type of equipment, per modality. Distances between stacks, quays, gates, etc. are derived from satellite photos (Google-Earth ©). The distance calculation is based on the Manhattan-distance-metric system. Figure 3.2 shows an example of a distance calculation at the APM terminal on the Maasvlakte.

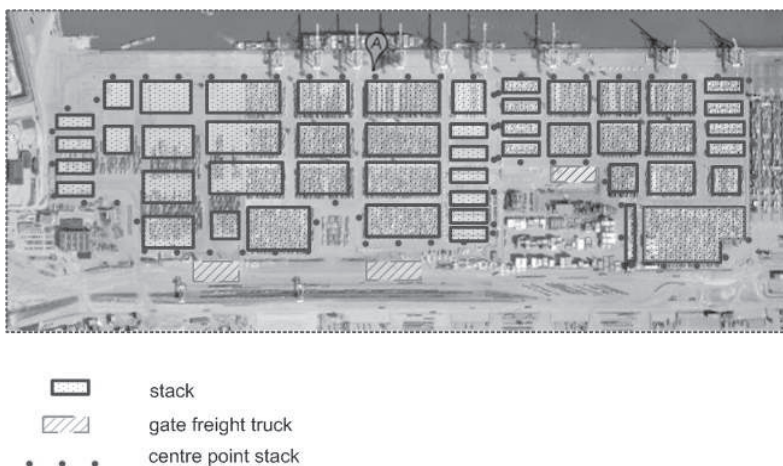


Figure 3.2: Input for distance calculation APM-terminal (Source: (van der Voet, 2008))

In this situation, the average distance for a straddle carrier (SC) is determined between the stack and the trucking gates. At the terminal there are three gates. For the distance calculation from the gates, the distance in two directions between the gate and the centre point of the stack (or buffer zones) are determined. In this way each type of equipment has its own average distance, depending on the sub-process.

Regarding the number of movements, it should be mentioned that a distinction should be made between a “container-move” and a “ride”. A “container-move” is a movement in which only one container is moved. A “ride” is a motion of an SC, a crane or another type of equipment, which may be assigned to one or more containers.

Electrical equipment, which is often static, is assigned with a fixed consumption per ride. For diesel-powered equipment the distance is adjusted using a variable consumption depending on the distance and a fixed consumption per ride for lifting operations (for example, by SCs).

Table 3.1: Energy consumption per type of equipment

Energy	Type of equipment	Fixed consumption per containermove	Variable consumption	Terminals	Source
ELECTRICITY	QC: Quay Crane	6.00 kWh		ECT-D, ECT-Ho, ECT-Ha, APM, RST, UNP	(Oonk, 2006)
	BC: Barge Crane	4.00 kWh		ECT-D, APM, BCT, CTN, WIT	(Oonk, 2006)
	RC: Rail Crane	5.00 kWh		ECT-D, APM	(Oonk, 2006)
	ASC: Automated Stacking Crane	5.00 kWh		ECT-D	(Oonk, 2006)
	RSC: Railmounted Stacking Crane	7.25 kWh		ECT-Ha, RST, UNP	ASC*
	P: Platform	5.00 kWh		RST	ASC*
DIESEL	AGV: Automated Guided Vehicle	1.10 l	1.80 l/km	ECT-D	(Oonk, 2006)
	SC: Straddle Carrier	0.80 l	3.50 l/km	ECT-D, ECT-Ho, APM, RST	(Oonk, 2006)
	TT: Terminal Tractors		4.00 l/km	ECT-D, ECT-Ho, ECT-Ha, RST, UNP	(Oonk, 2006)
	MTS: Multi Trailer System		4.20 l/km	ECT-D, ECT-Ho, APM, UNP	(Oonk, 2006)
	RS: Reach Stacker / Top Lifter		5.00 l/km	ECT-D, ECT-Ho, ECT-Ha, APM, RST, UNP, BCT, CTN, WIT	(Oonk, 2006)

The energy consumption patterns by the various types of equipment are shown in Table 3.1. In addition to the emissions of the two different energy sources in the investigation (electricity and diesel), some other assumptions are made. In our research a diesel emission factor of 2.65 kg of CO₂ emissions per litre is applied. This value is based on the calorific value (42.9

MJ/kg) and emission factor (74.3 kg/GJ) of diesel (ECN, 2008) combined with a density of 0.835 kg/dm³ at a temperature 150 C. For the emission of electricity, an assumption is made of 0.52 kg of CO₂ emissions per kWh. This value is based on an average provided by Dutch energy-suppliers (Groot, 2004).

3.3.2 Formalisation

Finally, the total CO₂-emissions of ‘Terminal x’ can be calculated as the total sum of emissions provided by combinations of various types of equipment (i) and their contribution to the sub-processes to tranship them to another modality (j). This leads to equation (1):

$$W_x = \sum_{i=1}^{11} \sum_{j=1}^5 ((v_{i,j} \times f_D) + (P_{i,j} \times f_E)) \quad (1)$$

where:

- W_x = Total weight of CO₂-emission produced at terminal x
- $V_{i,j}$ = Yearly consumption of diesel in lit with equipment i to modality j
- f_D = Emission factor in kilogrammes of CO₂-emission per litre diesel (= 2.65)
- $P_{i,j}$ = Yearly power consumption in kWh for equipment i to modality j
- f_E = Emission factor in kilogrammes of CO₂-emission per kWh (= 0.52)

combined with:

$$V_{i,j} = n_{i,j} * (C_{i,j} + c_{i,j} \bar{X}_{i,j}) \quad \forall i, j \in T \quad (2)$$

$$P_{i,j} = n_{i,j} * (p_{i,j}) \quad \forall i, j \in T \quad (3)$$

where:

- $n_{i,j}$ = Number of rides with equipment i to modality j
- $C_{i,j}$ = Fixed usage (for example lifting operations) per ride in litres
- $c_{i,j}$ = Variable usage per km in litres (see Table 4.1)
- $\bar{X}_{i,j}$ = Distance travelled according Manhattan-metric for equipment i to modality j
- $p_{i,j}$ = Fixed usage per ride in kWh Table 4.1 for equipment i to modality j

Next, Table 3.2 shows an overview of possible combinations with different types of equipment (i) and the modalities (destinations) (j):

Table 3.2: Types of equipment and transport modes at a terminal

i	i (Equipment)	j	j (mode)
1	Quay Crane (QC)	1	Inland shipping
2	Barge Crane (BC)	2	Road
3	Rail Crane (RC)	3	Rail
4	Automated Stacking Crane (ASC)	4	Shortsea
5	Rail-Mounted Stacking Crane (RSC)	5	Inter-terminal transport
6	Platform (P)		
7	Automated Guided Vehicle (AGV)		
8	Straddle Carrier (SC)		
9	Terminal Truck (TT)		
10	Multi-Trailer System (MTS)		
11	Reach Stacker (RS)		

3.4 Application of the model

To validate the model the next 12 terminals have been selected: the Delta, Home and Hanno terminals of ECT, the APM terminal, the Rotterdam Shortsea Terminal (RST) and the Uniport Multipurpose Terminal (UNIPORT) in the Rotterdam region and three inland terminals Bossche Container Terminal (BCT), Container Terminal Nijmegen (CTN) and Wanssum Intermodal Terminal (WIT). The selection of the terminals was based on their willingness to provide us the necessary data to validate our model. The ECT Delta terminal and the APM terminal are the biggest terminals with a maximum load water-line of 16.60 meters and a total surface of 350 hectares. Both terminals can receive the large container-vessels up to 10,000 TEU, in future up to 12,000 TEU. The other Rotterdam terminals (ECT Home, ECT Hanno, Uniport and RST) are located in the Eem-Waalhaven area, which is 25 kilometres inland with a total surface of 157 hectares. These terminals have on average a maximum load water-line of 14 meters and can handle vessels up to 5500 TEU. The Hanno terminal is mainly used to educate employees for crane-drivers and straddle-carrier drivers. The other three containers are inland terminals owned the BCTN-group can handle all seizes inland vessels. The surface of each terminal varies from 3 – 4.5 hectares. The volumes of terminals are shown in Table 3.3.

Table 3.3: Overview of selected terminals and their volumes

Terminal	Transshipment Volumes (TEU)
ECT Delta	4,260,000 (2006)
APM	2,200,000 (2006)
ECT Home	1,000,000 (2006)
UNIPORT	380,000 (2006)
RST	1,150,000 (2006)
ECT Hanno	50,000 (2006)
BCT	236,628 (2007)
CTN	169,019 (2007)
WIT	185,292 (2007)

The use of the model will first be illustrated in detail by using the case Delta terminal, and thereafter, all results obtained with the presented model will be explained in general.

3.4.1 Case of the Delta terminal

The Delta terminal is currently the largest and most automated container terminal in the Port of Rotterdam. The terminal is characterized by the fully-automated handling of containers from sea by means of the use of AGV's and ASC's. The landward-side processes are still mainly driven by people. The terminal covers an area of 293 hectares and has an annual cargo turnover of 4.5 million TEUs. In 2006 the Delta terminal achieved a throughput of around 4.3 million TEUs. Of these, 3,096,129 were destined for or, originating from the hinterland with the following breakdown on the modalities:

- Road 49%;
- Inland 34%;
- Rail 17%.

In Figure 3.3 below a satellite-view of the Delta terminal (light part) is shown.



Figure 3.3: Aerial photograph of the ECT Delta terminal (Source: Google Earth©)

The terminal configuration describes the establishment of the various sub-processes. The pivot of the sub-processes is the stack. Depending on the modality, the use of terminal equipment varies. At the Delta terminal, the following sub-processes can be distinguished:

- Throughput from the sea to stack, vice versa: QC> AGV> ASC;
- Transhipment of inland waterways to stack, vice versa: QC> AGV> ASC or BC> MTS> SC> ASC;
- Throughput on the way to stack, vice versa: SC> ASC;
- Transhipment of rail to stack, vice versa: RC> MTS> SC> ASC;
- Inter-terminal transport (Stack - Stack): (ASC> SC>) MTS> SC> ASC.

The deployment of equipment has already been provided in the investigation (Oonk, 2006) and can follow a matrix display (see Table 3.4). The matrix clarifies what the contribution of each type of equipment is per container-move. A '1' means that this type of equipment is

fully-used for each container-move; and a ‘0.2’ means that this type of equipment is used only once per (on average) 5 container-moves. What is also important for the determination of emissions is the average distances covered by the various types of equipment. For the Delta terminal, these average distances are known from the investigation (Oonk, 2006). These have been incorporated into our study.

Table 3.4: Equipment contribution per type of modality

	SEA	BARGE	ROAD	RAIL	ITT
QC	1	0.71	0	0	0
BC	0	0.29	0	0	0
RC	0	0	0	1	0
ASC	1	0	1	1	1
RSC	0	0	0	0	0
P	0	0	0	0	0
AGV	1	0.71	0	0	0
SC	0	0.29	1	1	0.9
TT	0.02	0.01	0	0.02	0.1
MTS	0	0.06	0	0.2	0.18
RS	0.02	0.01	0.02	0.02	0.1

Note: an explanation of the abbreviations, see Table 3.2

The emission results can be found in Figures 3.4(a) and 3.4(b) below. In addition, the actual consumption of the terminal in 2006 and the observed differences in energy consumption of the model are compared with the actual energy consumption of the terminal (really measured in practice!) in Table 3.5.

Table 3.5: Energy consumption estimated by the model (= result) versus actual performance (= provided by the terminal)

	Estimates	Real consumption	Difference
Diesel	15,005,338 litres	17,654,322 litres	-15.0 %
Electricity	45,503,821 kWh	47,142,857 kWh	- 3.5 %

The deviations of 15 and 3.5 per cent are relatively small in the context of the investigation, and this, combined with the easiness of method (usage of macro data), indicates that the model and the related method provide acceptable estimates.

The total energy consumption produced CO₂-emissions of 63.43 tonnes per year. Conversion to TEUs for 40ft and 45 ft containers implies, respectively, 24.55 and 14.88 kg per kg move. The emissions per type of equipment and the total sums of the equipment used by modality are shown in Figures 3.4(a) and Figure 3.4(b). The annual emissions are shown in grey, indicating the proportion of the total emissions of the terminal. The emissions per container are shown in black.

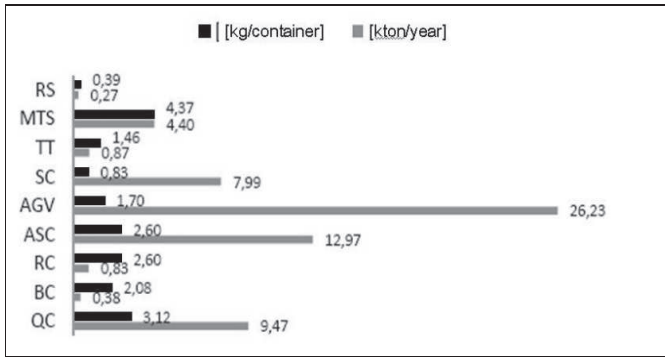


Figure 3.4(a): CO₂-emissions per type of equipment

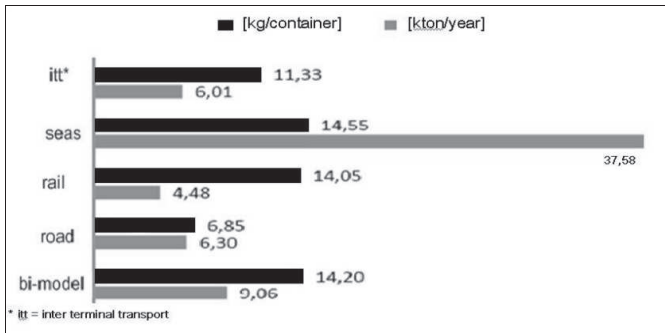


Figure 3.4(b): CO₂-emissions per transport mode

Figure 3.4(a) clearly shows that the AGV is the most energy-consuming of the Delta-terminal. Because of the large volumes of sea transport we can also clearly observe in Figure 3.4(b) that the facilitating processes produce the largest weight of CO₂ (see ‘seas’ in Figure 3.4(b)).

3.4.2 Application of the model to all terminals

To validate our model the explained way of working in the case Delta terminal has been applied to all terminals. Our first modelling results shown in Table 3.6 indicate only limited deviations from the actual consumption of the terminals. This is a first encouraging indication for the possibility of a further application of the model in researching other ports and terminals.

Table 3.6 (a)+(b): Energy consumption (3.6(a) = Diesel, 3.6(b) = Electricity) estimated by the model (= result) versus actual performance (= provided by the terminal)

	Terminal	Model Estimates			Real consumption			difference %
		l/year	l/TEU	l/cont	l/year	l/TEU	l/cont	
Diesel	ECT Delta	15,005,338	3.52	5.81	17,654,322	4.14	6.83	-15.0
	ECT Home	4,577,564	4.40	7.27	4,190,952	4.03	6.65	9.2
	ECT Hanno	324,718	5.62	9.28	684,000	11.84	19.54	-52.5
	APM	11,827,265	5.38	8.87	Unknown			
	RST	2,285,928	2.29	3.78	1,900,000	1.65	2.72	20.3
	UNIPORT	1,366,188	3.87	5.73	1,100,000	2.91	4.32	24.2
	BCT	90,222	0.38	0.58	99,788	0.42	0.64	-9.6
	CTN	69,099	0.41	0.69	61,429	0.36	0.61	12.5
	WIT	140,731	0.76	1.35	154,390	0.83	1.48	-8.8

	Terminal	Model Estimates			Real consumption			difference %
		kWh/year	kWh/T EU	kWh/con t	kWh/year	kWh/TE U	kWh/con t	
Electricity	ECT Delta	45,503,821	10.67	17.61	47,142,857	11.06	18.25	-3.5
	ECT Home	4,691,736	4.51	7.45	7,500,000	7.22	11.90	-37.4
	ECT Hanno	640,544	11.09	18.30	1,250,000	21.65	35.71	-48.8
	APM	10,489,636	4.77	7.87	Unknown			
	RST	9,498,600	8.24	13.59	11,000,000	9.54	15.74	-13.6
	UNIPORT	6,313,260	16.70	24.78	6,960,000	18.41	27.31	-9.3
	BCT	480,401	2.03	3.10	505,976	2.13	3.25	-4.7
	CTN	301,276	1.78	2.99	315,501	1.87	3.13	-4.5
	WIT	232,628	1.26	2.23	219,788	1.19	2.11	5.8

From the Tables 3.6(a) and 3.6(b) we can observe that the model outcomes for the ECT Hanno differ significantly (-52.5% and 48.8%). The explanation for this difference can be found by the fact that this terminal is used as an educational terminal for cranes-drivers. This means that for this terminal, the energy consumption of the cranes does not represent the number of container moves, since the exercise-movements are not recorded.

By multiplying the consumption data with the emission factor for diesel and electricity, the total CO₂ production of a terminal will be known (see Table 3.7). For the selected terminals the total CO₂ production is around 157 kton. To have some reference this share of CO₂ production represents around 2% of the whole CO₂ production freight transport caused by the transport modes road, rail and barge in the Netherlands (the calculations are based on the total tkm per transport mode (Noreland, 2008) and the average emission in grams per kilometre transport mode (EEA, 2009)). With respect to the sea container terminals one can see clearly that the RST terminal produces a significant lower level of CO₂, both in diesel and electricity consumption per TEU. This can be explained while the terminal is relative new and it has a very compact design. The influence of the spatial design (the lay-out) can be clearly observed from the small inland barge terminals. The contribution of the driven kilometres by the fork

trucks/ reach stackers (type Hyster H18), combined with inter terminals transport, are extremely less compared to the travelled distances at the large seaport-terminals.

Table 3.7: Yearly CO₂ production per terminal

Terminal	CO ₂ kton/year (actual)	CO ₂ kton/year (model)	CO ₂ kg/TEU based on diesel	CO ₂ kg/TEU based on electricity
ECT Delta	71.3	63.4	9.33	14.88
ECT Home	15	14.6	11.67	14.02
ECT Hanno	24.6	11.9	14.90	20.67
APM		35.9	14.03	16.34
RST	10.9	10.7	5.25	9.54
UNIPORT	6.9	6.5	9.58	18.26
BCT	0.53	0.52	1.1	1.1
CTN	0.33	0.32	1.0	1.0
WIT	0.46	0.52	2.2	0.7

To validate the model, some statistical testing has been carried out to check the correlations between our inputs, the moves of the terminal equipment and the variables to be explained: the diesel consumption and the electricity consumption. Due to the limited number of observations (n=9) no hard conclusions can be drawn; however they can indicate whether the modelling formulations are based on correct assumptions. With the statistical testing, the discussion that the model might predict well is no longer valid and it proves that our approach is based on a set of well selected and highly significant indicators.

Table 3.8: Correlation testing Electricity and Diesel

	Usage terminal	QC moves	BC moves	RC moves	ASC moves	RSC moves	P moves
Sig. (1-tailed)	0.0000	0.000	0.060	0.000	0.000	0.494	0.459
	Usage terminal	AGVkm s	SCkms	TTkms	MTSkms	RSkms	
Pearson Correlation	1.0000	0.973	0.628	0.100	0.964	0.078	
Sig. (1-tailed)	0.0000	0.000	0.048	0.407	0.000	0.428	
N	9	9	9	9	9	9	9

Table 3.8 contains the correlations between the dependent variable usage terminal. As can be observed QCmoves, BCmoves, RCmoves en ASCmoves have a strong correlation with the dependent variable: Usage Electricity, showing a significance at a 5 percent significance-level. The variables RSCmoves en Pmoves show very little correlation and both show no significance. The variables AGVmoves, AGVkms, SCmoves, SCkms en RSkms have also strong correlation with the dependent variable diesel usage. They all show a significant correlation. However the variables TTKms en RSkms have little correlation and show no

significant results. With respect to insignificant variables it seems very logical since their contributions are relative small (varies from 0.05 - 0.1) with respect to the large container volumes handled by other equipment. Regressions analysis has been applied on the data, however the statistical analysis gave similar insights with respect to the Spearman-correlation-tests.

3.5 Conclusions

The developed bottom-up method provides new opportunities for a relatively simple assessment of the CO₂-emissions per terminal, based on macro terminal data and can be adopted reasonably well and simple for different terminal configurations. To our opinion this is a first and promising step, however the reliability of the model should be verified by further research on a larger sample of terminals. In practice, the number of deep-sea terminal operators is limited as we observe that this research covered already 95 percent of all the deep sea terminals in the Port of Rotterdam. Therefore it is important to note that the first estimates with the developed method provides reliable predictions for the total CO₂-production at terminals and the differences to the real consumption energy consumption data are within an acceptable range.

With respect to the mitigation of CO₂-emissions, the analysis of the emission model shows that, compared with the electrically powered equipment, the diesel-powered terminal equipment represents a large fraction of the total harbour wide CO₂-emissions by transshipment processes. From a policy perspective it seems to be an interesting policy option to stimulate the usage of biodiesels by mixing 30 per cent bio-fuels with the presently used diesel. Application of our model shows a potential reduction of CO₂-emissions by between 13 and 26 per cent per terminal and a reduction of the emissions of the whole container transshipment sector by 21 per cent.

Furthermore, it is noticeable that the Rotterdam Shortsea Terminal and the inland barge terminals emit considerably less CO₂-emissions per container handling. The main difference with the other terminals is the procedure; these terminals work on a principle whereby the stacks (locations where containers are stored temporarily) are positioned directly at the quayside. This method of unloading ensures that there is much less (extra) horizontal transport needed at the terminal, which ultimately, is more efficient. However one can imagine that the design of these terminals is only possible with less container volumes and steady arrival patterns of the vessels. Therefore it is recommended that the layout of the terminal site and the energy consumption of equipment should be considered, when it comes to the design of new terminals.

In practice most terminals have shown a strong interest in this method since they are forced to provide insight in their CO₂-production by the local governments. For these companies application of the method had sufficient precision in estimating the overall CO₂-production at their terminals.

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4 Towards governance on noise between municipality and terminal operator by the use of simulation modelling

‘We live in a time of complete resources and confused objectives’

Albert Einstein

This chapter is based on:

Duin, J.H.R. van, Heijden, R.E.C.M. van der (2012). A new barge terminal in a residential area; using simulation modeling to support governance of noise. *Journal of Computational Science*, 3(4), 216–227.

Abstract

The development of multimodal transport terminals in urban areas generates various serious environmental problems. The available tools for the analyses of the use of such terminals offer insufficient support for decision-making on the location and design of these terminals from the sustainability perspective. New approaches are needed. This article contributes to satisfy this need, triggered by the planning of a new Barge Terminal in the Dutch city of Tilburg (BTT). Presently, the existing terminal in Tilburg is operating near full capacity and the construction of a new terminal is considered the best strategy to cope with steady growth. The main question concerns the optimal design of the new barge terminal to offer a high operational performance, however without exceeding the environmental quality standards, in particular noise. The article presents a simulation approach to assist in the process of finding a balance between the operational performance and the noise effects of alternative designs of the new terminal.

Keywords: Barge terminal, simulation, noise, environmental planning, urban planning

4.1 Container barge transport in urban sceneries

Today's tendency to develop an urban policy in favour of sustainable development also affects the urban freight transport system. Urban freight transport tends to follow its own economic rationality and often does not seem sensitive to policy interventions. Examples of this urban economic rationality are found in Holguín-Veras (2008) and Quak (2008) where the limited effect of a policy measure pricing scheme is demonstrated by imperfections in the freight transport market due to contractual limitations and poor interaction between different actors. A key problem to implementing a feasible strategy for sustainability is determining the parameters of impact measurement (e.g. geographical scale, environmental and social impacts, etc.), and inertia for impact assessment. Banister (2008) notes that consistency between policy measures and integrated policy-making across different sectors is a key element in making sustainable mobility publicly acceptable. Diverging interests, multiple actors and different institutions create an inertia which makes it extremely difficult to achieve a workable, acceptable set of targets, actions and measures which will result in more sustainable cities.

More and more cities explicitly address the contribution of barge terminals to a sustainable urban development. The embedding of terminals into urban sceneries is not just a matter of technical and physical specifications of its elements, like the crane capacities, the location of the harbour and the connections to the main roads. Policy makers necessarily have to take into account the whole urban context. Before taking such policy decisions, public policy makers need to know the potential consequences of the accommodated operational logistical processes on the environmental quality. At the same time, the logistical operators need to know the consequences of policy measures on the costs and efficiency of their operations.

In exploring the consequences of logistical processes for the environment, problems do not present themselves to the 'problem solvers' in a clear and obvious setting. They must be constructed from incomplete information on problematic situations which are puzzling, troubling, and uncertain ((Eden et al.,1983), pp. 39-40). As Kohn et al. (1990) argue, many unique factors play a role in this context. They stress that it is critical for logistics managers to in-depth understand the strategic issues facing their firms and their companies' strategic responses to those issues. Therefore, we need to 'think around' a problem; we redefine it a few times, we mentally simulate some of the possible outcomes from possible courses of action, we try to make sense of the situation (Eden et al., 1983).

In this context it has been frequently argued (Tekinay et al., 2010) that dedicated models quantifying logistical as well as environmental effects provide more insight for every specific actor involved. This might lead to adjustments of the actors' perceptions, since the outcomes of the dedicated models can objectify or reduce uncertainty with respect to the outcomes as perceived by the actors. On the other hand, the outcomes of the dedicated models might also lead to adjustments of the logistics concept which then will correspond more closely to the desired outcomes of the actors. Methodologies used to develop such integrative assessment models include interviews and meetings of stakeholders, field research and empirical measurements, operational flow design and modelling and the analysis of outcomes.

As an illustration of this way of working in this article we report on a case study on the design and location of a new terminal. The Barge Terminal Tilburg (BTT), located in the city of Tilburg since 1998, is one of the most successful inland intermodal transport container

terminals in the Netherlands. Currently, this container terminal is operating near full capacity with an annual throughput volume of 85,000 TEU. With an annual growth rate of 5% on average in waterway transport the existing terminal will be short of handling capacity in the near future. Since terminal expansion is not possible at the current location, plans for constructing a new terminal are being prepared.

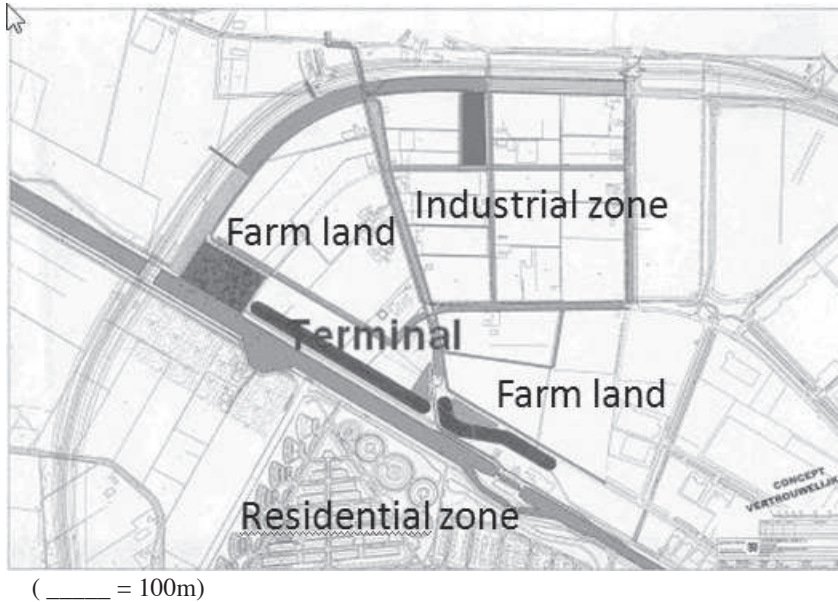


Figure 4.1: Potential location of the new barge terminal (Municipality of Tilburg, 2005)

Figure 4.1 shows the potential location of the new terminal located at the banks of the canal Wilhelminakanaal. The municipality has offered a new location which is the only candidate site, a situation that often occurs in densely built urban environments where space of a certain quality and size is scarce. The site borders to an ecological zone (Farm land); the protective status of this zone has been strengthened in recent years. Southwards, at the other side of the canal, a residential zone is located. Since the distance from the residential zone to the terminal is relatively small, most of the residents will be affected by the noise from the terminal if no noise protection measures are taken. Studies based on cross-sectional data analysis on (road traffic) noise have for example shown that exposure to noise increases the risk of myocardial infarction and total ischemic heart disease (Van Kempen et al., 2002). Dedicated analyses show that operations at this location will not violate external safety standards.

The municipality believes that the design of a new, large terminal can solve the capacity problems in the future. However, the municipality is also concerned about the living environment around the terminal. In particular an increased noise level in the neighbourhood is not acceptable. In policy practice of terminals the consequence of noise are seldom foreseen, although at the start of a terminal project an environmental impact assessment is executed to visualize the environmental consequences (including noise). Operating terminals nevertheless appear to be confronted with noise constraints after a while, notably when they start growing in their volumes. Recent examples of these practices are found in the

Netherlands at the inland terminal Alpherium (Stad, 2011) and the inland terminal of Wanssum (Peel en Maas, 2011). In case of the terminal Alpherium, terminal manager asked the municipality for permission to operate night shifts since many ships arrive after 11.00 pm. People living in adjacent neighbourhoods forced the municipality not to give this permit. Also the authorities at the Provincial level concluded, after having received the outcomes of the real noise measurements, that the noise-constraints are permanently and significantly exceeded. The Province threatened to raise high penalties in case the terminal continues with the current noise production at night.

These examples illustrate an issue in practice that needs a well elaborated governance approach. The aim of this article is to illustrate an analytical approach to support local decision making by systematically increasing awareness of the consequences of optional policy measures (in this case the noise constraints) on the logistical operations of the new terminal. The analytical approach significantly contributes to the required governance approach. The main research question underlying this study was *“How to find a balance between the operational issues and the noise effects of alternative designs of the new terminal and how to evaluate the performance of these alternatives?”*

This article follows the modelling paradigm of Sargent (2010, p. 170) which shows the processes of developing system theories and simulation models, and relates verification and validation to both of these processes. First Section 4.2 explores the literature on intermodal transportation followed by the description of the first process step of the paradigm concerning the definition of the conceptual model. Section 4.3 presents the second step of the paradigm, the specification and validation of the simulation model. Section 4.4 elaborates on the issues of noise, resulting in the specification of potential noise reduction measures. Section 4.5 describes the last step of the paradigm showing the results of the experiments with noise reductions and growth scenarios. Section 4.6 ends with some conclusions and reflects on the role of the simulation model in the policy making process.

4.2 Towards a conceptual model of a barge terminal

This section gives a short literature review on intermodal transport and develops a conceptual model of the terminal operations.

4.2.1 Literature review on intermodal (barge) transport

The dominant focus in intermodal research is on the socio-economic impacts of the shift from truck transport to intermodal transport (e.g. (Clarke et al., 1996; Fonger, 1993; Engel, 1996; Jensen, 1990; Kim & Van Wee, 2011)). From these studies we learn that intermodal transport research requires a multi-disciplinary approach. The review also shows that the structure and complexity of intermodal problems demand further development of operations research techniques. Especially, models which can better deal with the complexity of intermodal problems are required. The complexity for research is shaped by the application of logistics, economic, management and policy theory and methods in relation to the operational parts of the intermodal chain (Bontekoning, 2005; Platz, 2009).

From a policy making perspective, policy makers search for effective measures for improving the structure and/or the use of infrastructure networks. They like to know the effects of certain measures before taking the decisions. For instance road pricing measures can have positive

effects on the usage of intermodal transport services. For this type of problems, spatial price equilibrium models and network models have been developed in the past. These types of models, however, have been developed for one mode only and cannot deal with intermodal flows. Crainic et al. (1990), Loureiro (1994), D'Este (1995), van Duin & van Wee (2007), Jourquin et al. (1999), Southworth & Peterson (2000) and Groothedde (2005) have developed network models that are capable of dealing with intermodal flows, which implies that in these models freight can be transferred from one mode to another via transfer nodes.

Most intermodal modelling deals with the complementary nature and the competitiveness of the various modes of transportation (Beuthe et al., 2001), the choice of modes or routes (McGinnis, 1989; Lozano & Storchi, 2001), economic returns versus congestion (Van Schijndel & Dinwoodie, 2000), the logistical aspects of multimodal terminals (Bostel & Dejax, 1998; Kozan & Preston, 1999, Kozan, 2000), or the environmental impacts of the different transport modes (Campisi & Gastaldi, 1996).

Location characteristics of freight handling facilities have a significant impact on the competitiveness of intermodal transport. They appear to have a stronger weight than criteria such as pricing systems, distances travelled, volume of flows, transshipment costs, queuing time, et cetera. However, apart from market area theory (see e.g. (Niérat, 1997)) and some multi-criteria approaches (see e.g. (Ashayeri & Rongen, 1997; Macharis & Verbeke, 1999)), most approaches do not explicitly address the location characteristics in site selection for terminals. Consequently, wrong location choices are sometimes made.

A lot of literature is available on decision making at the container terminals. As Murty et al. (2005) stated in their work, all the decisions to be made at terminals are related to the berth allocation of vessels. Given the multi-dimensional nature, the complexity of operations, and the size of the entire operations management problem, it is very difficult to make an optimal decision to achieve the overall objectives. In general, two types of approaches can be distinguished: analytical and simulation. Applying the analytical approach, mostly the problem needs to be simplified to be able to formulate a mathematical model. Often the hierarchical approach is used to break the problem into sub-problems and solve each as an optimization problem (see for example (Taleb-Ibrahimi et al., 1993; Castilho & Daganzo, 1993; Roux, 1996; Kim & Bae, 1998)). To cope with the complexity of the terminal operations, (micro-) simulation models are used to evaluate the performances (see, for instance (Liu et al., 2002; Saanen, 2004; Rijsenbrij & Saanen, 2007)). The micro- simulation models break down to the smallest sensible connected components (Roadknight et al., 2011) and can be applied to any scenario involving complex vehicle interactions. They have been used to modal roads, rail, air and sea ports (see for instance (Dobson, 2007; Campbell et al., 2007; Smith et al., 2008)).

The literature survey has shown a wide variety of modelling approaches (socio-economic, transport modes, networks, locations and terminals) in the intermodal transport chain. It has provided us with several modelling suggestions for improving the efficiency, profitability and level of competitiveness of intermodal transport. Simulation modelling seems to provide good insight in the performances of the terminal operations. However, the integration with more policy related issues like environmental impacts has not been established yet, except the CO₂-emission calculations of terminal designs (van Duin & Geerlings, 2011). Integrated transport policy is closely linked to the idea of sustainable mobility, where sustainability tends to be defined along three dimensions: the economic, environmental and social (or equity)

dimensions. In the remainder of this article we propose a simulation modelling approach to integrate both operational parts of the terminal (economic dimension) and the related noise effects (environmental dimension) on its surrounding (social dimension).

4.2.2 Conceptualization of the barge terminal

The spatial zone to be modelled is the zone of the terminal operations within its urban environment, including the quay wall, the storage zone and the parking place of the trucks. Two interfaces are assumed between the model and the external system area: the entrance (gates) of trucks and the quay wall for the vessels.

The processes

The terminal is controlled by the daily *Schedule of the terminal*, which is the order of the daily activities that will be followed by the operations of the terminal (see Figure 4.2). The main inputs and outputs are the vessels and the trucks: vessels arrive with the (import) containers that need further transport by truck. In the opposite direction vessels leave the terminal with (export) containers transported by truck to the terminal. The resources at the terminal are the reach stackers and cranes. The quay cranes are responsible for loading and unloading the containers on the vessel. The containers will be temporarily stacked at the buffering area straight behind the cranes. The reach stackers will do the processes: loading and unloading the containers in the stacks (Export and Import); loading and unloading the containers on the trucks. The outputs of the terminal are the number of served vessels and the number of served trucks.

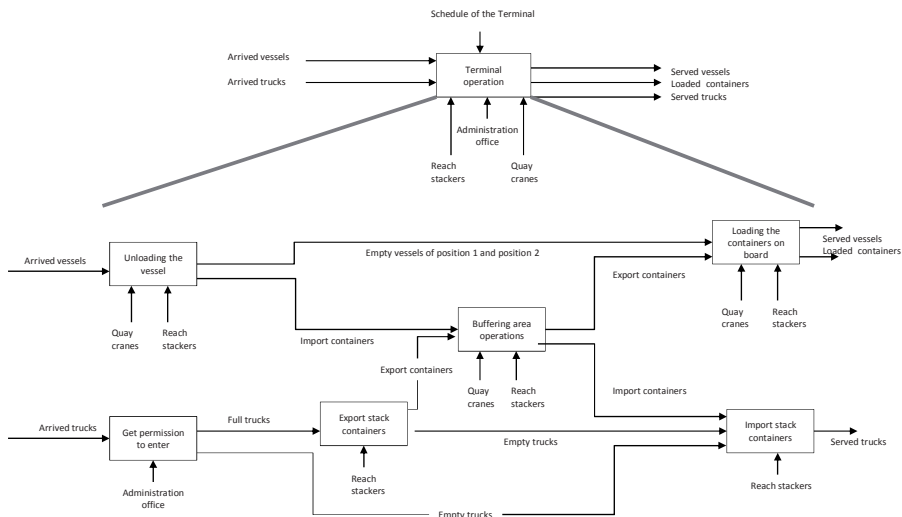


Figure 4.2: IDEF0 diagram of the operations at the container terminal

To structure and specify the terminal processes the Structured Analysis and Design Technique (SADT) is used. The processes of vessels, containers and trucks can be well represented (*see Figure 4.2*). According to Marca & McGowan (1988) ‘SADT is one of the best-known and most widely used system engineering methods’. SADT is a graphic notation and an approach to system descriptions that has been applied in many different fields such as aerospace engineering, military weapons control and logistics management (under the name IDEF0, Integrated DEFinition). IDEF0 includes both a definition of a graphical modelling language (syntax and semantics) and a description of a comprehensive methodology for developing models. The benefit of using IDEF0 approach is a formal description method of the (logistics) processes in terms of input and output schemes, which allows easy communication with (non)-simulation experts (terminal operators and the policy makers) on the one hand and on the other hand can be easily transferred to simulation blocks by simulation experts.

Principles for modelling

The model of the terminal is based on discrete event modelling, since the operations at a terminal can be represented as a chronological sequence of (sometimes parallel) events. The daily activities of terminal operations can be interpreted as a discrete queuing system. Two main queue systems can be observed in the case of terminal operations:

- The vessel queuing system: the arrived vessels are served by the cranes or the reach stackers one after another.
- The trucks queuing system: the arrived trucks with containers will be unloaded by reach stackers one after another and the free trucks will be loaded by the reach stackers one after another.

There are several reasons for selecting simulation modelling. The most important ones are (Verbraeck et al., 2004):

- The mathematical part of the problem can be treated as a stochastic queuing system;
- The problem is complex in such a way that the outcomes are not simple and one-sided;
- The new terminal we want to study does not exist yet and it is too expensive, and too time-consuming to experiment with a ‘real world’ model;
- Not all information required to describe the problem situations is available;
- There is no simple, analytical solution to the mathematical models of the system.

To model the discrete event system, in particular the dynamic interactions between the terminal operations, stochastic simulation is chosen as the modelling technique. Stochastic simulation can improve the confidence of the modelling outcomes by replicative experiments.

4.3 Simulation model of the terminal

This section describes the simulation model, the empirical measurement of the terminal operations, and the validation of the model.

4.3.1 Description of the simulation model

The model logic is implemented in Arena (10.0). A general layout of a container terminal can be divided into working areas: the berth(s), the quay and buffering area, the import and export

stacks, the gates and parking area for the trucks (see Figures 4.3A, 4.3B, 4.3C, 4.3D & 4.3E). Each working area has a unique functionality and all areas are connected to each other.

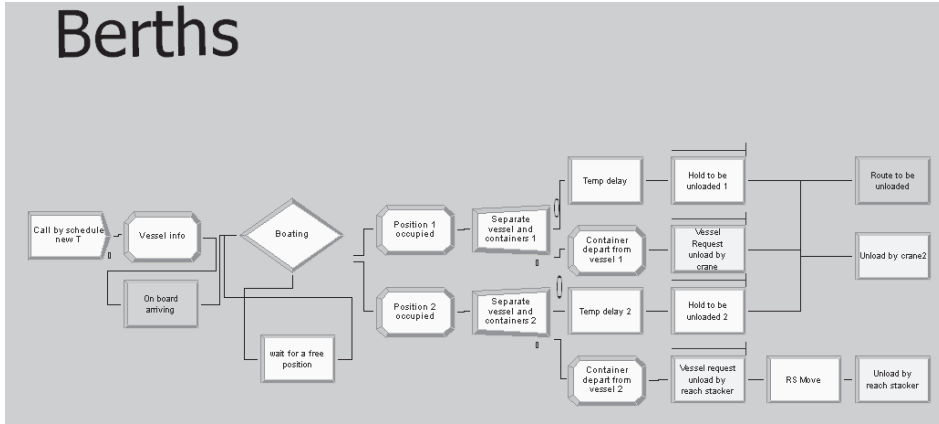


Figure 4.3A: Berth operations (part of the Arena model)

Berths (main activities: serve the arrived vessels by loading and unloading containers on the vessel)

The berths are responsible for the loading and unloading of the containers on the vessel. They are connected through the canal to the main seaports. The quay wall can serve at maximum two vessels at the same time. A vessel that calls at the position 1 will be served by the quay crane, and the vessel at the position 2 will be operated by a special reach stacker, which can unload the containers from the vessel. If both positions are occupied, the new arriving vessel will wait for the first freed position. When it comes to the anchor the crane or the reach stackers will be requested to serve the vessel. The vessels will be served with the highest priority at the terminal. The containers on the vessel will be unloaded to the *buffering area* at first. Once all containers have left from board, the export containers will be taken from the buffering area and put on the vessel. If the number of containers on the vessel reaches the volume of the vessel or the vessel stays too long at the quay, it will leave the quay and the current position will be freed.

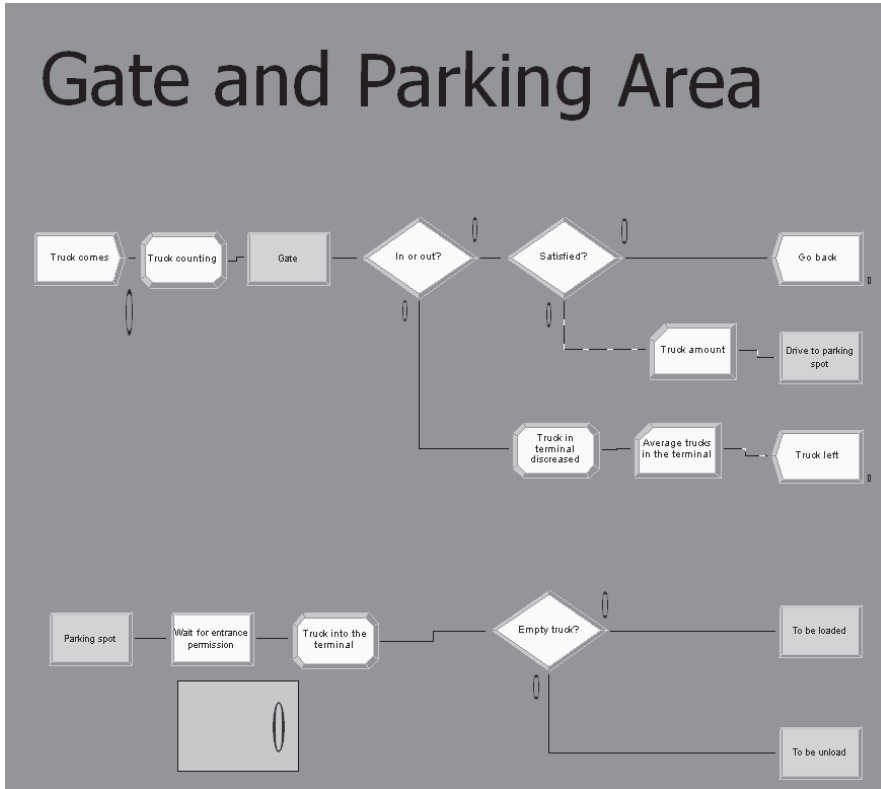


Figure 4.3B: Gates and Parking Area operations (part of the Arena model)

Gates and Parking area (main activities: give permissions to the arrived trucks and measure the weight of the containers)

The gates and parking area have the connections to the inland transportation modes. In this case, trucks are the only vehicles that transport the containers to or from the terminal. An assumption is made that all the trucks have a capacity of two TEU to load at a same time; however they can differ with respect to the number of containers on the truck. Once a truck arrives at the gate, it will be checked, since a certain percentage of trucks will be denied due to problems with accompanied documents. The accepted trucks with containers will go to the parking area and wait until they can enter the export area. The empty trucks will move to the import storage area to pickup import containers for further transport.

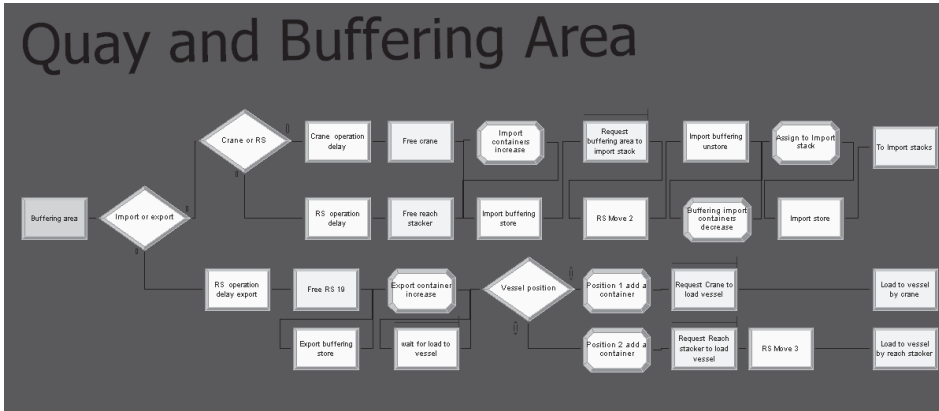


Figure 4.3C: Quay and buffering area operations (part of the Arena model)

Quay and buffering area (main activities: temporary storing of import containers that will be sent to the import storage area; temporary storing of export containers that will be put on board)

The quay and buffering area is a small storage area, which temporally stacks the containers that will be sent to the import storage area or to be boarded on the vessels at the quay. When a container is moved to the buffering area, it will immediately give a request to the crane or the reach stackers. The request will be fulfilled if there is a vessel available with fewer containers than the maximum vessel capacity and if the related crane or reach stacker is free. Since the import containers will be first removed from the vessel, the priority of the request to send a container on board has medium priority. Requests to send the containers from the buffering area to the import storage area have low priority.

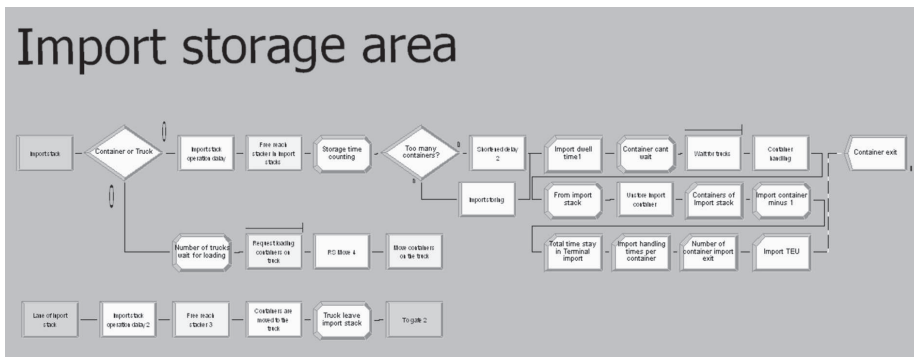


Figure 4.3D: Import storage area operations (part of the Arena model)

Import Storage Area (*main activities: storing import containers for a period; loading the trucks at the storage*)

When a container is moved to the import storage area, there are two choices: to be transported immediately or to be stored for a certain period. If it needs to be transported immediately, it will give a request to be put on a truck, otherwise it will be put into one of the stacks that it belongs to. A few days later (which depends on the real data of the terminal), it will again request a reach stacker. If a truck arrives at the import storage area, and one of the reach stackers is free, the container will be loaded to the truck, send to the gate and exits. Once the number of containers in the terminal is near the capacity of the storage, the terminal will encourage the transportation of import containers to the region as soon as possible (any empty truck available needs to carry a container away).

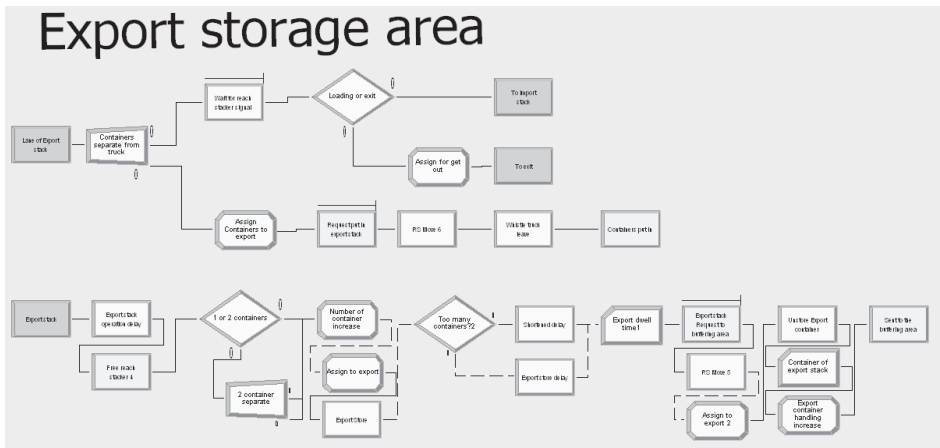


Figure 4.3E: Export storage area operations (part of the Arena model)

Export Storage Area (*main activities: storing export containers for a period and unloading trucks at the storage area*)

Once a truck arrives at the export storage area, it will make a request to the reach stackers. Any available reach stackers will unload the containers from the truck and the containers will be left in the stacks. The storing period will be the same as the containers in the import storage area. The stacks are divided into two parts for the containers with two different destinations. After the storing period has past, the container will make a request to be sent to the buffering area.

The animation screen of the developed model is shown in Figure 4.4. The flow of import containers is illustrated by symbol (A) and the flow of export containers is illustrated by symbol (B). Each process is modelled and verified separately.

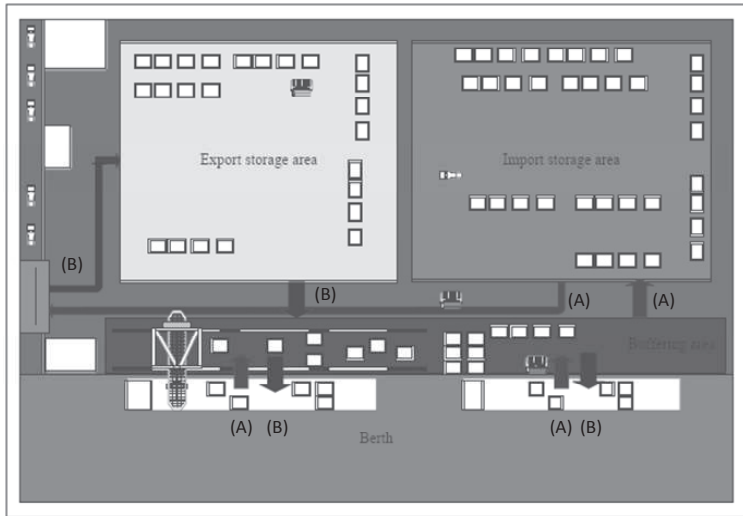


Figure 4.4: Container flows of the terminal (screen dump of the simulation model)

Historical data are important for building and validating the simulation model. Most information was provided by the terminal operator BTT (Barge Terminal Tilburg) and these data represent a base reference for the year 2005 (see Table 4.1).

Table 4.1: Terminal characteristics (Municipality of Tilburg, 2005)

Terminal Parameters	Values
Throughput volume of existing terminal	85,000 TEU/year
Expected growth of throughput volume	15% per year
Maximum growth for at least	2 more years
TEU factor (ratio between 40ft and 20ft)	90% of 40ft , 10% of 20ft
Maximum stack size	10,000 TEU per acre
Storing period of a container	Mostly between 1 and 5 days
Vessel owned by BTT	3 Neokemp new type push barges 2 Kempenaars
Call intensity and capacity	20-22 on schedule calls per week; A few vessels are out of schedule; 90% of the vessels are full
Vessel working information	4 trips/week/vessel 9 h/trip for existing terminal 7 h/trip for new terminal
Truck information	Capacity of 2 TEU 1 - 1.5 hours to make a trip

To complete the input information of the model, some additional data needed to be collected by measurements during a working day at the terminal. This concerns mainly data on container handling times and transport times for moves. These reference data were collected on June 3, 2005, which was considered as a representative day at the existing terminal. All

data have been transferred into distributions by application of the Chi-square test. Table 4.2 summarizes the measured process activities.

Table 4.2: Terminal activities fitted by distributions

Name	Number of samples	Sample mean (s)	Square Error(Fit)	Best fit	Expression
(Un)loading Crane activities	32	73.07	0.11	Beta	66.5 + 91 *
Average handling time RS for all kinds of operations	95	75	0.013	Weibull	BETA(1.04,0.722) 26 + WEIB(53.7, 1.63)
Handling time for (un)loading a container on a truck	62	79.0	0.005	Weibull	40 + WEIB(41.4,1.22)
Handling time for (un)loading a container on a vessel	28	93.5	0.49	Weibull	54.5+WEIB(20.7,1.64)
Handling time move a container form one stack to another	26	58.12	0.008	Triangular	TRIA(26,48.2,100)
Movement time with a container	28	38.15	0.018	Normal	N(38.1,18.5)
Movement without a container	96	103.2	0.005	Exponential	3+EXP(38.2)
Truck arrival interval	40	210.54	0.033	Exponential	EXP(162)
Number of containers on a truck	40	1.05	0.39	Discrete	Discrete(0.05,0,0.85,1,1,0,2)

4.3.2 Validation

According to Shannon (1998, p.11) validation is the process of reaching an acceptable level of confidence that the assumptions drawn are correct and applicable to the real-world system being modelled. Several questions must be answered by the validation process:

- Does the model form an adequate representation of the real situation?
- Does the model behave like the normal logistics processes?
- Are the results derived by the model close enough to reality to create confidence of using it for future decisions?
- How long should the start-up time be defined and how long should one simulate?
- How many replications are needed to obtain sufficient reductions in variances to support reliable predictions with the model?

Sargent (2005) presents several validation techniques. These techniques are partly combined and applied for the validation of the terminal model. The outcomes of the different tests are

presented here, ordered per validation technique. Data from the BTT terminal (*see Table 4.3*) are used to validate the simulation model.

The first step of the validation process concerns checking the face validity. In our study, similar to the verification process, experts were asked to judge the validity of the model. They were invited to use the model and assess its output. The terminal managers were invited to look at the model output to check whether the results of the model were within acceptable ranges compared to the real world figures. They concluded that the model output seems to be valid (*see Table 4.3*).

A next step in the validation process concerns the predictive validity. Checking for this type of validity implies that the forecasted model output (behaviour) is compared to the numbers observed in real world.

For the check on the predictive validity of the terminal model four categories of data can be compared to historical data: container throughput, average stock size import and export containers, average dwell times of import/export containers and number of vessels arrived at the terminal. The values used and calculated in the model were compared to the observed values, extracted from the existing terminal in Tilburg. Although the activities of the terminal were traced and recorded by the BTT, as mentioned earlier, not all the information of the terminal could be found in BTT's database. Additional data were collected by measurements during a working day in June 2005 at the terminal (*see Table 4.3*: right column Measured practical output). The day is a representative day since large companies like Sony, Fuji, Hanjin and Dell Computers, the main users of the terminal, have a very stable production demand. Table 4.3 shows that the simulation results fit well to the observed performance. The conclusion therefore drawn from this predictive validity analysis is that the terminal model can indeed be considered valid and that it has sufficient predictive power. The management of the terminal found the simulation output valid and we had no serious indications that more testing than face-validity was needed.

Table 4.3: Validation on Terminal performances (Municipality of Tilburg, 2005)

Performance indicators	Simulation output	Measured practical output
Annual throughput	84,000 TEU	85,000 TEU
Number of vessel calls per year	1544	Around 1.5 thousand
Number of trucks into the terminal per year	22,000	Not measured in practice
Quay crane utilization	0.28	Not measured in practice
Average utilization reach stackers	0.51	Not measured in practice
Average amount of stored import containers	186	Around 200
Average amount of stored export containers	200	Around 200
Average dwell time of import containers	3.00 days	3 days
Average dwell time of export containers	3.14 days	3 days

Based on the validity analyses, one can accept the model of the terminal for simulating the future performance to generate values for the performance indicators that are relevant for

decision making on the future of the terminal. To perform such simulation, two important choices have to be made: the start-up time and the number of replications.

Start-up time

In a non-finite system, a start-up time is involved. When the model begins simulating the terminal operations, there are no containers in the model. The number of containers will stabilize after some vessels and trucks have entered the model. Table 4.2 shows the number of containers in the import container stack and export container stack. Figure 4.5 shows that after five days the fluctuations reduce and both curves get more stable. A five-day warm up time appears to be a suitable start-up time for the model. The run length of the model will be a year. Since the terminal will not be operational at Sundays, a year will only have 313 working days. A working day starts at 05:00 and ends at 23:00.

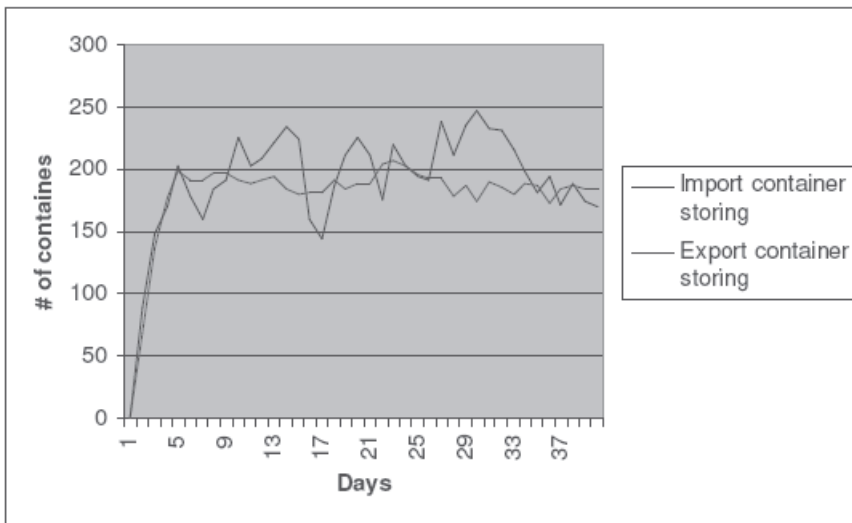


Figure 4.5: Start-up time after 5 days

Set-up of replications

Simulation literature (Pegden et al., 1995) suggests that the required number of replications can be calculated by determining the required confidence interval on the mean of the performance indicators. This method assumes that the estimation of the mean of the model results based on the replications are normally distributed. As an example, in our study the *number of exported containers* constitutes the output to test the necessary number of replications. Seven replications were used for the initial replication number. The data indicates almost certainly (95%) that the number of exported containers is between 1,055,039 and 1,070,103. The variance (8,130) seems quite small compared to the average value (1,062,571) and based on a chosen half-width confidence interval of 1 percentage the number of replications will become 4.

4.4 Environmental noise constraints

Since the terminal is located adjacent to the residential area, regulation on noise emissions will restrict the operations of the terminal. When the noise level cannot be controlled within the (according to law) acceptable range, the construction of the terminal will likely be postponed or do not get permit to build the terminal. Over the last years, the Law Noise Hindrance (in Dutch: 'Wet Geluidhinder') restricted the regulations.

The acceptable noise level at a newly built house is 5 dB lower than according to the former regulation (DHV, 1999). Noise experiences and data are derived from a meeting with the management of BTT and noise experts of the municipality Tilburg.

According to these noise experts, the noise problem is evaluated in terms of two indicators: the equivalent noise level, which is marked as L_{Aeq} and the maximum noise level, which is marked as L_{max} . The L_{Aeq} is the average value in decibels of the noise level produced in 24 hours. The average equivalent noise level L_{Aeq} relates to the working intensity of the terminal. The more activities in the terminal during a day, the higher equivalent noise level it creates. The L_{max} stands for the highest noise value produced. The maximum allowed level of noise in the old residential area is settled in the general law, which is currently fixed and unchangeable (see Table 4.4):

Table 4.4: Limits of noise in residential area (Van Spaandonk, 2005).

Time period	Acceptable L_{Aeq}	Acceptable L_{max}
07:00-19:00	50 dB	70 dB
19:00-23:00	45 dB	65 dB
23:00-07:00	40 dB	60 dB

L_{max} relates to the noisiest activities in the terminal. The maximum allowed noise level remains the same for days with intensive terminal use as well as days with less intensive terminal use. No difference is made. According to the data collected by the municipality, trucks have a maximum sound level of 109 dB(A) at the body, for a reach stacker 111 dB(A) and for a reach stacker picking up a container it is 121 dB(A). A crane to put down a container will produce at maximum 60 dB(A) (DHV, 1999).

For the noise calculations of the trucks we need to consider the location of the entrance and exit gates. The gates will be located at the North-side of the terminal and will have a minimal distance of 200 meters to the residential area, located at the South of the terminal (at the other side of the river, *see Figure 4.1*). For the terminal operations of the cranes and reach stackers the distance from the residential zone to the operating zone of the terminal gates is 100 meters. The noise L_2 at distance r_2 from the resource can be calculated by the following formula:

$$L_2 = L_1 - 20 \text{ }^{10}\text{LOG} (r_2/r_1)$$

(assuming that $L_1 = L_{max}$ measured at 1 meter ($= r_1$) from the source),

The noise production of various activities in relation to distance becomes:

Entering/leaving trucks (with $L_{max} = 109$ dB(A)) at distance 200 m = 63 dB(A)

Driving reach stacker (with $L_{\max} = 111$ dB(A)) at distance 100 m	= 71 dB(A)
Lifting reach stacker (with $L_{\max} = 121$ dB(A)) at distance 100 m	= 81 dB(A)
Lifting crane (with $L_{\max} = 60$ dB(A)) at distance 100 m	= 20 dB(A)

These figures indicate that the cranes will never exceed the noise limits. During night time the trucks can exceed the noise limits, however at daytime the trucks are never problematic with respect to their noise production. The noisiest operating sources at the terminal are the reach stackers. Given these calculations the terminal operator has various options to control the noise level within the range of acceptable sound levels. Basically the following three measures have the largest potential:

- **Limit the number of operational reach stackers in the terminal**

As it is known that a reach stacker is the noisiest machine in the terminal, the daily work should be performed with a minimum of reach stackers. The possibilities in this respect depend upon the container flows to be handled.

- **Adjust the working time of the terminal**

Normally, to synchronize the operations of the terminal with the operating schedule of the seaport terminal, operation during night time would be preferred. However, control of the noise level might not allow for this due to the location of the residential zone. Besides the noise emissions, the level of light is a constraint. Since the terminal is located near a couple of farms, the light of the terminal might affect the biological clock of the animals on the farm. A major choice would therefore be not to perform terminal operations during night time (23.00 –05.00). In addition, one might consider limited operations in the early morning hours (05.00–07.00) and/or in the late evening (e.g. 22.00 -23.00), e.g. in terms of no use of vehicles at the area. In that situation, only the cranes can operate (load or unload vessels) ($L_{\max} < 40$ dB(A)). Also the choice for limited operations depends upon the container flows to be handled.

- **Create container walls or green belts**

Between the terminal and the residential area, one might consider the erection of a permanent container wall with e.g. five layers. Such a container wall can reduce the average noise level in the neighbourhood by 8-10 dB. In addition, the municipality can create some greenbelts around the terminal which can lead to an additional noise reduction of 5dB(A) on the average (Ozer, 2008).

Of course, all three measures can in theory be combined. The evaluation of the measures will be measured in terms of costs, cumulated noise effects and whether a logistics service level can be offered. The first two options can be evaluated with the help of a simulation model. For the last option a simulation is not necessary since it just reduces the noise with a constant factor and has no influence on the terminal parameters. Under different scenarios we can find out which terminal configuration can provide most satisfying results for all parties.

4.5 New terminal experiments

Scenarios are often defined as a set of events that might take place in a future state (Jarke et al., 1998). Grossman & Özlük (2009) specify a scenario as a set of input variables with

varying values, used in forward-looking planning models to represent different future states of a system. This definition will be used to see what happens if the demand remains stable or has an annual growth of 15% on the different terminal configurations in which several potential noise reduction adjustments are applied.

The new terminal has a 25% larger surface (2.5 ha) than the current terminal. Hence the storage capacity will also be approximately increased by 25%. Due to the expected innovations in ship technology, the speed of barge vessels will be increased in the future, due to which the time length of the trip from Rotterdam to Tilburg of a vessel will be shortened from 9 hours to 7 hours, which means that the new terminal will have more calls in the new location annually with the current number of vessels. The reach stackers can cover all the operations in the terminal and match the functionality of the crane. In some combinations the reach stackers will replace the crane. Reach stackers are less costly and more flexible in their operations.

4.5.1 Logistics performances

Table 4.5 presents the simulation results with scenarios based on the stable and current demand and scenarios with an annual demand growth of 15 %.

Table 4.5: Simulation results with stable demand and 15% annual growth

Demand Performance Indicators	Stable	Stable	Stable	Growth	Growth	Growth
	New terminal With Crane	New terminal No Crane	Existing terminal	New terminal With Crane	New terminal No Crane	Existing terminal
Annual Volume	82,649	83,616	82,642	190,635	190,940	146,670
# Vessel calls	1,577	1,596	1,567	2,140	2,140	1,648
# Trucks	21,970	21,673	22,032	50,135	49,978	38,084
Utilization crane	0.26	-	0.26	0.6	-	0.4715
Utilization reach stackers	0.33	0.31	0.329	0.76	0.7	0.58
Average amount IC storing	213.13	217.41	180.99	215.7	206.59	165.51
Average amount EC storing	204.51	203.73	191.86	313.49	306.47	244.37
Average dwell time IC (days)	2.96	2.93	2.50	1.19	1.22	1.21
Average dwell time EC (days)	3.40	3.39	3.18	2.55	2.48	2.55
Utilization crane (-1)	0.27	-	0.26	Not realistic	Not realistic	Not realistic
Utilization reach stackers (-1)	0.48	0.42	0.49	Not realistic	Not realistic	Not realistic

(IC = Import containers; EC = Export containers; Utilization = active time / total time)

A market demand that remains stable (no growth of containers) reflects the situation in the first year of the new terminal. In order to reduce noise, simulation experiments have been

carried out assuming the use of fewer reach stackers for all the operational container handling tasks. The table shows that the terminal can still perform well with fewer reach stackers. The last row shows that all 3 combinations with one reach stacker less (-1) perform well in this situation. The main outputs (annual throughput volume, utilizations) do not significantly differ in the stable demand scenario.

In a growth scenario of 15 % per year the new terminal shows clear advantages over the existing terminal. Due to the reduced turnaround-time of the barges (the new location has a beneficial location with respect to the locks and the quick response speed of the trucks), the new terminal can have a much higher annual throughput volume than the existing terminal. Moreover the average dwell time for import containers will reduce from 2.9 days to 1.2 days and the average dwell time for export containers will reduce from 3.3 days to 2.5 days. There is not much difference between the performances of the new terminal with or without a crane, which means that the crane is not essential for the terminal, while the impact on the noise emission is unknown. It needs to be noticed that the utilization of the reach stacker is near the maximum capacity (i.e. 0.76 and 0.7) for the growth scenarios; if the intensity of the calls continues to go up, more reach stackers may have to be purchased.

4.5.2 Noise

The noise measurement is related to the noise level at the nearest house located in the residential area. The measurement is based on the terminal working conditions of the noise measuring day. This implies the use of almost full capacity. The noise emission based on full capacity does not strongly vary between the scenarios with or without a crane. For obtaining permit one picks an ideal, desired situation for terminal operations with almost all equipment working in a normal way (i.e. operating under the standard conditions of the supplier with sufficient and qualified personnel) (Witte, 2005) as a worst case situation for noise production. To start, it is assumed that the terminal does not operate during night time: the regular working period is from 05:00 until 23:00. During such a measuring day 100 containers arrive and 100 containers depart. On average each container takes 4 handlings (ship to shore, shore to truck and vice versa). In total there are 24 transport movements in the night period, 144 transport movements in the day period and 32 transport movements in the evening period (a total of 200 movements). The number of ships to arrive is 3 during the day period, 1 during the evening period; and 1 during the night period. Each ship can carry up to 32 so called 40 feet containers. The west side load and unload area are being served with a reach stacker during the day period. During the night period this area is used to store 12 containers that should be further transported with trucks. Other ships are served with the container crane. Another reach stacker is available for loading or unloading trucks, or the assessment of noise effects, as said, we should focus on the worst case. Therefore, we have used the simulations that represent the terminal working at its maximum operating capacity (busiest days, implying a 100% use of equipment as indicated by the utilization rates). This situation occurs more than 12 times per year.

The question then is how to determine the noise level of the (at its maximum operating) terminal. We basically only have noise production data on different sources (see Section 4.4) and the link to cumulative equivalent noise production levels is extremely difficult to make. The choice was therefore made to use real noise level measurements of the present terminal by (DHV, 1999). Although these measurements are not of recent date, the lack of recent updates made us assume that these measurements also apply to the operations of the new

terminal. The noise level measurement by DHV was based on similar conditions as assumed for the new terminal: the same terminal configuration (1 crane, 2 reach stackers) and a terminal usage rate of 100%. Table 4.6 summarizes the equivalent sound levels, adding also measurement data for the terminal operating at 60% level and with and without taking industrial zone noise into account.

Table 4.6: L_{Aeq} estimated noise level measurement (DHV, 1999)

Terminal usage	Isolated noise output (dB (A))	Cumulative noise (with industrial zone) (dB(A))
100%	46	49
60%	44	47

From the simulation of the busiest days, we learn from the utilization rates that 100% use of the terminal equipment occurs during daytime as well as in the evening period. At daytime the equivalent noise production level of 46 dB(A) is not a problem since this remains within the daytime limit of 50 dB(A). Since the choice was made on forehand not to operate during night times, no problems are expected for that period too. In the evening the noise limit of 45 dB(A) is seemingly hardly exceeded by 1 dB(A). However, it is common practice to increase the equivalent noise level with 5 dB(A) in the evening hours because of the reduction of the general noise level (Witte, 2005). This implies an equivalent noise level of 51 dB(A) for the evening, an unacceptable violation of the limit with 6 dB(A).

So the conclusion is that a full operating new terminal, even when the operating hours of the terminal is limited from 5:00 am to 23:00 pm, creates a noise problem that hinders to receive a permit to operate. The equivalent noise level at evening hours is too high and the maximum noise levels are too high during all hours. The L_{max} is independent of the working intensity of the terminal. We already stated that a reach stacker picking up a container is the noisiest activity at the terminal with a noise production of 121 dB(A). At a distance of 200m the noise production reduces to 81 dB(A), which is still high. Even in case a green belt is constructed and the noise level reduces with 5 dB(A) a level of 76 dB(A) remains. The acceptable L_{max} during daytime has to be less than 70dB, 65 dB during the evening and less than 60 dB during the night. So in the long run replacements of reach stackers for lifting operations by cranes who produce not more than 70 dB(A) per lift is essential.

As mentioned in Section 4.4, one option is to reduce the number of reach stackers. Based on the simulation model, this measure was concluded to be not a realistic option. Given the container flows, the utilization of the remaining reach stackers becomes too high and unrealistic in practice. It would result in too many difficulties to fulfil the logistics service tasks in the near future, given that one has to face a continuous growth in the terminal service demand, which will increase the service intensity of the terminal.

From the simulations we also learned that there are positive effects of limiting operations in the early opening hours of the terminal, without serious negative effects on the logistics performance of the terminal. It was decided to only allow for crane operations from 05.00 to 07.00 (L_{max} at 200m = 20 dB(A) < 40 dB(A)) for loading/unloading vessels. Hence, no vehicles will drive around at the terminal during these hours.

Finally, from the analyses it was concluded that the construction of a green belt around the terminal should also become part of the noise reduction program.

The model has provided insight into the consequences of noise effects of the future operations at the new to be built terminal. These were compared to the noise constraints. This led to the shared conclusion that the new terminal should implement some noise reduction program including the investment in straddle carriers or silent cranes by the terminal operator and investments in a green belt by the municipality to guarantee the terminal services in future. As such, the development and application of the model has given a mutual understanding with respect to a noise control strategy supported by both the potential terminal operator and the municipal authorities of Tilburg.

4.6 Conclusions

In policy practice we observe a tendency to strive for a more sustainable development of our cities. Policy makers aim to urbanize transport in such a way that the pursued architecture of the transport networks enables a strong connection of these networks to the urban context and meanwhile protect the inhabitants from noise and pollution. As a result many local authorities are preparing new environmental strategies. Like Hull (2005, p.322) we emphasize the importance in this context of integrating transport planning across administrative boundaries of municipalities.

A key problem to implementing an achievable sustainable strategy is determining the parameters of measurement (e.g. geographical scale, environmental and social impacts, etc.). Not surprisingly, it is extremely difficult to achieve a workable, acceptable set of targets, actions and measures which can promote more sustainable cities, and more sustainable urban freight transport systems.

Both developments, combined with the favourable environmental performances of barge transport, have led to a tendency that more cities consider barge terminals into the urban scenery. The embedding of terminals into urban sceneries is not just a matter of technical and physical specification of its elements, like the crane capacities, the location of the harbour and the connections to the main roads. One has to take into account the whole urban context in the assessment of the effects of terminal operations.

In this article we have developed a modelling approach, based on simulation with strong animation facilities, to integrate the operational parts of the terminal with the related noise effects for its surrounding. We have applied this approach to the case of a new container terminal in the city of Tilburg. With the aid of the simulation model a terminal location assessment was carried out in a very conscious and open process with constructive communication between private and public actors.

The model simulates the operational flows of the terminal. Based on the 12 busiest days in a year we have linked the operational performance of the new terminal, based on a maximum use of cranes, reach stackers and trucks, to its noise production. This was done assuming different circumstances and noise reduction measures. The resulting insight enabled the terminal operator and the municipal authorities of Tilburg to jointly select the best terminal option in terms of the balance between logistics performance and noise reduction. The terminal is planned to be operational in 2014.

In the near future we expect to see an increase of similar studies for the design of rail and water borne terminals in urban environments. The lesson from our study is that modelling approaches like simulation helps to formulate the agenda for decision making, to gain deep

insight in relevant processes and to improve the mutual understanding between the public/private actors involved.

Acknowledgement

This article is based on key components of the master thesis work of Bin Wang (2005), developed under supervision of the first author. The authors thank Bin Wang for his work.

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5 New challenges for urban consolidation centres: the case of The Hague

'Magna civitas magna solitudo'
(A big city means great loneliness)
Erasmus

J.H.R. van Duin, H. Quak, J. & J. Muñuzuri, (2010). New challenges for urban consolidation centres: the case of The Hague. *Procedia - Social and Behavioral Sciences*, 2(3), 6177-6188.

Abstract

The objective of this research is to advice the Municipality of The Hague whether, if and under which conditions, the implementation of an Urban Consolidation Centre (UCC) is possible and desirable. To determine factors that caused the success or failure of UCCs in practice, a survey of 6 cases in Europe is conducted. The cases were selected because of the similarity of the service area of the UCC and the city centre of The Hague or because of the uniqueness of the UCC. To determine the possible success for a UCC in The Hague four scenarios are evaluated. Two major difficulties with implementing the UCC are the allocation of the costs and benefits and the willingness to cooperate of the transportation companies. Both consignees and transportation companies can benefit financially from using the UCC. The UCC operator, however, incurs the costs. The municipality should play a role in bringing the costs and benefits together.

Keywords: Urban Consolidation Centre, feasibility study, evaluation

5.1 Introduction

The urban area of The Hague suffers from the negative effects of the goods distribution. These negative effects are noise hindrance, air pollution, un-safety, congestion and damage to the historical city. The high amount of vehicle movement of goods distribution vehicles and the loading and offloading times in the often narrow streets cause these effects. The Municipality of The Hague tries to reduce the vehicle movements and loading and offloading times using several measures. Current measures like restriction of the shop supply hours by introducing time-windows, the introduction of environmental zoning, and agreements with retailers ('De schone stad') in urban areas only have limited effects. The benefits of the voluntary actions to reduce vehicle movements are not high enough to encourage the private parties (shop owners, senders, shipping agents) to take measures and the obligatory measures do not have the effects as expected to have (Buck Consultants International, 2008; Emberger, 2004; Lemstra, 2004). Another option to reduce the negative effects is improving the efficiency of the distribution. This efficiency comes together with higher occupation rate of the load capacity. In that case less vehicles have to enter the main centre. It can also be more efficient to enter the main centre with more, but smaller vehicles. The efficiency of the distribution to businesses in the main centre can be improved in several ways. The efficiency of the supply chain can be improved by improving information flows and increasing transparency, by using the vehicles and load carriers most suitable for the work or by streamlining the supply chains. A way of consolidation is to transship the goods of different suppliers to one area just before entering the city centre. All cargo to one area in the city, for example a main shopping area, will be put together in one vehicle. This can potentially lead to better occupation rates of the vehicles and thus to less vehicles in the urban area (Govera, 2006; Marcucci & Daniels, 2008). The Municipality of The Hague wants to know whether it is useful to facilitate/initiate an Urban Consolidation Centre (UCC) for The Hague (city council motion RIS143046_26-JAN-2007). The use of a UCC can potentially result in substantial transport benefits. The different types of consolidation mentioned above can be combined into better solutions. Amongst others the benefits are (Huschebeck & Allen, 2005): reductions in the number of vehicle trips, reductions in the number of vehicle kilometres, and better utilization rates for vehicles.

In our research it is necessary to determine whether it is possible to establish a viable UCC in The Hague and to identify what the conditions are for such a UCC to be successful. Therefore we have formulated the next research objective:

'The objective of this research is to advice the Municipality of The Hague about if and under which conditions the implementation of an Urban Consolidation Centre is possible and desirable.'

To give this advice research is necessary about the factors that determine the design of a UCC and the factors that influence the success of a UCC. Factors can be e.g. reliability, influence on congestion etc. (Derksen & Schaap, 2007). These factors will determine the feasibility of the UCC. This feasibility depends amongst others on the benefits (for example less vehicle movements) and costs (for example the effort for stakeholders to change their current way of distribution) of the UCC. The central research question in our paper is:

'Under which conditions is the implementation of an Urban Consolidation Centre in the Municipality of The Hague possible and desirable?'

To meet the research objective, the next research questions will be answered in our paper.

- What successful and unsuccessful Urban Consolidation Centre concepts are there in the Netherlands and abroad?
- What factors influence the success of an Urban Consolidation Centre?
- In what way do these factors exist in the main centre of The Hague?
- What technical and institutional constraints mark down the design space of an Urban Consolidation Centre in The Hague?
- How can/are the factors of success be influenced by the stakeholders, in particular the Municipality of The Hague?

The following section 5.2 will provide an overview of the possible UCC concepts that are applicable on the The-Hague case. European reference projects have been chosen because of the similarities with the situation in The Hague, their uniqueness or their obvious success. Based on this exploration important success and failure factors can be identified. The next section 5.3 contains a feasibility study according to the economical model of Feitelson & Salomon (2004). The last section 5.4 lists the main findings and conclusions of our research.

5.2 Evaluation of European urban consolidation centres

Using literature and evaluation of other European reference projects will give an overview of the possible UCC concepts that are applicable on the The Hague case. Surveys and data collection activities have been undertaken in several countries and cities such as Leiden, Nijmegen, Bristol, Kassel, La Rochelle and Malaga (Ruesch & Glücker, 2001; Allen et al. 2002; Morris et al.,1999; Schoemaker, 2003; www1, www2). The city distribution centres analysed are all located in Europe. Information can also be found about Asian projects (e.g. Tenjin, Japan), however the hierarchical governmental powers applied to the implementation of these city distribution centres are totally different and therefore not comparable to situation in the Netherlands. For this reason Asian (Japanese) cases are left out in this research. Much information is derived from practice. The large quantity of research on city distribution centres creates the possibility to identify the success and failure factors regarding the implementation of city distribution centres both using literature, reference projects and consulting experts. The right balance between scientific literature and information from the practice is pursued.

5.2.1 Leiden, The Netherlands

In 1994 the UCC started as an initiative of the Municipality of Leiden. The UCC was a public-private-partnership (PPP) with the municipality, a consultancy company, a real estate company, a transport company and a re-employment organisation. Transporters could drop-off their freight at the UCC. With 5 electric vehicles bundled freight was transported to the city centre of Leiden or by vehicles owned by transportation companies with distribution license (Schoemaker, 2003; City Ports project, 2005). The electric vehicles were obtained with European Commission funds (Allen et. al., 2002). The licensing system issued by the Municipality was a function of several criteria such as: vehicle load, number of deliveries per day, etc. (Browne et al., 2005). The service area was planned to be only the city centre of Leiden. In this area time windows for delivery were implemented. Due to too few participating shops the service area was extended to the whole city. UCC Leiden failed

because of low profitability due to the disappointing number of parcels handled in the distribution centre. The objective was to deliver 500 shipments per week to the city centre. This objective was not met by far. At best only 26 addresses in the city centre were supplied via the UCC (Schoemaker, 2003). The Leiden project was stopped in 2000 due to low profitability. The reason for low profitability was twofold. Shortage of participants as well from the retailers' side as from the transportation companies' side was the first reason. There had been strong opposition from the transportation companies against the UCC because they claimed that the municipality was aiming to create a monopoly in the service of urban distribution of goods. The shortage of retailers participating is hard to explain, however a reason could be found in the efficient way retailers had already organised their distribution. The second reason for low profitability had to do with the location of the UCC and the choice of distribution vehicles. The UCC was located in Leiderdorp (next to Leiden) and was located far from the highway. This disadvantage was aggravated by the choice to use non-appropriate electric distribution vehicles. The electric vans were only suitable for transport in the city centre zone. They were far too slow for the transport from the UCC to the city centre and vice versa (15 km/h). Because of the shortage of participants at one time the service area was expanded from only the city centre to the whole city. The vehicles, however, were not suitable to cover the size of this new service area.

5.2.2 Nijmegen, The Netherlands

The most recent experience with a city distribution initiative in the Netherlands is '*Binnenstadservice.nl*' in Nijmegen. '*Binnenstadservice.nl*' is a city distribution centre opened in April 2008 as an initiative of two entrepreneurs. The UCC is still in its test phase and started with 20 end-users (shopkeepers). The shopkeepers using the UCC change the delivery address for their suppliers to the address of the UCC. The packages are bundled in the UCC and twice a day the packages are delivered to the shops. At this moment local subsidies pay for the service. Although initially it was thought that subsidies would be needed only during the starting phase, the funding of the second year is not yet completely finished. When the shop-owners want to use the warehousing options of the UCC, or want extra transactions being made (value added logistics like making goods ready for the shop), they have to pay for these services. '*Binnenstadservice.nl*' uses a courier bike and a van to deliver the goods to the shops from the UCC located at a business area near the city centre. A disadvantage of the location is bad connecting infrastructure to near highways. The van runs on natural gas. The service area is the whole city centre of Nijmegen. The results of this pilot project are described in Van Rooijen and Quak (2009). Whether it will be a success should be experienced in the long run. Some pitfalls from the past are foreseen in this project. The provision of subsidies and the offering of value-added services are important elements for success. Most remarkable observation is the fact that the project-leader of this service was former city manager and a mediator. Providing a way to cope with their different goals and views and continuously monitoring the attitudes of the involved parties seems to work quite successful since the growth of participating shopkeepers has increased from 20 shopkeepers to 98 shopkeepers within a period of a year. *Binnenstadservice.nl* started services in a second Dutch city, Den Bosch, in 2009.

5.2.3 Bristol, UK

In 2004 the municipality in Bristol took the initiative to start a UCC (www3). The UCC is operated by a logistics service provider DHL Exel supply. The municipality selected DHL by a public procurement (www2). Currently 63 out of the 300 shops in the 'Broadmead' shopping centre receive consolidated deliveries from the UCC. A survey among 118 retailers in 2003 helped to establish this target group. The users are medium-seized retailers and their goods are non-perishable and not very high value products. Suppliers can deliver their goods 24/7 to the UCC. DHL bundles the goods and delivers them to the shops. DHL guarantees 100% in time deliveries. More than half of the retailers save over 20 minutes per delivery (www1). Cost-efficiency for DHL is good, because of the funding being fully covered by subsidies from the EC VIVALDI project (www4). The UCC is located 16 km from the service area. This is a 25-minutes trip. The UCC is located close to the highways M4 and M5. Distribution is done with one 9 ton vehicle and one 17.5 ton vehicle. A successful four-month trial is carried out with a 9 tons electric truck. No accompanying measures have been taken by the municipality. The service area has a surface of approximately 1.5 km². At this time the 'Broadmead' shopping area is expanded. It is expected that the amount of users will increase in the near future (Hapgood, 29-06-2008).

5.2.4 Kassel, Germany

As an initiative of private transport companies, in Kassel a UCC was set up in 1994. Ten transport companies that carried out deliveries to the city centre of Kassel decided to cooperate (Kohler, 2004). One of the reasons to cooperate was that the transport companies had difficulty with improving their environmental friendly image (www3). Using a UCC their cargo is consolidated and delivered by a single 'neutral' carrier (www3)(Browne et al., 2005). During the first years the UCC was subsidised by the municipality. In 2005 the results were good. A doubling of the capacity use of the vehicles going in to the city centre reduced the vehicle kilometres in the city centre with 60% (see Table 5.1). Looking at the situation in 2008 the UCC is paid for by the cooperating transportation companies itself. A slow collapse in use can be observed due to the high costs for the transportation companies, now that the subsidy has stopped (Krichel, 08-07-2008). An incentive for the cooperation was the introduction of a pedestrian only zone in the city centre of Kassel. Conventional vehicles of the transport company execute the distribution (Browne et al., 2005; City Ports project, 2005).

Table 5.1: Results of the UCC in Kassel (City Ports project, 2005)

	<i>Without UCC</i>	<i>With UCC</i>	<i>Difference</i>
Vehicle kilometres inside the city,	6500,	2600,	-60%
Utilisation of vehicle capacity (volume)	40%,	80%,	+100%
Number of trucks per retailer per year	300	260	- 13%

5.2.5 La Rochelle, France

The Communauté d'Agglomération de La Rochelle initiated a UCC in La Rochelle in France in 2001. The UCC of La Rochelle serves 1300 businesses. The manager, Transports Genty, is a private company founded by a competitive tender (van Binsbergen & Visser, 2001; City Ports project, 2005). Around 30% of the deliveries to the city centre are handled by the UCC.

This is approximately 450 parcels/day and between 5 and 10 pallets per day. Delivery from the UCC to the inner city costs 3.75 euro/parcel. The distribution is done with electric vehicles (Vermie, 2002). Deliveries from the UCC are made using nine electric vehicles of which two are equipped with dedicated temperature control for the delivery of perishables. Subsidies are provided by the local government for the infrastructure and a fixed amount per package. The time-window management of the municipality encourage transport companies to drop of their goods at the UCC. The city centre is banned from vehicles with a loading-capacity higher than 3.5 tons, except during the time window from 6:00-7:30 hour (Commission of the European Communities, 2007). The service area of the UCC is the medieval city centre of La Rochelle and the UCC is situated 1.5 km South of the city centre (Communauté d Agglomération de la Rochelle, 2004). The UCC is not financially viable yet, but it is expected to be so in the coming years. The UCC is successful according to most stakeholders and there are 61% less vehicle kilometres with conventional trucks in the city centre (Patier, 2006). Carriers can avoid wasting time in delivering in the city centre and retailers and residents appreciate better traffic and parking conditions and noticed the general improvement of their local environment (Browne et al., 2005; City Ports project, 2005). The success of the La Rochelle UCC is in the first place due to the shared sense of urgency of all stakeholders. The initiator, the municipality, involved important stakeholders in the process in a very early state. The good participation is presumably also due to the funds provided by the municipality. The (time) savings for the carriers are larger than the costs of using the UCC.

5.2.6 Malaga, Spain

The UCC in Malaga is a building for cross-docking in the outskirts of the historical centre. The municipality is the initiator promoting the initiative. All stakeholders were questioned and in this way involved from the beginning. The cross-docking activities are managed by a private urban transport organisation. The UCC basically is a freight car park which transporters can use to tranship goods. Still, cross-docking activities are performed by the same agents that were active in the logistics chain before. The municipality is the owner of the land. A company based on participation of the distributors manages the centre. The municipality also participates in the parking company SMASA who facilitated the construction of the freight car park. This company has the experience and follows the policy established by the local authorities. An accompanying measure by the municipality is the establishment of a pedestrian zone where only vehicles coming from the UCC are permitted to enter. For the distribution both electric and conventional vehicles are used. Although the service area is expanded to the whole city, there is low usage of the UCC. Only one third of the capacity is used (Browne et al., 2005).

5.2.7 Important success and failure factors identified relevant for The Hague

The outcomes of this exploration do not point out that the *actor who started the initiative* could be seen as a factor for success or failure. Two out of the three times the initiative to implement a UCC came from the municipality. Only once a carrier initiated a UCC. The initiative in the failed cases also started from the municipality in three of the four cases. The other failing initiative came from shopkeepers. The *number of users*, however, seems to be a most important factor in all success and failure cases. The way how the *organisation of the UCC* is setup can be as identified as critical factor. The fact that a UCC is privately organised can possibly explain success. *Subsidies* can also be seen as an important factor for success.

Two of the three success cases get a structural subsidy for exploitation provided as local subsidy as well as EC subsidy. The Kassel UCC received a local subsidy in the first years. The selection of the right *type of distribution vehicle* should meet the unique requirements for the case and therefore the distribution vehicle has to be determined for every UCC separately. In two cases conventional trucks were used and in one case electric ones. All unsuccessful UCC's made use of conventional vehicles to distribute the goods to the service area. In three cases also electric vehicles were used in combination with the conventional ones. In La Rochelle the fact that electric vehicles are used created 60% reduction in vehicle kilometres with conventional trucks. However in Leiden the badly adjustable vehicles were part of the failure. The *location of a UCC* can determine its success as can be seen in the Leiden case. Also Browne et al. (2005) and the BESTUFS report (Allen et al., 2002) emphasise the importance of choosing a right location. Evaluations of decision making on this issue however reveal that in many cases the result of what was available at the moment (Hesse, 2004; Quak, 2008). From the exploration it is not clear what influence *accompanying measures* have. In one of the successful cases no accompanying measures are taken. In the other two cases respectively time-windows and a pedestrian zone support the UCC. The unsuccessful cases were all supported by accompanying measures. It can therefore be concluded that accompanying measures are no guarantee for reaching success. Well chosen accompanying measures (e.g. limited access conditions —physical or time related), however, possibly can to a certain extent help to acquire more users for a UCC. Learning from the European practices we can formulate that for the city of the Hague, the number of users, the organisation, the type of vehicle and the location are no guarantees for success however these are important factors for consideration as initial steps for success.

5.3 Feasibility of UCC in The Hague

To evaluate the feasibility of a UCC in The Hague firstly the theoretical factors for success of a UCC (Huschebeck & Allen, 2005) and the factors that can be found from the European practice, will be divided in three classes based on the political economical model of Feitelson and Salomon (2004) to be able to handle each factor appropriately. The classes are: technical feasibility, commercial feasibility, and political feasibility.

5.3.1 Technical feasibility

To technical feasibility belong: the characteristics of the service area, the characteristics of the UCC, the type of UCC, the type of distribution vehicles and the location of the UCC.



Figure 5.1: Inbound routes freight vehicles and two possible locations for a UCC

The research has been done for a target group of 531 shops in the city centre of The Hague with branches in fashion, living, electrics, entertainment, books and other retail, all self-employed businesses with less than 1000 m² sales surfaces (see Figure 5.1). Vans, light trucks, medium trucks and heavy trucks are distinguished. It is assumed they have a load capacity of respectively 7, 18, 38 and 60 m³. In our research the use of light or medium electric trucks for distribution are chosen, because using vans will increase the number of vehicles extremely high and some load units will not fit in vans. Heavy trucks are excluded since they have a very bad effect on urban distribution problems, such as safety. The vehicles must be able to drive from the UCC to the city-centre and vice versa at normal speed (50 km/h) and must be able to do trips the whole day so recharging the batteries can be done at night. Light trucks will have a range of at least 40 km and medium trucks will have a range of at least 30 km. From the data collected by the enquiry of DHV (2008) is known that the shops in the sample get an average of 5.4 deliveries per week. Multiplying this with the number of shops in the population (target group), it makes 2858 deliveries per week. The average number of deliveries per vehicle in the city centre is 7.2. From this can be concluded that 397 vehicles enter the city centre of The Hague per week for supplying the shops in the target group. A volume of 4653 m³ goods is brought to the shops in the target group by 397 vehicles per week. The distribution vehicles are assumed to come equally spread over 6 days per week. Flexibility is an important factor of service. To be able to meet this service aspect it is important to give shops the possibility to receive goods at the time they want. Preliminary the opening times of the UCC will be 10 hours per day, 6 days per week. The arrivals of incoming vehicles will spread over the day with a peak between 11:00 and 12:00. It is assumed that at the most 75% of the goods that pass the UCC in a day will be in the storage area at the same time, and that goods can be stacked up to 1.5 m. Therefore, for consolidation of 100% of the goods for the target group 388 m² of space is needed purely for storage. Some more surface area is needed for handling the goods. An important notion from the survey is that often the capacity of the UCC is too large compared to the usage. It is good to be realistic about the use of a UCC. Also Quak (2008) and Hesse (2004) say that one must not be too

ambitious about the use of a UCC. When the positive impact of a UCC is proven, the usage can be extended. The suggested type of UCC is an Urban Consolidation Centre. The location of the suggested UCC is in the Binckhorst business area (see Figure 5.1, location 2), because the Binckhorst is near to the future inbound routes, it has a good and short connection to the city centre.

5.3.2 Commercial feasibility

Commercial factors that influence the feasibility of a UCC are the way a UCC is organised and funded. These factors are derived from the earlier analysed European examples. Here we will elaborate on the benefits and costs of a UCC to be able to evaluate the possibilities for a UCC in The Hague on the criterion of positive net benefits. The organisation of a UCC can be in hands of a private organisation, a public organisation or a public private partnership organisation (Browne et al., 2004). From the exploration we can conclude that the most promising way to organise the UCC is with a private organisation. This means a new stakeholder involved, being the UCC operator. The funding depends on two major factors being the costs and the benefits of the UCC. However, the costs and the benefits are subordinated to a variety of factors. The costs can be divided in initial costs and operating costs. Benefits of a UCC can come from two sides. Benefits can come from subsidies and from paying users. All the successful UCCs had subsidies of one kind. Some received a one time subsidy, others structural. As well as local, national and European Commission subsidies are provided for the different UCCs. These subsidies are for most of the UCCs essential for their continuity. This notion is supported by Browne et al. (2005) who say that structural subsidies almost always necessary. Participating in a European Union project can provide funds by (structural) subsidies. The success of the UCC in Bristol can partly be explained by the fact that it is supported by the EC VILVALDI project (www4).

Benefits

A UCC could cause direct financial benefits for consignees and transportation companies. These financial benefits can be an incentive for usage of the UCC, but can also be used to determine a realistic price for the service the UCC provides. Indirect financial benefits such as extra income for shops due to a more attractive shopping climate are not taken into account in the evaluation of a UCC, because these effects are very uncertain and on the long term. For *consignees* flexibility in the time at which the goods are delivered in the shops can potentially lead to a financial benefit. Consignees benefit from the fact that no personnel have to be in the shops before opening times. In the current situation 23% of the goods is delivered before opening times (DHV, 2008). Averagely deliveries are made 1.5 hour before opening time. It is assumed that personnel costs for that 1.5 hour are €23 (Kuiper, 2006). The benefit per m³ is $0.23 * €23 / 1.6 = €3.32$. For *transportation companies* benefits will come both from flexibility in planning and from time reduction. Since the transportation companies do not have to take into account the time windows they are more flexible in planning. This will probably cause a reduction in transportation cost, although it is hard to calculate the exact extend of the reduction. With regard to time reductions a calculation can be made. When the vehicles of the transportation companies do not have to enter the city centre anymore this will save a lot of time. Our calculation shows that averagely delivering the goods to the UCC saves 0.7 hour per roundtrip. Averagely 7.2 shops are delivered per roundtrip. This means that 0.10 hour (6 minutes) is saved per delivery. An average delivery is 1.6 m³, so per m³ 0.0625

hour is saved. Assuming that an hour costs the transportation company €112 (Kuiper, 2006), per m³ €7.02 euro is saved.

Costs

When the UCC is operated by a private organisation the costs that are presented below are costs for that organisation. Assumptions about the costs are presented below in Table 5.2. The investment costs that are taken into account in the CBA consist of ground, real estate, mobile material and distribution vehicles. To be able to calculate the costs using the specified prices the number of m² ground for the building has to be calculated, the number of m² ground around the UCC has to be calculated and the number of units of mobile material and of distribution vehicles has to be calculated. The source data, assumptions and calculations about these numbers are presented in (Kloppers, 2008). The estimations are based on the situation when a UCC tranships between 25,000 and 250,000 m³ goods per year. A UCC outside this range need different principles and this CBA is therefore not suitable to evaluate bigger or smaller UCCs.

Table 5.2: Costs specification of the UCC

Type	Object	€	Per
Ground		400	m ²
Real estate	Building	800	m ²
	Other infrastructure	50	m ²
Mobile material		15,000	Unit
Distribution vehicles	Light trucks	110,000	Unit
	Medium trucks	140,000	Unit
Personnel		80,000	person/year
Insurance		0.25	m ³
Energy costs		0.085	km

The yearly operational costs are partly the depreciation of the real estate, the mobile material and the distribution vehicles. The depreciation term of the real estate is 20 years and of the mobile material and the distribution vehicles it is 5 years. No residual value is taken into account. The batteries of the distribution vehicles will be worn out after the life span of the distribution vehicles (van der Kamp, 29-09-2008). Contrary to other real estate a distribution centre has little or no residual value. The maintenance costs are 2.5% of the new value of the mobile material and the distribution vehicles (EPRI, 2004). To obtain a good insight in the costs and benefits four scenarios have been defined:

- **Scenario 0:** *No measures are taken.* Actually it is the current situation without the UCC in order to make a comparison with the other scenarios
- **Scenario 1:** *Full participation, light trucks.* In scenario 1 all goods for the shops in the target group are delivered to the UCC. From the UCC 17 electric light trucks transport the goods to the shops in the city centre doing roundtrips 10 hours a day to shops. A 100% participation under the target group means that 241,956 m³ goods per year are transhipped in the UCC.

- **Scenario 2:** *Full participation, medium trucks.* This scenario also presumes 100% participating shops in the target group. Difference with the first scenario is that 2 medium trucks are used for distribution.
- **Scenario 3:** *Few participants.* In scenario 3 voluntary participation is assumed. In this case there is 10% participation under the target group. This participation level is chosen because from experiences in other cases 10% seems to be a participation level that can be reached in an initial state without obliging use of the UCC. In scenario 3 light trucks are used for distribution. It is assumed that 10% of the shops in the target group take care of 10% of the goods. This means that the UCC in scenario 3 handles 24,196 m³ goods per year.

Comparison of the scenarios (see Table 5.3) clearly shows that scenario 2 scores the best on the criteria. A reduction of vehicle kilometres of 8% can be reached when all shops in the target group participate. This will have a positive net benefit and a positive influence on the service level for the stakeholders.

Table 5.3: Evaluation of the scenarios

Criteria	Scenario 0: Current situation	Scenario 1: Full participation, light trucks	Scenario 2: Full participation, medium trucks	Scenario 3: Few participants
Vehicle kilometre reduction	0	-2%	-8%	-0.8%
Net benefit	0	-/- €50,577	€118,083	-/- €220,040
Service	0	++	+	+

Facing the future we will not know which scenario will happen and therefore the CBA is extended showing the costs and benefits of the UCC in € per m³ for different amounts of goods handled per year. Figure 5.2 shows that when the UCC uses medium trucks, from the point that approximately 150,000 m³ goods per year are trans-shipped in the UCC the benefits are higher than the costs. The 150,000 m³ goods per year means a participation of approximately 60% of the target group shops. Using light trucks that point is presumably also reached but more goods have to be trans-shipped per year than only that of the target group shops. Because of the characteristics of the input data and assumptions the model is not suitable to calculate costs and benefits in this case. The peaks in the cost lines are there because of the point when one vehicle more is needed or where one employee more is needed. From the figure also can be learned what has to be contributed by a possible financier to exploit a UCC with less than 150,000 m³ per year or with light trucks. It can be seen that the one participant more will decrease the costs considerably, until 75,000 m³ goods per year is reached (approximately 30% of the target group shops).

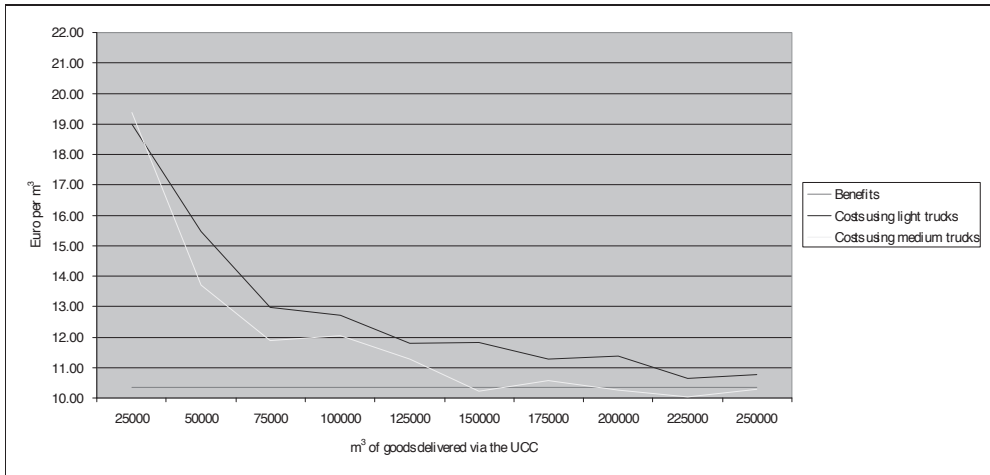


Figure 5.2: Costs/benefits per m³ for different amounts of goods delivered to the UCC

5.3.3 Political feasibility

Retailers in The Hague have shown interest in consolidation as a solution for the problems with distribution vehicles. The two major difficulties with implementing the UCC are the allocation of the costs and benefits and the willingness to cooperate of the transportation companies. Both consignees and transportation companies can benefit financially from using the UCC. The UCC operator, however, makes the costs. The municipality should play a role in bringing costs and benefits together. The problem with the willingness to cooperate in a UCC is that the transportation companies will not simply give away the delivery of the goods to another party, because of reliability issues and the fact that the picking up and delivery of the goods is their core business. The information that needs to be shared with the UCC operator is very competition sensitive. A solution could be exploiting the UCC as a cooperation between different transportation companies. The municipality should take the initiative to organise the first meetings because of the problems with the competition sensitive information.

5.4 Conclusions

The survey was a good method to identify factors that influence the success of a UCC. However, limited quantitative data can be found about the UCC cases. In most cases no ex-post evaluation is conducted. This makes it hard to determine to which extent the objectives are reached. The factors that can affect the success or failure of a UCC are one of the results of the UCC survey. These observed success factors for a big part match the conclusions of the City Port Project report (2005), the BESTUFS handbook (Allen et al., 2002) and the study done by Browne et al. (2005) and Quak (2008). This research shows that full participation of the shops in the target group a reduction in vehicle kilometres of distribution traffic of 8% can be reached. Browne et al. (2005) assessed the most commonly quantified impacts in ex ante studies of 17 studied UCC cases. The performance indicator *vehicle kilometre reduction* was

calculated in 7 out of the 17 cases. The calculations were all done in preparation of the implementation. In these cases the predicted reductions in vehicle kilometres of distribution traffic varied between 30-45%. From this could be concluded that the distribution activities in The Hague are fairly efficient (averagely 50% of the load capacity of the distribution vehicles that enter the city centre are filled with goods for the city centre and the average total load capacity of the vehicles is 80% (DHV, 2008). Secondly, the fact that many of the 17 UCCs studied by Browne et al. (2005) have stopped because of the unsatisfactory results indicates that the benefits of the UCCs in some cases were not based on realistic estimations. In addition to the recommendations for the municipality, further research can be recommended for urban distribution research in general. Firstly, a stated preference study amongst the transportation companies that deliver to the shops in urban areas, can determine the factors that influence the choice of transportation companies to participate in a UCC. Research shows the factors that shopkeepers find important, but about the reasons for transportation companies to deliver the goods to the UCC of deliver the goods to the shops itself, only assumptions are done. Secondly, it has to be noted that as expected most of the literature that is available about the practice of urban freight distribution exists of non-scientific papers. Most reports on urban distribution practice are of engineering companies and local governments. Scientific theory could provide more accurate advises, but evaluations of UCCs are often poorly documented. TNO is currently evaluating the pilot with the UCC in Nijmegen. This study can be followed for information from the practice at this time. When a pilot would be started in The Hague, following this with a profound scientific research, would be a windfall for urban distribution knowledge (see van Rooijen & Quak, 2009).

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6 Globalization and intermodal transportation: Modelling terminal locations using a three-spatial scales framework

Models should try to their best to look like their portrait

Salvador Dali

Duin, J.H.R. van & Wee, G.P. van (2007). Globalization and intermodal transportation: modeling terminal locations using a three-spatial scales framework. In R. Cooper, K. Donaghy, and G. Hewings (Eds.), *Globalization and Regional Economic Modeling* (pp. 133-152). Heidelberg, Germany: Springer.

Abstract

In the process of increasing globalization, the role of ports and their hinterland connections has become more important. The significance of ports having a well-developed infrastructure with their hinterland can be observed in the settlement of 700 European Distribution Centres in the Netherlands over the last 20 years, almost one third of all the European distribution centres. The Just-In-Time concepts of the multinational shippers ask for more reliable transportation. Due to the increase in road congestion, there is a growing interest in intermodal transport as a competitive alternative in terms of enough capacity, an interest that is further stimulated by environmental concerns. The increasing interest in intermodal transport is to be observed in the Netherlands as well in many other European countries. The European Ministers of Transport try to coordinate at macro level the development of intermodal transportation networks in their plan 'Trans European Networks'. In contrast to this plan, the practice of terminal development and intermodal transportation initiatives seems to develop more whimsically.

The novelty of this paper is to show that all policy levels (European, national (Dutch) and regional) are important for the location choice of new terminals. We will also define how to

use a modelling framework for these policy levels to support the location choices of the terminals. Finally, we will show how these models can be used for policymaking processes aiming to select the location of new terminals, and to promote the use of them. The approach is not only a hierarchical top-down one, but also contains feedback-loops from lower to higher spatial scales, allowing to learn from more detailed insights at a lower level. It has been successfully applied in case studies, showing which variables are important for decision making at different spatial scales with respect to locations of terminals for intermodal transportation, enabling us to identify two promising new terminal locations within the Netherlands.

Keywords: Modelling, intermodal transportation, spatial scales, stakeholders

6.1 Introduction

During the last decade the influences of globalization have shaped our countries. The meaning of the word globalization has changed from a ‘catch all’ term used in economics to a much broader meaning of describing the impact of increased international integration across a range of fields – from literature to sociology, to technology (Ruane & Sutherland, 2002). In the early 1990s some companies in Europe began to integrate operations across national boundaries. The removal of trade barriers increasingly enabled geographical integration and thus operations spanning country borders in creating economies of scale (Bowersox et al., 1996). In order to sustain economic growth, many companies felt the need to develop new markets outside their home countries. New manufacturing plants and distribution centers were established in Asian countries. Not only the market conditions but also manufacturing conditions seemed to be favorable. Low labor wages, good employment and expansion opportunities were the main motives for these companies to invest. As a result relocation and re-allocation of existing manufacturing activities were set-up (Vos, 1993). This global shift of manufacturing activities caused a tremendous pressure to change the distribution structures. To guarantee the delivery demands, the organisation of distribution channels became of importance. While maintaining the speed of delivery, the price of delivery, and the flexibility of demand, the distribution channels needed to adjust the logistics activities in their structure. Activities of transshipment became important value-adding links to the distribution channel (Porter, 1996). As an observation of this tendency, it can be noticed that around 700 European Distribution Centres have been set up in the Netherlands over the last 20 years, almost one third of all the new distribution centres in Europe (Ernst & Young et al., 2002).

The high demands for reliability in distribution structures of companies ask for the presence of well-developed infrastructures. Loyola de Palacio, Vice-president of the European Commission, responsible for energy and transport, states in the foreword of the EU white paper (2001): ‘Transport is crucial for our economic competitiveness and commercial, economic and cultural exchanges. This sector of the economy accounts for some 1000 billion, or over 10% of the EU’s gross domestic product, and employs 10 million people. However, the warning signs are clear. Congestion, resulting in environmental nuisance and accidents, is getting worse day by day, and penalizing both users and the economy. If nothing is done, the cost of congestion will, on its own, account for 1% of the EU’s gross domestic product in 2010 while, paradoxically, the outermost regions remain poorly connected to the central markets. Europe must bring about a real change in the Common Transport Policy. The time has come to set new objectives for it: restoring the balance between modes of transport and developing intermodality, combating congestion and putting safety and the quality of services at the heart of our efforts, while maintaining the right to mobility.’

As for the development of intermodality, a new approach has been developed to identify attractive locations of terminals. In this approach the perceptions of the actors involved at the different levels of policymaking play an important role in the choice of a new terminal. The way actors think and make their decisions is important to understand. Due to this way of thinking and reasoning, studies of decision making in networks have caused a fundamental change in thinking about the role of decision makers, stakeholders, and analysts (Fischer 1993). The image – illusion perhaps – of decision making as a (bounded) rational design effort by an elite group with implementing power is replaced by an emergent perspective on

policymaking in which policy is seen as the result of interaction in a network of corporate actors (Marin 1991).

The traditional research on policymaking for transportation and logistics is mainly based on operational research techniques. Mulvey (1994) indicates that these techniques are poorly understood by the general public. A translation of the technical issues like mathematical assumptions and solving-methods into 'plain English' is usually not done. According to Nemhauser (1993): 'Great strides have been made in the use of optimization. Models with thousands of variables and constraints are being solved regularly and the results are being applied routinely. Still we need to do a better job in making optimization easier to use and in making solutions meaningful to all types of stakeholders'.

As Vidal and Goetschalckx (1997) mentioned in their critical review on models, some research opportunities for developing more comprehensive modelling should focus on:

- general simulation of qualitative factors;
- environmental conditions, such as availability of infrastructure, determination of adequate local access capacities;
- modelling of alliances and multi-company network configurations, and
- development of specialized solution methods.

Of course, it is almost impossible to develop a general single model that integrates all these aspects. This conclusion leads to the development of an overall methodological transportation framework, supported by multiple interrelated models being capable of representing qualitative factors and uncertainties. The development of an approach to build these interrelation models must fill the gap between logistics decision processes on the one hand, and the specification of the design contents on the other hand. The new models must be easy to use and understand, with user-friendly capabilities, such as graphical representations of the systems under analysis. Sijbrands (1993) clarifies that the task to support strategic logistics issues seems to be simple; however, the way to process and support is the main research objective to be tackled in the future.

One of the key elements in intermodal transport is the location of the terminals. With this paper we want to demonstrate a first modelling approach to tackle some of the issues mentioned, in order to provide more adequate decision support for the selection of locations for new terminal initiatives.

The remaining part of this paper is organized as follows. In section 6.2 we will discuss the policies and actor perceptions on intermodal transportation at the different levels of policymaking. With insight into the main actor perceptions we have been able to select the main decision variables for each level of policymaking. Using these decision variables, we have made dedicated models to identify potential terminal locations. Section 6.3 includes the descriptions of the models and the results obtained from the models. Section 6.4 gives some conclusions.

6.2 Policies for Intermodal transportation

In paragraph 6.2.1 a general introduction on intermodal transportation will be given. In order to get some insight into the perceptions of actors, the policies and actor attitudes for intermodal transportation are discussed on European, national (Dutch) and regional level in

the paragraphs 6.2.2, 6.2.3, and 6.2.4, respectively. Paragraph 6.2.5 briefly describes the operational level. Paragraph 6.2.6 will give an overview of the main factors to be considered for all actors.

6.2.1 Intermodal Transportation

For the description of intermodal transportation is referred to the description of the European Conference of the Ministers of Transport: 'the movement of goods in one and the same loading unit or vehicle, which uses successively several modes of transport without handling the goods themselves in changing modes' (ECMT, 1995). In our research we have only focused on containerized transport, other forms of intermodal transportation (of bulk-goods, fluids and/or gasses) are beyond the scope of this research. For a good understanding the general logistical practice for intermodal transport can be described as follows:

A carrier picks up an empty container from an empty depot by truck, stuffs the container at the shipper's location, and takes the container to the nearest terminal. The terminal operator receives this container, stacks the container temporarily and tranships the container on the scheduled train or barge service. On fixed departure-times a train or barge departs for a long-distance trip to another terminal. Then the container is temporarily stacked and a carrier arranges the final delivery to the customer.

'Above all, intermodal transportation is not just the hardware or equipment involved with the freight movement, but the process, which becomes a major component of the systems approach to business' (Muller, 1995). For destination to be reached by sea transport, one of the terminals is always located at a port. For the seas-containers this means that one extra container handling is not needed. The implication can be reflected in Table 6.1 with the break-even distances for intermodal transport in relation to road transport.

Table 6.1: General break-even distances (in kilometers) compared to road transport (Ministry of Transport, 1994)

	Barge	Rail
Continental Containers	250	400
Sea Containers	100	200

In the global logistics supply chains of multinational companies, i.e. the demand-side of transportation, a growth of importance of reliable transportation can be observed due to the rise of more Just-In-Time oriented logistics, i.e. the value-adding functions being at the right time at the right place. From the supply-side of transportation the competition between the transport modes is still focused on price. Table 6.1 shows that road transport still seems to have a competitive market position, especially up to distances of 250-400 kilometres.

6.2.2 The European Level

The first policy level is oriented towards the actors playing a part in the European hinterland. The main borders of this area stretch out from the seaports Le Havre, Zeebrugge, Antwerp, Rotterdam, Bremen, and Hamburg to several European hinterland terminals, such as Milan,

Metz, Munich etc. The main actors involved are European Ministers of Transport, shippers, road carriers, intermodal agents and their carriers. Many shippers have changed their distribution structures as a result of the removal of trade barriers. Due to the cost reducing opportunities many stock-holding units have, in their distribution structure, been eliminated or outsourced. In order to maintain the same reliability Just-In-Time deliveries have become more important. This has led to growth in transport, mainly conceived by road carriers. Therefore, this growth has been inevitable and has, in interaction with the increasing passenger car traffic, caused congestion on important highways (Bovy, 2001). The congestion negatively influences the total transport time for delivery, the reliability of the delivery and, eventually, the costs. This provides opportunities for intermodal transportation. Also the trend of spatial concentration of inventories increases possibilities to cluster (combine) transport, i.e. the necessary initial condition for intermodal transportation. That is the reason why the shippers are not unwilling towards new intermodal transport initiatives. Apart from this reason, some shippers strive for a 'green' company image by choosing environment-friendly transport like intermodal transport. There are still some obstacles in the eyes of the shippers which have to be solved. Their main concern is the current price of intermodal transport. A large survey showed that the 'cost-oriented' group of actors uses intermodal transport most intensively. With more than 50% of the sample (92 companies) it shows the largest actual demand for intermodal transport (Spin, 2002).

A point of concern is the number of intermodal destinations in the European hinterland. The total number of terminals connected by water and/or rail infrastructure is still too limited to allow intermodal transport to compete with road transport on a large scale, due to the high level of flexibility and detailed networks of road transport. The European Ministers of Transport try to draw up plans for the development of Transport European Networks (TEN). These plans are focused on the integration of transport modes and define the transport networks in hubs and spokes. At hubs fast transshipment should be facilitated and subsequently transported by the spokes. The integral management of the transport at a hub consists of physical transport infrastructure, traffic-controlling systems, positioning systems and navigation systems. The European Ministers of Transport try to coordinate and stimulate the infrastructural developments of each country in the direction of the plans for TENs. The Figures 6.1 and 6.2 represent the TEN for the Netherlands, i.e. the railways and waterways, respectively.

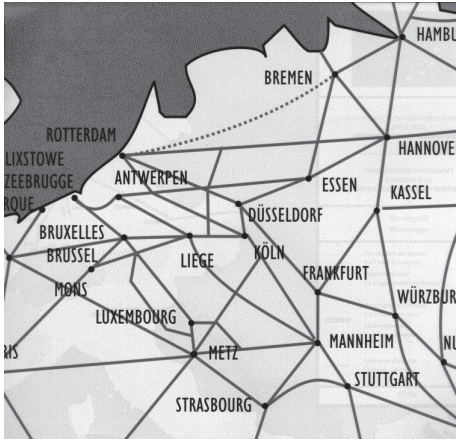


Figure 6.1: Part of the Trans European network - Railways connected to Holland (horizon 2010)

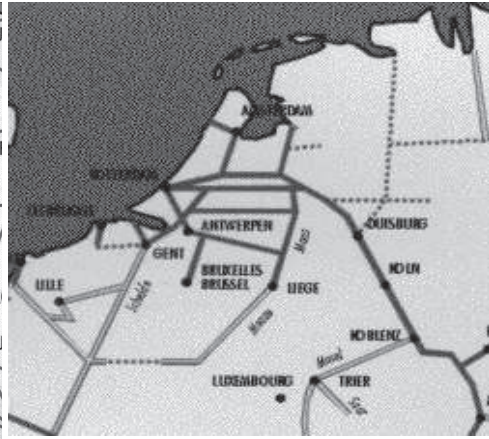


Figure 6.2: Part of the Trans European network - Waterways connected to Holland (horizon 2010)

They do not have an explicit disposal for steering instruments on national governments, but they can stimulate some developments by providing subsidies. The PACT-program was a first initiative for promoting intermodal services and now the Marco Polo program has been set up as a start-up aid for new non-road transport services (EC-DG/ET, 2003). The intermodal agents and carriers have already established intermodal transport services for long-distance haulage. Thick maritime container flows are transported by these agents from harbours to far locations in the hinterland (for example from Rotterdam to Milan). So far short-distance intermodal initiatives have not been undertaken since it seems almost impossible to collect thick container flows for short distances. Because of their strong competitiveness, price and flexibility, the road carriers still have the greatest market share of transport in Europe. The internal competition between road carriers is strong and therefore many carriers operate break-even or even less than break-even. As in other sectors mergers, takeovers and new alliances are daily news and should be interpreted as a matter of strategic management to survive in the long run. Some road carriers experience hindrance caused by some measures of national policies which aim at reducing truck traffic. For instance, in Switzerland and Austria truck traffic has strongly been reduced and a lot of trucks are placed on trains. Germany currently tries to solve the remaining technical problems of the announced MAUT-levy (a levy on infrastructure use by trucks).

6.2.3 The National Level (Dutch)

The national government is represented by respectively the Ministry of Transport and Public Works, the Ministry of Economic Affairs and, the Ministry of Environmental Affairs. All these Ministries show a strong compassion for the development of intermodal transport. The Ministry of Transport tries to stimulate intermodal transport initiatives in order to maintain accessibility to important economic centres. The water infrastructure, and to a lesser extent, the rail infrastructure still have enough capacity to accommodate extra traffic. The environmental performances of these modes appeal to the Ministry of Environmental Affairs.

The Ministry of Economic Affairs attaches importance to generating economic value at the hub-terminals. At these terminals a lot of transshipment is carried out and these terminals attract companies providing good accessibility to all kinds of transport modes. While the Ministry of Economic Affairs is strongly focused on generating economic value, a governmental policy can be observed being extremely focused on terminal development within the frontiers of the Netherlands (Roermund *et. al.* 1995) (see Figures 6.3 and 6.4). With a minimal break-even distance for intermodal transport of at least 100 kilometres, it is not strange that the national policy is completely ‘frontier-oriented’ by trying to locate the (new) economic activities around terminals within the Netherlands. The so-called Trans European Inland Terminals (TEIT) and their connected infrastructure should function as the spokes in the European hub-spokes network, having intermodal services on these lines. Therefore we have seen upgrades of the terminals of Twente, Nijmegen, Venlo and Veendam. In the policy plans Valburg was mentioned as a promising new water and railway terminal. The areas within the vicinity of the terminals should develop as logistics service parks for value-adding services. That is the reason why the Ministry of Transport had provided SOIT-subsidies (Subsidies Of Inland Terminals) for seven new terminal initiatives in the regions of Brabant and Overijssel (Modal shift, 2004).

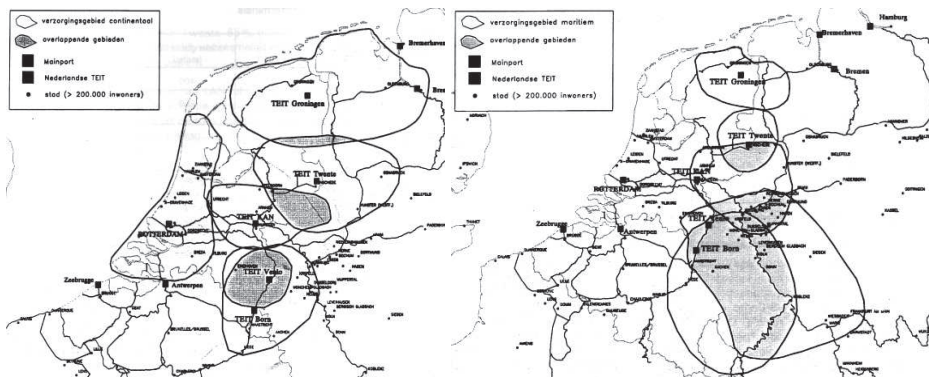


Figure 6.3: Continental container service areas⁴ **Figure 6.4: Maritime container service areas¹**

Two branch organisations also playing an important part at national level are the interest groups EVO and TLN. The EVO serves the interests of the shippers with self-organized transport in the Netherlands. Facing these interests, the EVO is quite similar to the attitude of the shippers at European level. The freedom of transport choice seems to be an important issue. TLN represents the carriers, the members of which consist for 90% of traditional road carriers and for 10% of intermodal carriers. This important union strives after fair competition on the transport market without governmental interference regarding any of the transport modes (apart from infrastructure provision). Within TLN, the road carriers want to maintain their current position as well as their total number of members. At this moment the road transport sector has a keen internal competition and many carriers even accept losses. The inland intermodal agents are to a limited extent represented in the TLN. These agents develop

⁴ Source: Roermund *et. al.*, 1995, page 111

long-distance services in the Netherlands. Because the Netherlands is a small country, the number of these services is limited.

6.2.4 The Regional Level

At regional level local authorities would like to develop their cities in terms of economic growth by providing accessible industrial sites. The attraction of an intermodal terminal could be a serious alternative for the improvement of the accessibility. By providing subsidies or/and raising low ground taxes they try to attract companies to their areas. That is why some shippers are reconsidering locations, but the main motive for changing locations is the accessibility and their location towards their customers' positions. Shippers try to organize their transport with high frequencies (allowing inventory reductions) against low prices and demand a high flexibility towards the ordering times. Therefore, terminal agents have to attract large freight volumes, and transport them with high frequencies on a regular basis.

6.2.5 The Operational Level

At operational level the carriers do their utmost to follow the fixed transport schedule. The terminal operator wants to use its transshipment equipment and its floor space as well as circumstances allow. If the shipper agrees on price and transport schedule, he/she wants to be 'on-line' informed about the transportation progress.

6.2.6 Overview of actors' factors

Now all actors' perceptions have been identified for each level of policymaking, it is possible to sum up the main factors to be considered. The identification of these factors is important since they need to be incorporated in the models to be built. Table 6.2 gives an overview of the main factors to be considered.

Table 6.2: Factors to be considered for each policy level

Policy Level	Actors	Factors
European	Shippers	Price # connections of intermodal transport services
	Ministers of Transport	# connections of intermodal transport services
	Intermodal Agents	Price Long-distance intermodal transport
	Road carriers	Price Transport for all distances
National	Shippers (EVO)	Price # connections of intermodal transport services Freedom of transport choice

	Ministry of Transport	Hub-and spoke terminal network with frontier orientation Economic value at Dutch terminals
	Ministry of Environmental Affairs	Environment benefits of intermodal transport
	Ministry of Economic Affairs	Hub-and spoke terminal network with frontier orientation Economic value at Dutch terminals
	TLN (carriers and intermodal agents)	Long-distance services Maintain market positions Free market
	Local government	Terminal attraction by low ground taxes
Regional	Shippers	Price Frequency of the transport service Flexibility
	Intermodal Agents	Attraction of transport volumes Frequent schedules
	Local government	Terminal attraction by low ground taxes
Operational	Shippers	Transport information of transport progress
	Carriers Terminal Operator	Transport on schedule Crane utilization Floor utilization

6.3 Modelling Intermodal Networks

This section describes the modelling approach and presents the results of applying the approach to identify the locations of potential terminals in the Netherlands.

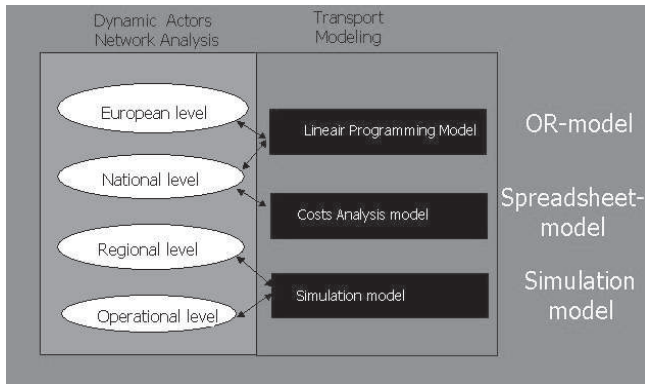


Figure 6.5: Modeling Approach for intermodal transportation

Figure 6.5 represents the modelling approach for the support of selecting good terminal locations at all levels of policymaking. The approach includes three steps:

1. Railway or water infrastructure permitting, the model decides on the basis of regional transportation demands whether it is more cost-efficient to service by intermodal transportation or by road transportation. The focus of the model is to determine the economic feasibility of the connections between national terminals and other European terminals. The formalisation is based on a linear programming model (OR-model) minimising the integral transportation costs. The description of the model and the modelling results are given in paragraph 6.3.1.
2. When the rough locations of terminals are identified in a region, a second model is applied to search for the exact location in the region. The preference locations are determined on the basis of their infrastructural accessibility. A detailed cost model is developed to support this exact location decision. The model and the results are given in paragraph 6.3.2.
3. The last part of this approach is focused on the possible customers in the neighbourhood of the terminals. Analysis of suitability, timeliness, and deliverance reliability of goods are factors of logistics importance. These aspects are both for the terminal and its customers specified by a simulation model. The model is given in paragraph 6.3.3.

6.3.1 The Linear Programming model

Since price seems to be the most important performance indicator at both European and national level (see paragraph 6.2.5), we developed a linear programming model based on the main factor for selecting transport: ‘price’. The model is applied for locating shuttle-services between terminals in Europe and based on

the calculated volumes of the shuttles, whether a new terminal location will be attractive or not. A shuttle-service is a general logistics concept for intermodal transportation services. The service operates with a fixed (time-)schedule to fixed terminal locations elsewhere and vice versa. The continental container transport demands (NEA, 1992) between several European regions, with origin or destination Netherlands, are optimally assigned to the transport network. Actually, the model is a special case of location/allocation models (Koopmans &

Beckman, 1957; Daskin, 1995; Drezner, 1995). The transport network contains direct road transport connections and intermodal transport connections between terminals. The optimisation is restricted to one year. The objective function is defined as follows:

$$\begin{aligned} & \sum_j \sum_k X_{jk} d_{jk} C_s(j,k) + \\ \text{Minimize} \quad & \sum_i \sum_j \sum_k \sum_l x_{ijkl} (d_{ij} C_p(i,j) + d_{kl} C_p(k,l) + C_h(j) + C_h(k)) + \\ & \sum_i \sum_l x_{il} d_{il} C_r(i,l) \end{aligned} \quad (1)$$

Before describing the model in more detail, we will first elaborate on the objective function which includes the following three cost elements (*see Formula (1)*):

1. Shuttle Costs per TEU⁵ between terminals. The costs of a shuttle connection are determined (by the model) at the largest volume in one direction. The volume in the reverse direction should be geared to this volume as much as possible.
2. Costs per TEU for pick-up and delivery, and the transshipment costs per container at a terminal.
3. Costs per TEU for direct road transport between regions.

The linear search algorithm minimizes the objective function subject to the following constraints:

$$X_{jk} \geq \sum_i \sum_l x_{ijkl} \quad \forall j, k \in T \quad (2)$$

$$X_{jk} \geq \sum_i \sum_l x_{ikjl} \quad \forall k, j \in T \quad (3)$$

The capacity of an intermodal shuttle-service connection is determined by the volume of the largest transport flow in forward or backward direction. This restriction is necessary to model the return of empty containers.

$$x_{il} + \sum_j \sum_k x_{ijkl} \geq D_{il} \quad \forall i, l \in R \quad (4)$$

The sum of transported containers between region i and region l must be met for the specific demands.

- x_{il} : volume TEU of direct road transport from region i to region l
 x_{ijkl} : volume TEU of the intermodal transport from region i via terminal j and terminal k to region l
 X_{jk} : maximum volume TEU of a transport connection between terminal j and terminal k
 D_{il} : transport demand between region i and region l
 d_{od} : distance from location o to location d
 $C_r(i, l)$: costs per TEU-kilometer for road transport between region i and region l

⁵ TEU = Twenty foot Equivalent Unit

$C_p(j,i)$:	costs for pick-up and delivery per TEU-kilometer from terminal j to region i
$C_s(j,k)$:	shuttle costs per TEU-kilometer between terminal j and terminal k
$C_h(j)$:	costs of transshipment/handling per TEU at a terminal j
T :	collection of selected terminals
R :	collection of all regions.

Assumptions and data

Applying this model formulation to the TEMII-data provides us with a large solution space. The model contains 129 regions in Europe with a transport demand, 21 choices for intermodal rail terminal locations, and 13 choices for intermodal barge terminal locations enabling more than 9 million alternative transport connections. To reduce the solution space, some restrictions have been added to the formulation. For instance, regions having a road distance larger than 100 kilometres to a terminal, have been excluded from the solution space since the chance that these regions will use this terminal in an optimal solution is zero. This LP-formulation allows us to make a network optimization based on costs. The results of this model indicate which terminal locations could have competitiveness towards road transport. Furthermore, based on the incoming and outgoing transport volumes, an evaluation of the geographical location of a terminal could be given. The following tariffs (Konings, 1993) (Table 6.3) were applied in the model:

Table 6.3: Overview of cost drivers (Konings, 1993)

Cost drivers	Price per TEU
Road transport direct	€0.55 per km
Road transport drayage	€0.55 per km
Rail Transport	€0.15 per km
Barge Transport	€0.11 per km
Transshipment/handling rail	€27.27
Transshipment/handling barge	€22.73

Considerations about the assumptions and data:

- The cost-prices shown in Table 6.3 are an average representation of regular tariffs at that time. Especially road drayage costs can have a different cost-price structure since in congested areas their prices are based on time instead on travelled kilometres.
- The differences in prices between barge and rail (Table 6.3) are sometimes the reason that a rail terminal will not attract volume in contrast to a barge terminal, especially at origin-destination combinations that have both accessibility to barge and rail. This situation occurs especially for the terminals Born (part of TEIT Born), Almelo (part of TEIT Twente), and Valburg (part of TEIT KAN).
- The number of TEUs calculated for each terminal is not the real demand to be expected. However, this number should be interpreted as a maximum feasible quantity for this terminal. The model expects to have an optimal market, assuming that any shipper would always choose the cheapest transport alternative available. In reality criteria like quality and deliverance reliability are also important for a shipper (Muilerman, 2001).

- The *TEMII*-data (NEA,1992) omit some precision in the distance matrices. The distances are rounded off to units of 25 kilometres. The calculated potential European shuttle-connections are quite precise. However, the determination of the exact location of a terminal is rather rough due to the scaling of 25 kilometre units. Therefore the results at regional level are only indicative.

This analysis has a special focus on the Dutch TEITs Twente, KAN, Venlo and Veendam. Table 6.4 presents the main results, and also the continental flows for Rotterdam in order to have some reference values.

Table 6.4: Modelling results for the TEITs

Terminal	# TEUs/year	Mode	#Shuttles
Veendam/Leeuwarden	77,500	Rail	5
Venlo	150,500	Rail	5
Born	175,750	Barge	4
Nijmegen	307,000	Barge	5
Almelo	113,750	Barge	5
Leiden	31,326	Barge	5
Utrecht	43,050	Barge	5
Rotterdam	890,000	Rail	8
Rotterdam	811,750	Water	6

Remarkable are the results for the barge terminal in Nijmegen. At that time no continental containers were handled at this terminal. Also very remarkable is that the results show no volumes for the new to be built terminal Valburg. The favourable location of the terminal Nijmegen attracts all the possible demand in this region. For the validation of the model it was quite convenient that the total volume transhipped for the TEIT Veendam exactly matched the number of containers 77500 TEUs determined by Buck consultants at the Rail Service Centre in (Buck Consultants International, 1996). The results of the model indicate a restricted attraction for the terminals mentioned in Dutch policy plans. Apart from the barge terminal at Nijmegen, the other terminals located nearby the frontiers seem to be less important. The Dutch policy plan for terminal development has forgotten to consider the international competition of terminals situated nearby the Dutch frontiers, such as Duisburg in Germany and Liège in Belgium. The Dutch policy plans do not cover terminals for short distances, i.e. less than 50 kilometres. However, the model results show good opportunities for inland terminal development with terminal distances shorter than 50 kilometres.

rs, i.e. Utrecht and Leiden/ Alphen. These results are contrary to current break-even distances, but if enough bundling of volumes can be reached, then the break-even distances can be shorter.

6.3.2 Detailed Cost Model

With the linear programming model we obtain rough indications of possible terminal locations. The next model is applied to identify more specifically where a terminal should be located on a detailed cost specification at regional level. For one of the identified terminal initiatives Leiden/Alphen, a detailed Activity-Based-Cost-model (spreadsheet-model) was

developed (van Ham *et al.* 1997). In order to determine the total costs more precisely, the costs for transshipment, the cargo-handling equipment, acreage and personnel requirements are relevant. Each cost component will be discussed.

Table 6.5: Typical requirements for inland (barge) terminals (NEA/Haskoning, 1991)

Cost Drivers	<5000 TEU	5000-15000 TEU	>15000 TEU
Equipment:			
-gantry crane		1	1
-mobile crane	1		
-fork-lift truck	1		1
Personnel:			
-crane operator/	1	1	2
fork-lift driver	1	2	2
-gatehouse			
Acreage (hectares)	<0.33	0.33-1.0	>1.0

On this basis (Table 6.5) the costs of transshipment can be calculated. In this model, due to economies of scale, the costs per container will decrease, but what is even more interesting, stabilize when throughput exceeds approximately 10 thousand containers annually.

Transportation by barge

For transportation by barge two situations can be distinguished. A new inland terminal may be located near an inland waterway, where scheduled services by barge already exist. In this case the new terminal is just an extra port of call and a fixed tariff can be arranged with the inland water carrier. Otherwise, a complete new service must be organized. The vast majority of the major Dutch inland waterways can accommodate ECMT IV class-barges with a capacity of 1500 tons or 90 20-foot containers. To charter such a barge amounts 450 thousand euros annually.

Drayage

Local pick-up and delivery of containers is usually carried out by truck. The fee charged for the movement of a container between the terminal and the point of origin/ destination differs from the tariffs in long-distance road haulage. On short distances, costs are determined more by time (€30.05 per hour) than by distance (€0.32 per TEU kilometre). For long-distance road transport an average tariff of €0.84 per TEU kilometre was applicable.

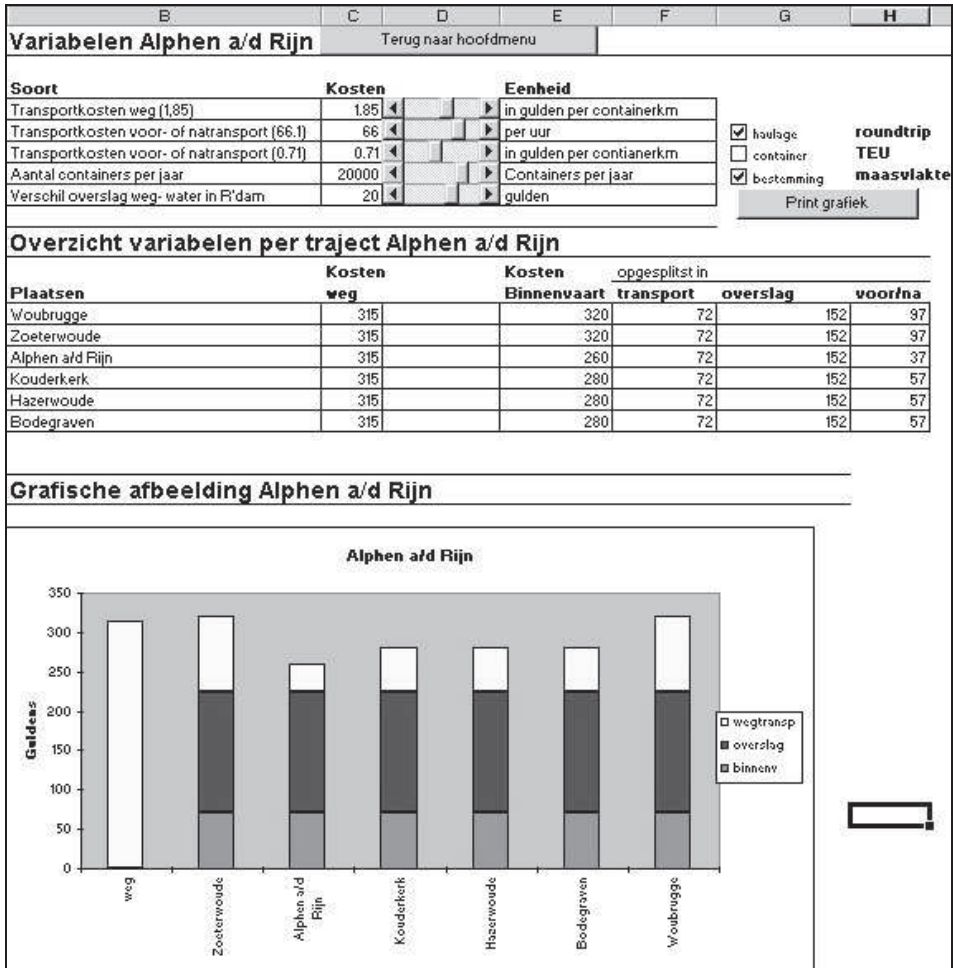


Figure 6.6: Overview of cost comparison (model) between different terminal locations and direct road transport. The model shows that Alphen a/d Rijn is the best location. The model was developed for Dutch application.

Results Cost model Alphen a/d Rijn

At the time of writing this paper, a new inland terminal in Alphen aan den Rijn is under consideration. In this region several large shippers are to be found. Amongst these shippers the Heineken Brewery and the Swedish Electrolux company are the most important ones. This initiative received a warm welcome. Given the amount of cargo, forecasts indicate a throughput of at least 20,000 containers annually, or 80 containers every day. To get an impression of the terminal operations, the rail-mounted gantry crane needs approximately 5 hours to (un)load the barge. In the vessel, two out of every three slots are in use. The terminal is to be built south of Alphen aan den Rijn, which allows a daily sailing schedule to the Port of Rotterdam with just one barge. Special attention should be paid to minimizing the number of callings at the deep-sea terminals in the port area. Moreover, handling barges at the sea

quay incurs extra costs. These extra terminal handling charges (THC) were added as a surplus of €9.09 on the transshipment costs. The final cost comparison between road transport and intermodal transport showed four favourable locations in the vicinity of Heineken. Figure 6.6 shows that the total costs for transporting one container by barge are lower compared to road transport in case of the use of a terminal at the locations Alphen a/d Rijn, Kouderkerk, Haserwoude, and Bodegraven. The calculated tariffs demonstrated opportunities of cost reductions up to twenty percent of the road tariff.

6.3.3 Simulation Model for terminal operations

If shippers have decided to service their transport demands by intermodal transport, the management of the operations becomes an important issue. The transport schedules have to be determined in such a way that from the shippers' perspective the time conditions for delivery have to be met, from the carriers' perspective the vessel/train loads have to be filled up as much as possible, and from the terminal agents' perspective the productivities of the cranes have to be guaranteed. From the municipality perspective the usage of space and related truck movements is important with respect to the development of their town-planning plans.

To visualize these individual important factors of the actors, the logistics processes are modelled in a simulation model. The simulation model shows the entering of a ship at a quay. When the ship has arrived, the cranes start to unload the ship. The straddle-carriers pick up the containers and take the containers to the stack. The straddle-carriers also perform the opposite action, taking containers from the stack to the position below the crane. This action is carried out by the straddle-carriers after the ship has been unloaded. Other straddle-carriers work on-demand for the trucks entering the terminal. The trucks bring their containers. If a gate is available, the straddle-carrier will pick up the container from the truck and take it to the stacking area. The opposite handling is done for the containers coming from the stack. (*see Figure 6.7*)

The model has not been applied yet for the terminals Alphen a/d Rijn and Utrecht. However, with this model it is possible to determine a feasible terminal configuration with respect to the determination of the number of cranes, straddle-carriers and gates. Besides a visualization of the internal processes, it also provides insight into the space allocation used by the terminal. The seize of stacking area and the number of parking places outside the terminal can be determined. When all the gates are occupied, the trucks should park at parking places.

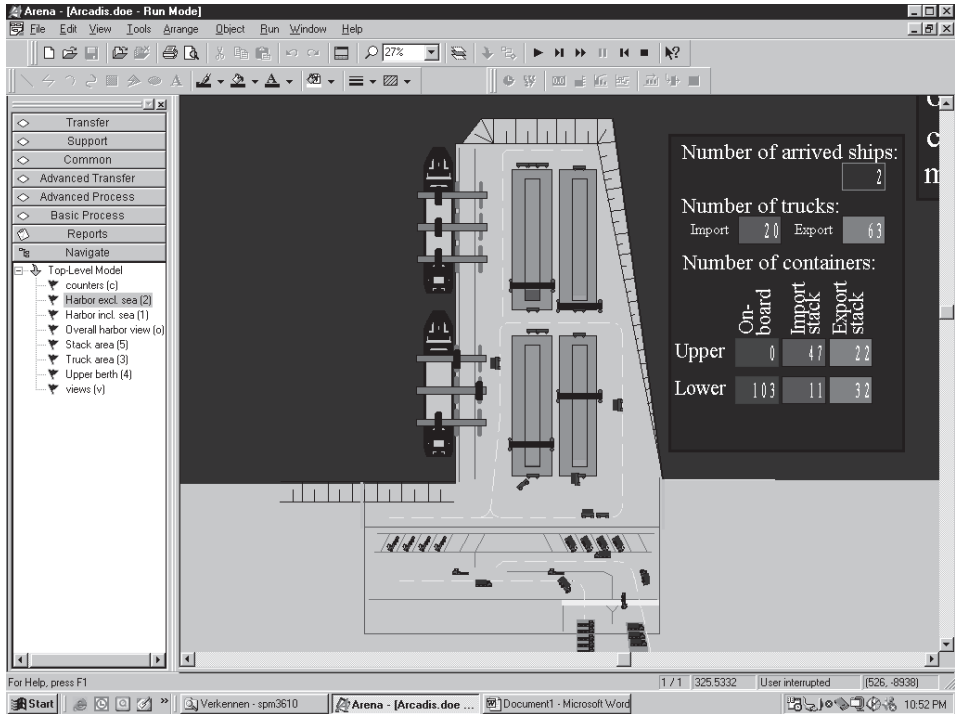


Figure 6.7: Snapshot of the simulation model

6.3.4 Models review

For each scope of analysis a specific model has been developed. First of all, the selection of (new) shuttle-initiatives is determined by a LP cost-minimisation model. Summing up all the shuttle-initiatives at a terminal, it is possible to identify whether enough volume will be generated. Secondly, for each identified terminal the exact location of the terminal should be determined. The first model just points to a possible region where a terminal could be located. Several alternative terminal locations are compared to each other. The main costs elements are based on the distances to the main shippers in the vicinity of the terminal, the terminal equipment applied and the number of possible roundtrips per day for a ship or train. At the end all the operational activities at a terminal will be analyzed with the simulation model.

Because of the hierarchy in the modelling approach, the higher level is directive for the level below. The approach starts from rough locations for (new) terminal location identification to more detailed location identification. If no terminal locations can be identified at a more detailed level, other terminal locations at the higher level should be studied over into more detail. This procedure continues until no attractive terminal locations can be identified.

6.4 Conclusions

Due to actor perception analysis, we have been able to identify critical (success and failure) factors which are felt to be important by the actors at every level. Thanks to the recognition of

actors in specific arenas we can build specific decision-support models for adapting specific factors of concern. With these models we can better predict where terminal locations can stay at the long run. With regional demands and national scale it is possible to appoint in which areas terminal locations can be built. The next step is to look over the area for certain possible locations and consider the distances to the most important multi-national companies. With this kind of modelling we can exactly show where the terminal can be built more competitive to the road transport.

Based on our experiences with this approach, we are able to indicate locations for new terminals. Two identified terminal locations have led to serious terminal initiatives in practice. The gap between the policy plans of the governments and the level of operational processes has grown too far apart. The dynamic behaviour of the actors involved cannot be statically stated in policy plans, but as Muller (1995) stated: ‘intermodal transportation is not just the hardware or equipment involved with the freight movement, but the process, which becomes a major component of the systems approach to business’.

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7 Synthesis, research findings and methodology

Honest differences are often a healthy sign of progress
(Mahatma Gandhi)

7.1 Introduction

In chapter 1.1 (Introduction) we argued that the scope of logistics systems thinking has changed from a mono-actor or company perspective towards a multi-actor perspective in which governmental policy-making actors and public organisations are more involved due to the societal effects and environmental impacts of logistics. A stronger cooperation with policy making is needed between institutional bodies, responsible for policy making, financing and investment decisions on the one hand and manufacturing companies, logistics providers, transport operators and managers of transport & logistics nodes on the other hand, whose decisions and supply chain strategies strongly affect the spatial pattern and the modal split of freight transport. In order to achieve sustainable logistics solutions at both a regional and a national level, logistics criteria should be adopted in spatial planning, in particular in the planning of infrastructure networks, the set up of industrial areas and in the choice of the companies to be located in production areas. This change in perspective has been referred to as a move towards more public logistics.

In this chapter we will review the cases in terms of identified research gaps, obtained results, input for methodology development and the performed case study validity checks. For each case (Section 7.2 until Section 7.6) the obtained results will be discussed. Furthermore the identified research gaps will be addressed in terms of theoretical or practical gaps, respectively labelled as Gap 1 and Gap 2 in Figure 1.2 in Section 1.3. For each case we have applied case study research and therefore we will reflect on the four validity tests mentioned in Chapter 1 (Kidder & Judd, 1986, pp. 26-29; Hutjes & van Buuren, 1992) in order to explore the generalisability of the developed knowledge:

- *Construct validity*

The empirical data should be collected by proper operational measurement. The empirical phenomenon ought to be measured precisely. The elimination of subjectivity towards the observations can be obtained by:

- the use of multiple sources of evidence;
- the establishment of a chain of evidence;
- the review of key informants which could be colleague researchers and participants in the case area (i.e. so-called ‘member check’)

- *Analytical validity*

Analytical validity or validity of causal interpretation (Molin, 1999) refers to the assumed causal relations between the variables in the case studies. To check the analytical validity we searched the literature for other studies where our presumed modelling causalities could be found with similar model functionalities and axioms.

- *External validity*

External validity deals with the earlier mentioned problem of generalisability (Cook & Campbell, 1979). In order to prove this type of validity the assumptions made and conditions imposed on a case should be studied carefully before suggesting a generalisation of the acquired knowledge. Applying replication logic on other cases is considered a satisfactory method to support the argumentation of generalisation.

- *Reliability*

The last type of validation is the reliability of working procedures. Following the working procedures ideally, identical results should be obtained. In each case the working procedure is explained and data are available to enable similar experiments to be set up with the models. Validation of the applied methods has been carried out.

As the final case activity we describe the methodological findings that can be used as a contribution to the concept design approach. The structure of this chapter is as follows. Section 7.2 shows the research findings from auctioning as a concept of bundling, section 7.3 shows the research findings from estimating the CO₂-footprints of container terminal port-operations, section 7.4 shows the research findings from a new barge terminal in a residential area, section 7.5 shows the research findings from new challenges for urban consolidation, and section 7.6 shows the research findings modelling terminal locations using a three-spatial scales framework. Section 7.7 summarizes the identified research gaps and the research findings based on the individual research cases and discusses some directions for improvement of the approach for logistics design to fill these gaps. Section 7.8 contains the description of a convergent design approach for logistics concept development in a multi actor environment. Section 7.9 shows how the cases have contributed to the approach. Section 7.10 presents the main conclusions of this chapter.

7.2 Case 1: Auctioning as a concept for bundling

Research gaps

In the literature we find many contributions on consolidation of urban freight transport flows (Binsbergen & Visser, 2001). The use of consolidation centres can potentially result in substantial transport benefits. Huschebeck and Allen (2005) have shown reductions in the number of vehicle trips, reductions in the number of vehicle kilometres, and better utilization rates for vehicles. However, in practice most consolidation concepts seem to fail during implementation in practice (Gap 2). The BESTUFS report (Allen et al., 2002) and Browne et al. (2005) have shown that the number of users (volume obtained) is the most important factor in explaining the success or failure of such implementation cases.

The ex ante analysis of the concept of consolidation should therefore be studied more broadly, beyond its traditional approach of a mono perspective (Gap 1). For example, initiatives such as night deliveries (Verlinde et al, 2011 and bundling concepts without consolidation centres (Verlinde et al. 2012) should be included as potential concepts for research. According to Verlinde et al. (2012) the main cause of inefficiencies in urban distribution is the lack of direct consultation between carrier and receiver which results in a flood of small orders and many small deliveries. Verlinde also concludes that within the existing literature and research on city logistics urban consolidation has never been treated as a stand-alone concept. Urban consolidation has only been examined in detail in relation to the concept of urban consolidation centres. Other bundling concepts have generally only been considered during the initial period of city logistics research, where they have only been examined superficially. Therefore Gevaers et al. (2011) emphasise the need for more in-depth analysis of goods flows. They address the importance of gaining insight into the underlying relationships between the various characteristics of the goods flows, to further optimize the allocation of scarce resources as an innovation for the final link of the supply chain. Also Holguín-Veras et al. (2011) conclude that freight mode choice can be best understood as the outcome of interactions between shippers and carriers, and that mode choice depends to a large extent on the shipment size that results from shipper-carrier interactions. Like Holguín-Veras et al. (2009), Gevaers et al. (2011) and Verlinde et al. (2012) we searched for an innovative solution for the last mile delivery and proved, using an in-depth analysis, that auctions are a potential innovation to service the last mile delivery.

Obtained results

Auctions can help to create more transparent, effective and efficient freight markets, as shippers have more information about carriers and vice versa. Through the real time and simultaneous auctioning and re-scheduling of deliveries, we were able to study in some detail the dynamics of bidding behaviour of both carriers and shippers which forms a contribution to theoretical research gap (Gap 1). The inclusion of realistic criteria for shippers and carriers has shown that a detailed picture of the effects of freight auction systems can be simply obtained. Like Song and Regan (2003) and Figliozzi et al. (2006) our study confirms that an auction system can contribute to a higher degree of consolidation by an improved clustering of routes. The case study also showed that benefits accrue to both carriers, shippers and municipality. For the carrier the auction can be seen as an opportunity to improve the occupancy rate of transport vehicles. Shippers can respond better to the delivery punctuality required and obtain better rates or price conditions. From the policy makers' perspective we

observe that both the total driving-time and the mileage covered in the city centre decreased. In addition, the transport market for shippers and carriers became more open and transparent for all parties involved. The analysis of the auction-concept showed benefits for all the parties involved which could contribute to a successful implementation in practice (Gap 2).

Construct validity

Like Song and Regan (2003) and Figliozzi et al. (2006) we found that an auction system can contribute to a higher degree of consolidation improving the clustering of routes. Similarly, Zhou et al. (2011) also identified the potential benefits of using a bidding system in their case of dedicated capital investment and operations in a regional logistics center. Qureshi et al. (2009) refer to our work by quoting that the vehicle routing and scheduling problem (VRP) can be used as a principal tool for evaluating many types of city logistics schemes. Another paper by Qureshi et al. (2010) refers to the use of the TABU-search method in solving soft time windows problems. Lin (2010) studied the integration of otherwise mutually exclusive hierarchical hub-and-spoke networks as a static operation planning problem. Lin (2010) mentions our work as the dynamic real-time variant which studies real-time matching of carriers' services and carrying capacities with shippers' uncertain demands through the auction process. Lin's studies showed that the integration of secondary routes by bundling leads to a substantial reduction in operating costs, especially in the reduction of feeder fleet size. These outcomes are in line with our findings.

From policy practice the former Ambassador of Urban Distribution Eric Janse de Jonge also stresses that parties must continue to work on bundling, bundling and bundling again because that is the way to handle urban distribution (from his farewell speech as Ambassador on 29th November 2011).

Analytical validity

The applied modelling formalisms (procurement model, simulation model and routing model) are based on representative casual relationships between the variables. In our case study we applied a multi-dimensional procurement model as presented by Koppius et al. (2000). In our simulation model the shopkeeper's request has attributes that can be any combination of values expressed in a monetary unit and a non-monetary unit, i.e. price and supplier's reputation. For the dynamic routing and scheduling we used a TABU-search algorithm which was calibrated on the Solomon VRPTW C101 problem instance order (Solomon, 1987).

External validity

The behavioural aspects of carriers and shippers are static in our experiments. Our research findings are therefore only an identification of hypothetical potential benefits. The validity of conclusions about the broader applicability of the e-auction concept should be further researched with adjustments of the modelling framework compared to more real-world actor behaviours (shipper, shopkeeper, carrier and municipality). A further step in assessing this behaviour as compared to our approach would be, for example, by developing a gaming environment based on agent-based modelling for the auctioning and planning of transport orders (see for example van Duin et al., 2012).

However, in practice we found an implementation of our e-auction concept as a bidding tool (e-SABIC/x-RFQ) for transport orders in hybrid markets. Similar to the market in our case study, the market is hybrid inasmuch as 'fixed' orders originating from long-term contracts

are scheduled by carriers at the start of a time-horizon while subsequent, ‘auctioned orders,’ obtained through successful bidding in an ongoing auction, are scheduled according to the sequence in which they are won by the respective carriers.

The Dutch Logistics Management Association annually rewards exceptional performance in logistics with the Dutch Logistics Prize. The prize is awarded for an innovative project clearly demonstrating its success. Last year a logistics prize (Ploos van Amstel, 2011) was given to SABIC (chemical producer) for their innovative Adaptive Dynamic Sourcing Process (ADS) which was related to their transport demand and in which the bidding tool has a prominent role. The e-SABIC/x-RFQ is an implemented copy of our e-auction concept.

In order to secure the transportation of future transport volumes in Europe SABIC proactively informs carriers about the expected need for transportation at the level of about 80% of the ‘regular’ order flow. On a monthly basis the new Sales & Operations Planning (S & OP) is determined and then planning the transport requirements can start. The contracted transport volumes are compared with the revised schedule for the next 2 to 3 months. Fluctuations in transport demand need to be shared with carriers. Additional unplanned volumes and new routes are created by contracted interim re-tendering. From the actual daily order intake the expected shipments for the next 1 to 2 weeks are forecasted. SABIC has several dozen carriers under contract for these shipments, representing over 10,000 unique routes and destinations. Carriers are automatically linked to a regular shipment once a valid contract and tariff arrangement is found in the system. The non regular shipments are scheduled via e-SABIC’s own bidding tool (x-RFQ). If a shipment arrives at x-RFQ and it fits within the carrier preferences, the carrier with the correct profile automatically receives an email alert. Once a shipment via a carrier x-RFQ has been accepted, it follows the standard shipment treatment procedure. One could argue that until now it is just one proof of implementing an e-auction concept. However, the innovation prize was awarded by an independent scientific jury of logistics experts. The innovative principles of e-auctioning can be applicable for both city logistics and multimodal transportation.

Reliability

The working procedures are well described in our case and the study protocol can be clearly followed. Calibration of the TABU-search algorithm might give some changes in outcomes. However, the use of the Solomon problem instance supports the calibration of the applied heuristics.

Contribution to concept development approach

The conceptualisation of the E-auction concept made us clear that the auction processes (sealed multiple auction) and the delivery processes of the vehicles are the main processes to specify. From the shipper’s perspective costs, pickup time, responsiveness, transport speed, punctuality/reliability are the factors of concern. For the carrier profit (bonus/discount), responsiveness and punctuality are important factors. The municipality hopes that application of an e-auction concept will lead to reduction of the total driving time, truck kilometres driven and the development a fair transport market. For understanding the e-auction several scenario’s for carrier behaviour were specified. These behavioural aspects were included in a large simulation model in which the bidding auction-processes, the delivery processes and the vehicle-routing planning were dynamically simulated. The optimisation of the vehicle-routing planning was solved using a TABU-search algorithm. With this model we were able to test

the effect of different assumptions concerning actors' behaviour on the cost of the transport system. For our approach important are the steps followed in this case as well as the capability to cover the factors of interest in a modelling framework (which is a combination of two methods: simulation and TABU-search).

7.3 Case 2: Estimating the CO₂-Footprints of container terminal port-operations

Research gaps

Current policies regarding container terminal development hardly address the issue of the reduction of CO₂-emissions related to the operations of the container terminal: generally we observe a lack of a clear plan, related instruments, and actions that focus on the reduction of the CO₂-emissions. A serious knowledge gap exists since there is almost no understanding and knowledge of the CO₂-production. Terminal operators in particular have no idea how to calculate a CO₂-footprint. It is even more difficult for policymakers to develop policies which might reduce the CO₂-emissions since they do not know what the most polluting factors in this sector are (Gap 2). As a first step, both for policy makers and terminal operators, it is therefore important to have insight in the total level of CO₂-emissions of different terminal configurations.

With respect to methods for getting this insight a lot of literature can be found on emission measurement of transport. Various measuring protocols exist (prescribing the boundaries of the measurement and the formula used to calculate the emissions) and also different databases are used for retrieving emission data per unit of fuel and fuel efficiency per transport mode. Different measuring protocols and databases result in the fact that none of the outcomes (carbon footprints) can be compared to each other (Van der Meulen & Kindt, 2010). The main problem is a lack of methodological standardisation (Agtmaal, 2008). Due to the fact that presently no standard calculation method exists and also the data which is being used for the calculation is not standardised, it is currently not possible to benchmark environmental performances. With respect to the terminals and terminal operations specifically, contrary to the field of freight transport, there is no method available which provides CO₂-footprints for the terminal activities (Gap 1).

Obtained results

A simple method is presented to estimate the CO₂-emissions from container port terminals based on fuel and energy-consumption. The developed bottom-up approach provides new opportunities for a relatively simple assessment of the CO₂-emissions per terminal, based on macro terminal data. The approach can be adopted reasonably well and simply for different terminal configurations. The approach was illustrated for various terminals in practice. The terminal managers (in Rotterdam, Den Bosch, Nijmegen, and Wanssum) have shown great interest in this method since they are forced to provide insight in their CO₂-production by local government. The method appeared to have sufficient precision in estimating the overall CO₂-production at terminals for the terminal managers. The case has provided a good contribution to the theory gap since the developed method provides clear insight into the emission behaviour of terminals for both terminal managers and authorities from the local government (Gap 1). The method also showed good potential as a standard tool for measuring CO₂-emissions at terminals (Gap 2).

Construct validity:

Based on empirical research Van der Meulen & Kindt (2010) have shown that outcomes of carbon footprints cannot be compared to each other due to the large mix of different measuring protocols and databases available. The main problem is a lack of standardisation (Agtmaal, 2008), i.e. there is no method available which provides CO₂-footprints for the terminal activities. Our model uses macro-level data such as the number of transhipments at the terminals and the deployment of various types of equipment, each with a different energy-consumption pattern, coupled with standard routes with average distances, and average energy consumption which is a simple and transparent way to calculate the energy consumptions and the related CO₂-emissions. The linear equations in the model seem to be good approximations of movements of the containers in reality and have been tested for significance.

Analytical validity

In our case study we have developed a method based on the terminal layout and the logistics routes for each type of modality. The chosen metric Manhattan distance reflects the container stacking movements over the terminal well. Our modelling paradigm was based on activity-based emission modelling (Beckx et al., 2009). We applied this modelling paradigm to develop a method to calculate the emissions caused by the operations of the container terminals, notably the movements made by the terminal-equipment. The model uses a bottom-up calculation of the amount of work performed by the equipment as input, instead of using an assessment of the amount of fuel. The fuel approach is more common in practice but much less accurate.

External validity

The external validity of the model was proven by comparing the modelling outcomes (i.e. the estimated energy consumption with the real energy consumption). For six terminals (Delta, Home, Hanno, Nijmegen, Den Bosch and Wanssum) the outcomes of the model (CO₂-production, Energy consumptions) were discussed extensively with experts at the terminals: the environmental manager at Europe Container Terminals and the vice manager of the BCTN-group (Binnenlandse Container Terminals Nederland b.v.). They confirmed the likelihood of the accurate estimates of the energy consumptions.

Most outcomes had an acceptable deviation. However, the sample size (n=9) is still small (although the case-study represented 95 percent of all terminal operators in the deepwater port of Rotterdam) and expansion of the sample size is needed. The business community has shown its interest, i.e. many international terminal operators linked in Greenport have shown interest, because the owners have been forced by the government to provide insight into their CO₂ production of the entire transport chain.

Reliability

The working procedures are well described in our case and the study protocol can be clearly followed. The method strongly relies on precise measurement of the energy consumption per type of equipment (Oonk, 2006). In order to provide good quality estimates of the CO₂-emissions, measurement of the real-world emissions should be done and the input data of the emission behaviour should be updated using these data. In future the model might be adjusted if the trend of equipment changes from diesel to electric-driven cranes. Also adjustments will be made for the energy consumption of ‘reefer’ containers.

Contribution to concept development approach

Discussions between terminal operators and local governments focus on sustainable development and economic growth. Part of the discussion on sustainability is related to the CO₂-emissions at terminals. Since neither actors have insight in the emission production at the terminals, a dedicated model was developed to estimate the emissions of the terminals based on their layout, throughput and terminal equipment configurations. The conceptual model made clear

- how the processes at terminals contribute to the total energy consumption and the related CO₂-emission.
- what the assumed causalities are and how they can be applied for many terminals.
- what are the energy consumption and emission levels of diesel and electricity for different processes/equipment.

The case illustrates here a point of convergence between the two design cycles (in Figure 1.1). We have presented the modelling results as well as the model for policymakers and managers of terminals. They identified well with the outcomes of the model. We can conclude that this case was successful in translating the insights obtained by our model to both types of actors. A shared understanding of results and the preferred solution directions (bio-diesel, compact terminal) was established.

7.4 Case 3: A new barge terminal in a residential area; using simulation modelling to support governance of noise

Research gaps

We can observe the tendency for more cities to address explicitly the contribution of barge terminals to sustainable urban development. The embedding of terminals in urban sceneries is not just a matter of the technical and physical specifications of a terminal, like the crane capacities, location of the harbour and connection to the main roads. Policy makers necessarily have to take into account the whole urban context and the effects of barge terminals on it and need to know the potential consequences of the accommodated operational logistical processes on the environmental quality. The logistical operators on the other hand need to know the consequences of alternative policy measures on their operations. In practice the consequences of noise are seldom foreseen and operating terminals are only confronted with noise constraints once their volume of operations grows (Gap 2). Inhabitants in the neighbourhood often complain then about the noise and safety conditions due to the terminal operations and the image of the terminal is negatively affected. Examples of these policy practices are the inland terminal Alpherium (Stad, 2011) and the inland terminal of Wanssum (Peel & Maas, 2011). No research contributions could be found in the literature which combines terminal performance measurement with noise constraints (Gap 1).

Obtained results

The model simulates the operational flows of a new to be built terminal in the city of Tilburg. Based on the 12 busiest days in a year and a maximum use of cranes, reach stackers and trucks, we linked the operational performance of the new terminal to its noise production. This was done assuming different circumstances and noise reduction measures. In a growth scenario of 15 % per year the new terminal shows clear advantages over the existing terminal. Due to the reduced turnaround-time of the barges (the new location has a beneficial location

with respect to the locks and the quick response speed of the trucks), the annual throughput volume of a new terminal would be much higher than the existing terminal. The analysis of terminal performances and noise measures is unique and contributes to the theory development of public logistics (Gap 1). The noise measures evaluated in the model are: (a) limiting the number of operational reach stackers at the terminal (as it is known that a reach stacker is the noisiest machine in the terminal) and (b) adjusting the working time of the terminal. The resulting insight enabled the terminal operator and the municipal authorities of Tilburg to jointly select the best terminal design option in terms of the balance between logistics performance and noise reduction, in other words an improved concept in practice (Gap 2).

Construct validity

For the success of the case study the general manager of the terminal Tilburg and the project manager noise participated actively in the study. The outcomes of the model were discussed and based on the outcomes of specific scenarios that were jointly formulated. Therefore, in an 'open' process the physical/spatial parameters were jointly verified, the noise experiments were scientifically documented and joint steps were sought after to improve both the environment and the terminal performance.

Analytical validity

The analytical validity is based on the structured approach to set up a simulation model for the terminal operations. We applied SADT as a graphic notation to describe the terminal operations in detail. According to Marca and McGowan (1988) 'SADT is one of the best-known and most widely used system engineering methods'. The model of the terminal was developed based on a discrete (event) modelling paradigm, assuming that the daily activities of terminal operations can be interpreted as a discrete queuing system. We have applied some of the validation techniques used by Sargent (2005).

The model provided insight into the consequences of the noise effects of future operations at the new terminal location. These can be compared with the noise constraints. As such, the development and application of the model provided a mutual understanding with respect to noise policies between the potential terminal operator and the municipality of Tilburg.

External validity

The number of new terminal initiatives will probably increase in the future due to the expected growth in port volumes of up to 33 million TEUs over the next two decades, of which 18 million TEUS will have a destination in the hinterland (Kuipers, 2010). Based on the experiences in Tilburg we are confident that simulation modelling can help in gaining understanding into the causal effects of noise. Even though our observation is based on only one experiment we are confident that the new terminal in Tilburg will not face the problems experienced in Alphen a/d Rijn or Wanssum (i.e. The terminal group BCTN, operating at Wanssum, is therefore forced to take various noise reduction measures like the use of a mobile crane to minimize noise and lifting trucks with a lower noise production level). The terminal location evaluation in Tilburg has been carried out with an open (constructive) communication between private and public actors. The terminal is planned to be operational in 2014.

Reliability

The working procedures are well documented in our case and the study results can be replicated. For the development of the simulation model we followed the methodology of Sargent (2005). Modelling approaches like simulation can help to achieve mutual understanding between the public/private actors involved.

Contribution to concept development approach

The study started with a description of the area of the new terminal. The main actors in the surroundings were identified. For the terminal operator the terminal performances are important such as throughput, costs and utilisation of equipment. The municipality has strong concerns about the quality of living environment (i.e. less noise) and the economic viability of the terminal. The residents and farmers desire a good quality of the living environment (i.e. less noise).

The terminal activities were described as a conceptual model showing the operational performance of the terminal. We developed a modelling approach, based on simulation techniques, to determine the effect of operations on noise. We carried out a terminal location assessment in an open process with constructive communication between the terminal operator and noise experts of the municipality. After having discussed the first simulation results, the design space of noise reduction measures was jointly determined. Different scenarios were developed for growth of throughput, adjustment of equipment, adjustment of working times of the terminal, and noise reduction measures. The resulting insights enabled the terminal operator and the municipal authorities of Tilburg to jointly select the best terminal option in terms of the balance between logistics performance and noise reduction.

This case made clear that decision making can be facilitated by a model that explicitly integrates the factors of the main actors. The model experiments gave clear insights for both the terminal operator and the municipality, leading to a mutual understanding about the preferred design.

7.5 Case 4: New challenges for urban consolidation centres (UCC): a case study in The Hague

Research gaps

The policy practice of urban consolidation centres often fail to look at/learn from the available experiences in other towns when they start with their own urban consolidation initiative (Gap 2). The critical success factors of these former consolidation practices are often omitted. Most of the literature that is available on the practice of urban freight distribution exists of non-scientific papers produced by engineering companies and local governments, describing the outcomes of their initiatives. A sound scientific theory could provide more accurate advice, but evaluations of UCCs based on such a theory are often poorly documented (Gap 1). Current research fails to look at financial feasibility of the UCCs and subsidies are too often the only way to compensate the losses in the current financial models.

Obtained results

In our survey of urban consolidation centres in the EU the *number of users*, and their related volumes, seems to be the most important factor for success or failure of all cases. The organisational setup can be identified as a critical factor. The fact that a UCC is privately organised can possibly explain success. *Subsidies* can also be seen as an important factor for success. The selection of the right *type of distribution vehicle* should meet the unique requirements for the case and therefore the distribution vehicle has to be uniquely determined for every individual UCC. All unsuccessful UCC's made use of conventional vehicles to distribute the goods to the service area. Summarising on the European practices we state that for the city of The Hague (the case that is studied here), the number of users, the organisation, the type of vehicle and the location are, although no guarantee for success, nevertheless important factors to consider for improving the chances of success (and can be seen as a contribution to implementing the concept in practice (Gap 2).

In the study elements of a Cost-benefit analysis were applied (CBA), which contributed to the methodological toolkit providing insight into this multi-actor situation (Gap 1). The analysis focused on the direct costs and benefits of the UCC in €per m³ for different amounts of goods handled per year. The analysis shows that if the UCC used medium-sized trucks (38 m³) and the transport demand was at least 150,000 m³ goods per year, the benefits are higher than the costs. A volume of 150,000 m³ goods per year implies a participation of approximately 60% of the target group shops. Application of the CBA shows that full participation of all the shops in the target area would lead to a reduction in vehicle kilometres by distribution traffic of 8%. Browne et al. (2005) assessed the most commonly quantified impacts in ex ante studies of 17 studied UCC cases. The performance indicator *vehicle kilometre reduction* was calculated in only 7 cases. The calculations were all done in preparation of the implementation of an UCC. In these cases the predicted reductions in vehicle kilometres of distribution traffic varied between 30-45% (Browne et al., 2005). Compared to these predicted reductions, our study in The Hague shows that the distribution activities in The Hague are fairly efficient (the average load capacity of the distribution vehicles entering the city centre is 50% and the average total load capacity of the other vehicles is 80%).

Construct validity

To validate the case findings of the UCC survey, representatives from both public and private actor groups were asked to verify the outcomes of our survey with their own experiences. The following people shown in Table 7.3 were contacted for each case specifically and were asked for information about the city, description of the project, type of UCC, origin of the initiative, organisation/funding, number of participants, accompanying measures, types of goods, amount of cargo, distribution vehicles, infrastructure, location, service area, results and lessons. In the end results of the interviews were used to set up the protocol for analysis of the case study in The Hague (Van Duin et al., 2010).

Table 7.3: Key informants Case 4

Name	Municipality/Company	Date	Mode of communication
Birgit Hendriks	Company Binnestadservice.nl	15-05-2008	personal
Vronie van Manen	Department Binnenstad (Municipality of The Hague)	16-06-2008	personal
Tim Hapgood	Bristol city council	29-06-2008	email
Magnus Jäderberg	Göteborg city council	03-07-2008	email
Jésus Muñuzuri	Universidad de Sevilla	03-07-2008	email
Peter Krichel	Universität Kassel	08-07-2008	email
Mark Degenkamp	Municipality Utrecht	06-08-2008	personal
Rainier van der Kamp	Company Miles Benelux B.V./ Allgreenvehicles	29-09-2008	telephone

Recently, the Policy Advisor for Traffic and Transport at the municipality of The Hague, Frans Botma (at the moment of research Frans Botma was the project manager of the urban consolidation centre), was contacted about the status quo of the project. He explained that our calculations based on the CBA were considered to be adequate and sound. The municipality of The Hague consequently decided not to implement a UCC in the Brinkhorst business area because the volumes were too low and would not reach the level necessary to break even. This decision is in line with the more general findings of Annema (2008) that unfavourable CBA results regarding certain projects have contributed to the postponement of decisions and to the downsizing of these projects.

Analytical validity

The analytical validity is based on the political-economic model of Feitelson and Salomon (2004). This model specifies the requirements for the information provided by one stakeholder to other stakeholders. Information regarding the technical feasibility is of interest to the private company, who will organise the UCC business, and the municipality. Information on the commercial feasibility is of interest to the private company, the municipality and the shopkeepers. Finally, information regarding the political feasibility is of interest for all stakeholders. All three types of feasibilities reflect necessary conditions to be checked in order to have a chance of implementing the UCC concept.

With respect to the economic feasibility we applied elements of CBA. The elements applied from the CBA are only related to direct costs and benefits to illustrate the financial viability of the UCC. Other elements of the CBA such as external cost due to emissions were not externalised. Eijgenraam *et al.* (2000) concluded that CBA should be the preferred approach for financial project evaluation. With respect to stakeholders involved we learned from Annema (2008) that if the answers elicited by CBA do not relate to the questions posed by policy makers and the public, the CBA results become irrelevant regardless of their economic and technical quality. Annema (2008) suggested applying three economical growth scenarios to create a strong case for CBA. Based on these experiences of Annema we applied three scenarios (low, middle and high) of assumed participation of the shopkeepers and compared the results with the current situation.

In the applied components of CBA some specified costs might also be highly uncertain, where the tendency in *ex ante* CBA is to assess costs too low. This might have consequences for the economic feasibility of the concept. However, for these types of costs one can make transparent assumptions and test the robustness and sensitivity with different scenarios.

External validity

Several of the 17 UCCs studied by Browne *et al.* (2005) have terminated operations due to unsatisfactory financial results which, based on our case study, correspond with the expectations. It indicates that the benefits of the UCCs in these cases were indeed not based on realistic estimations and assumptions. In our UCC survey, based on a theoretical analysis, we were able to ascertain the major factors affecting the success or failure of a UCC. The success factors we identified were: the *number of users*, the *organisation of the UCC*, the *provision of subsidies*, and selection of the *right type of distribution vehicle*, which fairly match the conclusions of the City Port Project report (2005), the BESTUFS handbook (Allen *et al.*, 2002) and studies done by Browne *et al.* (2005) and Quak (2008).

In terms of urban distribution, we have found various initiatives with urban consolidation centres showing similar financial problems, which provides evidence that the financial feasibility of the UCCs is the critical point of understanding. As an example, at their 2nd year anniversary the initiator of the concept ‘Binnenstadservice’ (*inner-city service*) in the city of Nijmegen recently (Prudon, 2011) announced the establishment of a supporters association to sponsor this new initiative (since subsidies will drop). Prudon wants to achieve a break-even in the third year of operation of ‘Binnenstadservice’ Nijmegen. Prudon declares that any financial support helps and that ‘crowd funding’ can help with an association of 200 supporters paying a €100 membership fee. In addition Quak & de Ree (2009) state that the urban distributor losses should be compensated by the savings received by most carriers (due to the unwillingness to pay for it by the shopkeepers). Equal division of the savings results in a more fair business model between carrier and urban distributor. A contract based on such a business model will guarantee the volumes needed to become break-even, as was shown in our study.

The article is referenced by Browne *et al.* (2011) as an example of continuing research into UCCs as an urban freight initiative. Browne *et al.* (2011) showed a successful pilot period for the micro consolidation centre with use of electric and electrically-assisted cargo tricycles. According to Browne *et al.* (2011) the trial was of particular interest as the company's existing delivery system prior to the trial already involved a high degree of product consolidation and hence high vehicle loading factors. According to Browne *et al.* (2011) his pilot was an

exception to the common practice of UCCs where UCCs are normally systems with poor load consolidation, as we also found in our case study of The Hague.

Reliability

The political-economic model of Feitelson and Salomon (2004) supports the process of identifying the actors' participations for each type of feasibility. The application of this model provides a well structured framework. With respect to the three types of analyses (technical, financial & political) one could say that no strict methods can be provided to give insight. We believe that a CBA can provide relevant insight into the commercial feasibility, but other methods such as simulation could also be applied to generate relevant insight. See for example the experiments with dynamic pricing strategies for UCC based on multi-agent technology (van Duin and van der Heijden, 2012). Therefore methodological rigidity is neither necessary nor productive for finding the right answers.

Contribution to concept development approach

To analyse the concept of a UCC we performed a literature survey to study the experiences of urban distribution centres. We identified the success and failure factors of the UCC concept. Secondly we performed a detailed analysis for the case of The Hague. We identified all the actors involved, their goals and their relationship to the concept. This gave us clear insights into which factors of interest should be analysed more in depth. The UCC-operator showed interest in profit, volume, and load factor of the vehicles. The municipality of The Hague wanted to reduce the vehicle kilometres in the inner city, have a sufficient load factor of vehicles entering, and provide minimal subsidies. The shopkeepers asked for good quality delivery service, low costs for delivery and receipt of goods. The inhabitants wanted also a reduction of the vehicle kilometres and less deliveries in their city. In our case the feasibility perspectives (technical, financial and political) of Feitelson and Salomon (2004) reflected well the factors of interest. Beforehand, in discussion with municipality and shopkeepers, several scenarios with different percentages of shopkeeper participation were combined with different types of vehicles. The number of shopkeepers who wanted to participate in this service was highly uncertain. As a modelling formalism, elements of a Cost Benefit Analysis were applied to integrate technical and financial factors. Based on this analysis we were able to achieve a shared understanding with respect to the outcomes of the model. This supported the decision making process between the municipality, shopkeepers, inhabitants and potential logistics service provider. This case showed steps similar to the former cases. Due to the increase of actors the importance of identifying the factors of interest is very important. Especially the uncertainties seem very important and can give direction to the definition of the solution space in different scenarios. Again, the modelling step preferably should cover all these factors. In this case, we also learned that even the choice of modelling can be influenced by the actors. A proper understanding of the model is important when the results and outcomes should be explained to a larger audience. The political feasibility analysis formed a good step to reconsider the actors' factors again in relation to potential implementation of the solution. The solution space was fully analysed and, in the end, the conclusion of not implementing the UCC was unanimously supported by the actors involved..

7.6 Case 5: Globalization and Intermodal transportation: Modelling terminal locations using a three-spatial scales framework

Research gaps

At the European level it is the European Ministers of Transport draw up plans for the development of Transport European Networks (TEN-T). These top-down plans are focused on the integration of transport modes and define the transport networks in hubs and spokes. On the other hand, the Marco Polo program is a bottom-up program of the European Commission that aims to (a) change mode choice in the transport of goods within Europe as much as possible towards modalities other than road transport, (b) increase the efficiency of the use of road transport, (c) remove market barriers and (d) improve professionalism in the transport sector through training and education. The Marco Polo program supports the fast growing number of initiatives for constructing new terminals, because the expectation is that these terminal initiatives will make losses in the initial phase. Subsidies are provided if a realistic expectation exists that cost recovery can be obtained after two years. The transport handled by the terminal must be physically carried across the border of at least two EU countries or associated countries – Norway, Iceland, Liechtenstein and Croatia. In practice however, new terminal initiatives tend to be directed more towards the local economic development such as the existence of large (multinational) companies in the vicinity of the terminal rather than following the TEN-T network plans (Gap 2).

At the national level the Dutch Ministry of Infrastructure and Environments supported all new terminal activities to improve the competitiveness of the intermodal transport services to road transport services. A new intermodal transport service can help to reduce both congestion problems and pollution from exhaust and can lead to local economic activities. At the regional level, the owners of areas within the vicinity of the terminals focus on the development of logistics service parks for value-adding services. For this reason the former Dutch Ministry of Transport provided SOIT-subsidies (Subsidies for Inland Terminals) for seven new terminal initiatives in the regions of Brabant and Overijssel (Hoekman, 2004). In the past these subsidies have been provided without a serious scrutiny of the future feasibility of the terminal.

Considering the dominant policies over the last two decades to improve intermodal transportation the actors involved at each policy level have tended to follow their own plans. The initial plans by the European Commission proposed an integrated vision, although the actual practice of new intermodal services seemed to develop more whimsically. The decision makers involved in the development of intermodal transport services have a completely different mindset to the actors at the policy levels (Gap 2). This diversity among actors and the changing involvement of these actors should be better included and dealt with in dedicated models. This is the main gap to be tackled in terms of research (Gap 1).

Obtained results

At the national level the Ministry of Infrastructure and Environment should, in line with the goals of the Trans European Networks policy, focus on multimodal network policies that strengthen the network in such a way that current Dutch terminal locations have competitive advantages compared to foreign terminals. Contrary to the TEN policy, our recommendation is that the Ministry of Infrastructure and Environment intensifies the communication with the regional policy makers. The focus of their terminal development should be on the large

(multi-national) companies, since a volume-oriented approach seems to be a good, successful selection criterion for the realization of new terminal initiatives. The model results showed good opportunities for inland terminal development with feeder distances shorter than 50 kilometres. At the regional scale we were able to select exact terminal locations. For each selected terminal location the competitiveness compared to road transport was precisely determined. Finally the exact terminal configuration was determined based on volumes by the use of simulation.

Construct validity

A large survey among logistics companies showed that it is the 'cost oriented' group of actors who use intermodal transport most intensively, more than 50% of the sample (92 companies) (Spin, 2002). For example, presently Heineken uses the terminal in Alphen a/d Rijn and large production companies like Sony, FujiFilm, Samsung, Dell Computers use the terminal in Tilburg. In-depth interviews with intermodal transport users Vos Logistics (Jorritsma, 2005)⁶ and P&O logistics (Vermunt, 2005)⁷ confirmed that cost reduction is still the main goal of optimisation of logistics services. Therefore we argue that the linear programming model (minimising the integral transport cost subject to deliverance of the regional demands) fits the shippers' perspective in deciding whether intermodal or road transport is more cost-efficient. In the policy plans the village of Valburg was mentioned as the location for a new terminal initiative although the outcome of the LP-model indicated insufficient volume for this terminal. The favourable location of the Nijmegen terminal in the vicinity of Valburg attracted all the possible demand in this region. The Dutch policy plans (Van Duin & Van Ham, 1996) did not cover short distances, i.e. less than 50 kilometres. However, the model results indicated good opportunities for inland terminal development when terminal distances shorter than 50 kilometres are included, i.e. Utrecht, Tilburg and Leiden/ Alphen.

Analytical validity

The analytical approach is based on linear programming, a spreadsheet-model based on gravity theory and a structured approach to set up a simulation model for the terminal operations. The linear programming model is quite similar to the LAMBIT model by Macharis & Pekin (2009). Their model incorporates the different network layers for each transport mode by setting up a GIS network that includes four different layers: the road network, the rail network, the inland waterways network and the final haulage network.

The search for regional terminal locations is actually based on a load-distance model for the drayage operations at preferred selected location sites. We applied SADT (Marca & McGowan, 1998) as a graphic notation to describe the terminal operations in detail. The identified volumes and terminal locations are based on the assumption that the initial condition that intermodal transport is cheaper than road transport, will be met. Otherwise shippers will not even consider intermodal transport.

Platz (2009) constructed a list of factors that influence the competitiveness of barge transport. Out of the long list of critical success factors the following principles have also been applied into our modelling approach:

⁶ Interview with Jorritsma, Operational planner at VOS Logistics

⁷ Interview with Vermunt, P&O Nedlloyd Logistics: responsible from/to BeNeSwiss region

- bundling in space (from the cargo areas around the terminals);
- grouping in volume (maximum extent possible, transport from A to B, which reduces costs);
- guaranteed throughput (transport may take longer, but delivery is guaranteed).

The first two principles constitute exactly the dominant modelling paradigms of our first two models. In our last model, the simulation model, it becomes clear whether the terminal performance really can guarantee the estimated throughput on time. This forms the link with the last critical principle of Platz (2009) since we check whether the throughput is guaranteed to be on time in the simulation model.

External validity

Kreutzberger (2008) concluded that streamlined hub-and-spoke networks with trunk-feeder lines and terminal handling at intermediate nodes will improve the competitiveness of intermodal transport. Part of his study focuses on distances and transport times in alternative bundling networks. When it comes to supporting policies, Kreutzberger (2008) advocated complex bundling in the allocation of train paths and a strengthened coordination of bundling initiatives at the European level. At the national level Konings (2008) shows that the development of more complex barge transport services, implemented for instance in collection/distribution-, trunk-feeder- and hub-and-spoke service networks, could improve the market position of barge transport in the hinterland transport of containers and enables new markets to open up for intermodal barge transport. Konings (2008) recommends that the government develops a vision of how the terminal network in the Netherlands should look like in the next 20 years. This implies making a choice of those terminals that function primarily as local collection terminals at the regional level and indicating what the major strategic locations are of these terminals. Both Kreutzberger (2008) and Konings (2008) made it very clear that a vision on the development of terminals for the long term is needed. Moreover they argue that evaluation tools could be helpful to cope with the potential growth and decline of terminals. Our study underlines these visions and conclusions.

At the regional level several locations in the regions have been evaluated. For each location the demand patterns are geographically different. The locations of the companies and their demand patterns influence the geographical centrality factor. Kim & van Wee (2010) found that, when distance-dependent cost functions are used, the impact of changes in the geometric factor is not more significant than cost changes. Furthermore, neither the oval-shaped market area nor terminal relocation significantly increased the intermodal share. However, when changes in the geometric factor occurred and an oval-shaped market area developed, a synergetic effect resulted that caused a significant increase in intermodal transport. These outcomes are similar to our findings since we found that Alphen a/d Rijn, Kouderkerk, Hazerswoude, and Bodegraven showed significantly better cost performances compared to road transport.

Kim & Van Wee (2010) state that the break-even distance of the intermodal freight system is highly dependent on the market situation, and generalisation is not possible, even though it is crucial information for both the private and public sectors involved in logistics. We also recognize the uniqueness of each market situation. Therefore, our modeling approach was based on the distinction between three scales, in order to be flexible with regard to various market situations: the potential volumes can be easily varied in the models. The selected

terminal locations and estimated terminal volumes provide evidence for the likelihood of this statement.

The forecasts of the container volumes at terminals based on an earlier version of one of our models (Van Duin & Van Ham, 1996) are remarkably close to the current (= 2011) situation of terminals. At the time of our research no continental containers were handled at Nijmegen, Utrecht, Alphen a/d Rijn (Leiden) or Tilburg. Based on the early model analyses we expected 307,000 TEU for Nijmegen, 43,000 TEU for Utrecht, 31,000 TEU for Alphen a/d Rijn and 64,000 TEU for Tilburg as potential transshipment volumes in 1997. Looking at the current practice of these container terminals we observe that Nijmegen handles 236,628 TEU (obtained from BCT year 2007), Utrecht 65,000 TEU (in 2006), Tilburg 85,000 TEU (in 2005), and Alphen a/d Rijn (due to Heineken's participation) between 40,000/50,000 TEU in 2011 (Bureau Voorlichting Binnenvaart, 2011).

Reliability

The working procedures are well described in our case and the study protocol can be clearly followed. The selection of the models can be predetermined and based on the result of the actors' analyses at each level. The factors of interest for the various stakeholders are deduced from the interviews and verification of the interviews with the actors involved.

Contribution to concept development approach

We started this case study with a definition of intermodal transport, a description of the TEN-T at the European level and, a description of TEIT at the national level. With respect to the approach used: we applied an actor perception analysis which gave us insight into the critical (success and failure) factors of all the actors involved with respect to the policy development of intermodal transport services. The factors identified were indicated to be important by the actors at every policy level (see Table 6.2). Thanks to the recognition of actors in specific arenas we can build dedicated models for adapting specific factors of concern.

For the policy advice at the European and national level we developed a linear programming model by minimising the total transport costs with decision variables based on direct road transport routes and intermodal transport routes. Shippers base their transport decisions first on costs. Application of this model provided reliable predictions regarding the question of whether a terminal at a certain location can attract enough volume to stay economically feasible in the long run.

At the regional scale we explored the area for possible locations based on a detailed Activity-Based-Cost-model (spreadsheet-model), looking at the distances to the most important multinational companies. The study was carried out for GOVERA, an organisation of the 4 biggest cities in the Netherlands, Chambers of Commerce, Provinces, Departments of the ministry of Transport, Union for Freight Transport, Agency for barge transport, Entrepreneur Organisation for transport and logistics, and an Environmental Federation. The main cost elements are based on the distances to the main shippers in the vicinity of the terminal, the terminal equipment applied and the number of possible roundtrips per day for a ship or train. Having found the final location for a terminal at operational level all terminal activities were analyzed with the simulation model. The model can evaluate the terminal performance and environmental performance of different terminal configurations and designs (see case number 3). We applied the whole series of our models and it provided good suggestions for new terminal initiatives.

This case showed the real complexity of a logistics concept. The importance of deriving a complete list of factors which are found important by the actors is crucial for the analysis. The case also taught us that the solutions spaces are mutually linked. We noticed also that we definitely need cycles to obtain insight. In addition, for each playing field, all the steps of describing the concept need to be executed, including: defining the actors involved, determining the actors' factors, definition of the solution space and final the modelling. In this case a convergence of perceptions on the outcomes of the models could not be registered since we were not in direct communication with the actors involved. However, we could observe that our predictions matched the volumes of the (new) terminals well and conclude that the case showed a convergence in results.

7.7 Research findings

Our case research has provided evidence for the addressed research gaps. Table 7.4 gives an overview of the identified gaps based on our research cases.

Table 7.4: Summary overview of research gaps addressed in the case-studies

Case	Public/private Stakeholder (Theory, Analysis)	Public/private Stakeholder (Practice, Implementation)
	Gap 1	Gap 2
<i>E-auction as a concept of UCC</i>	<ul style="list-style-type: none"> ▪ Omission of behavioural aspects of carriers, shippers and government. ▪ Collection principles are not seen from a broad perspective. 	<ul style="list-style-type: none"> ▪ The bundling concept should be made profitable in the long run, since it has potential benefits for carriers, shippers and municipality, however in practice the concept fails financially.
<i>CO₂-emissions at terminals</i>	<ul style="list-style-type: none"> ▪ There is no unique method to calculate CO₂-emission at terminals. 	<ul style="list-style-type: none"> ▪ Terminal operators have no idea how to measure/reduce the CO₂ emissions at their terminals. ▪ Policymakers have a pre-perception that terminal operators can reduce their CO₂-emission by 50% according to the Rotterdam Climate Initiative (RCI).
<i>Noise-emissions at Tilburg terminal</i>	<ul style="list-style-type: none"> ▪ External effects can seriously influence operations at a terminal. No adequate modelling approaches are available showing the consequences of noise limits on terminal performances. 	<ul style="list-style-type: none"> ▪ The terminal operators fail to recognize that the farmers and inhabitants might have an influence on their operations. ▪ Local authorities tend to forget that noise restrictions tend to have serious consequences on the operational performance of a terminal.

<i>Urban consolidation centre (UCC) in The Hague</i>	<ul style="list-style-type: none"> ▪ Other actors might also benefit or have extra costs due to the introduction of a UCC, so other financial models have to be considered. ▪ Theory fails to look at the financial feasibility of the UCCs and subsidies are too often the only way to compensate the losses. 	<ul style="list-style-type: none"> ▪ Policy makers fail to look at the success of other UCC initiatives. ▪ Basic principle for the existence of a UCC is to obtain enough bundling (volume) to become break-even.
<i>Policy making on intermodal transport</i>	<ul style="list-style-type: none"> ▪ The location of terminals heavily depends on the cost reduction choice of companies. ▪ It is impossible to formalise the process of choosing a location into one model. 	<ul style="list-style-type: none"> ▪ Decisions on the location of terminals are made at three different policy levels. ▪ Policy makers fail to recognise that companies only choose for intermodal transport on condition that it is cheaper than road transport.

Summarising the practice gap (Gap 2) we observe a restricted view from all the actors involved. Most actors involved tend to look at the logistics concept from the mono-actor perspective, which is understandable since the perceptions of the other actors are mostly not systematically investigated and thus largely unknown. To understand the complete picture of the logistics concept one should consider the perceptions of other actors involved and if available take former experiences with the concept into account.

In this thesis we want to develop an approach that forms a first step in filling the theoretical and practice public-stakeholder-gaps. Table 7.5 provides an overview of the theoretical contributions for each case and directions for the development of a concept design approach.

Table 7.5: Summary overview of theoretical contributions in the case-studies

Case	Contribution to the approach
<i>E-auction as a concept of UCC</i>	Identification of the main stakeholders and specification of their objectives structures the applied approach. Next, based on the most important factors of interest, we selected appropriate modelling techniques. The behavioural aspects were formulated and brought into a large simulation model in which the bidding auction-processes, the delivery processes by the trucks and the vehicle-routing planning were dynamically simulated.
<i>Relevance</i>	Adding the behavioural aspects of the actors involved into a simulation model provides a transparent insight in the operational performances of the logistics concept for all actors involved.
<i>CO₂-emissions at terminals</i>	Terminal operators and local governments have no insight into the CO ₂ emission production at the terminals. A dedicated model was developed to estimate the emissions of the terminals based on their layout, throughput and terminal equipment configurations. The model showed the energy consumption of diesel and electricity and made clear which processes/equipments at the terminal produce the most CO ₂ .
<i>Relevance</i>	The development of the model gave insight into the unknown external effect. This insight led to a convergence in the perceptions of the actors and provided a mutual awareness of the consequences of this external effect, both for policy and logistics decision making.

Noise-emissions at terminal Tilburg	We developed a modelling approach, based on simulation techniques, to integrate both operational parts of the terminal and the related noise effects for the surroundings and applied this for the new container terminal. With the aid of the simulation model a terminal location assessment was carried out in a very open process with constructive communication between private and public actors.
<i>Relevance</i>	The development of the model gave insight into the consequences of the unknown external effect on the operational performances. This insight led to a convergence in the perceptions of the actors and provided a mutual awareness of the consequences of this external effect, both for policy and logistics decision making.
Urban consolidation centre (UCC) in The Hague	As a first step we identified all the actors involved. Identification of their goals and their relationship to the concept gave us clear insight into which factors and interests should be analysed in more depth. In our case the feasibility perspectives (technical, financial and political) reflected the involved actors' factors of interest. As a modelling formalism elements of a Cost Benefit Analysis were applied to integrate both technical and financial factors. Based on this analysis we were able to make some advice to support political decision making.
<i>Relevance</i>	Identification of the actor perceptions gave insight into the factors of concern with respect to the logistics concept. Scenario-analysis of the model gave insight into the consequences for these factors. As a result actor perceptions converged and joint decision making (between policy makers and logistics actors) occurred. All the actors involved accepted this decision making fairly.
Policy making on intermodal transport	As a first step we applied an actor perception analysis which gave us insight into the critical (success and failure) factors of all the involved actors with respect to the (policy-) development of intermodal transport services. These identified factors were indicated to be important by the actors at every policy level. Thanks to the recognition of actors in specific arenas we can build dedicated models (a linear programming model, Activity-Based-Cost – model, and a simulation model) for adapting specific factors of concern.
<i>Relevance</i>	The awareness that decision making on the location of terminals involves three different policy levels. For each of these levels actor-analysis is important and different models are needed to provide insight into the factors of concern. Dependencies between the decision making levels should also be reflected in the development of the models, i.e. output from a model is input for the following model.

With respect to the theoretical gap (Gap 1) we observe identical shortcomings with respect to the embedding of the actor perceptions into the developed models. For each case we applied a similar case study protocol. In general we applied an actor perception analysis which gave us insight into the critical (success and failure) factors of all the involved actors with respect to the (policy-) development of intermodal transport services. These identified factors are indicated by the actors to be important at every policy level. This distinction of the policy levels, changing the involvement of the actors demands inclusion in dedicated models.

We demonstrated that quantitative modelling formalisms can cover many factors of importance for a logistics concept. The developed modelling approaches are shown in Table 7.6.

Table 7.6: Application of modelling approaches

Case	Modelling
E-auction as a concept of UCC	Simulation model combined with VRPTW-optimisation using TABU-searching algorithm
CO ₂ -emissions at terminals	Deterministic spreadsheet-model
Noise-emissions at terminal Tilburg	Simulation model
Urban consolidation centre in The Hague	Deterministic spreadsheet-model (CBA)
Policy making on intermodal transport	Linear programming model
	Deterministic spreadsheet-model (ABC)
	Simulation model

However, we must also conclude that no unique method or modelling formalism is dominant. In our study each case has its own characteristics and therefore we selected the modelling approach which could provide insight into the policy problem field. Application of various validation approaches and scenario analyses gave us insight into the sensitivity of the factors of importance. We concluded that all the models contributed to an open process with constructive communication between private and public actors.

Based on our experiences with the cases we are now able to develop a generic approach for designing and analysing public logistics concepts. First we will describe the approach, followed by our explanation how the case studies have contributed to the approach.

7.8 Towards a convergent design approach

Partially inspired by the participatory policy analysis described by De Jong & Geerlings (2003), we stress the desirability of developing problem definitions, concepts and alternative solutions with various parties in order to arrive at a shared view of reality (Geurts & Vennix, 1989; Eden & Ackermann, 1998; Mayer, 1997; Mayer et al., 2002). It has been argued that innovation is necessary in both the process and the analytical approach that supports this way of thinking. In Figure 7.1 we present such an integrative approach. It is based on the idea that policy making and logistics follow the management cycle (as shown in Figure 1.1). For application of the approach to succeed it is important that both logistics and policy making start at the same time as the planning phase for a public logistics concept.

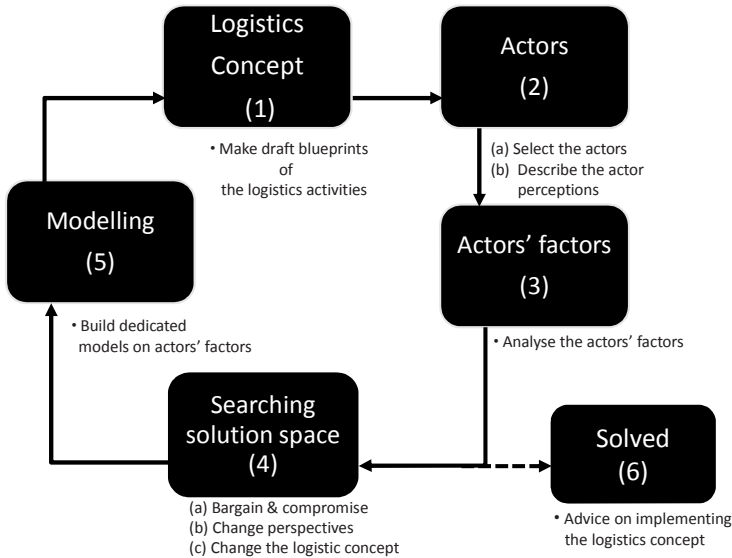


Figure 7.1: Integrative approach for public logistics concept design

The approach starts with the identification and description of the logistics processes that are part of the new logistics concept and the selection of all the actors within the arena of this concept (1). The next step is to portray all the actors' perceptions, defining the causal relation schemes of their way of thinking and to specify the relations of the actors in the network (2). After all the perceptions have been identified, a network analysis can be performed (3). The network analysis provides us with insight into which factors are considered to be important by which actors, and which factors receive very different weights or cause conflicts between actors. For actors with conflicting interests and positions one could look at the instruments of these actors and seek for actors who can benefit from the use of these instruments. Having identified actors who will potentially benefit from these instruments, this gives space for finding solutions (4) through bargaining and compromising or searching for changes in the concept. When conflicts or special factors of concern are detected, it might be useful to develop more dedicated models to quantify their effects to provide more insight for those actors who attach great weight to these issues (5). The outcomes of the dedicated models can clarify or reduce uncertainty with respect to the outcomes. Based on these insights some actors might be willing to change their perception or the logistics concept might be adjusted to meet more closely the perceptions of the actors. If all the consequences of the actors' factors are known for all the actors involved, then a step towards implementing the concept (6) can be made. Each step of the approach will be explained in more detail.

Logistics concept: Make draft blueprints of the logistics activities (1)

First we need to generate rough blueprints of the logistics concept. A graphical representation of flows, especially goods and information, can help to specify exactly which activities are to be performed. Although no specific graphical technique is recommended, the logistics concept needs to be clarified as well as possible to enable discussion with the relevant actors. In these

circumstances a graphical representation which mirrors the logistics concept at different layers is recommended. For example IDEF-0 schemes (ICAM, 1981) are well suited for these representations (see for example Figure 4.2). Elements which should be embedded in the final graph of a logistics concept are processes (or activities), goods flows, information flows, resources (and their relations to processes) and an indication of which tasks have to be performed by which actors. For some logistics concepts it is also necessary to have an accurate view of the timing of the relevant activities. For these cases precedence diagrams, Gantt-charts or interaction diagrams can be applied. For example De Vreede (1995) and Van Eyck (1996) developed a set of graphical modelling techniques for an extensive representation of logistics processes in relation to various actor positions. In their approach the tasks and responsibilities of each actor can be considered, while maintaining overview and insight irrespective of the complexity of the processes. Their set of techniques provides a nice bridge to the next step.

Actors (2)

After having determined the rough blueprints of the envisaged logistics activities, the actors involved in the logistics processes need to be more closely identified.

Actors: Select the actors (2a)

The relevant actors for a logistics concept are often dependent on each other. Interdependency is based on the uneven distribution of various resources between actors, the goals they pursue and their perceptions of resource-dependencies. Interdependency implies that there is something to be gained by the interaction between the actors involved. It leads to interaction between actors which creates and sustains relational patterns. Without collaboration between actors the individual ambitions cannot be realised. Not only the actors directly related to the logistics processes are important, but also the actors who have indirect influence on the final concept by raising conditions must be added to the selection of actors. With respect to the actor selection process it can be very useful to determine for each actor who is responsible for logistics activity and with whom this actor maintains relations of (anti-)truth, (anti-)power or (anti-)sympathy. This establishes a basis for understanding certain actor's behaviours.

In logistics it has already become common practice that a supply chain of actors in a logistics concept can be described as a dedicated network. But at the same time specific actors in this dedicated network operate within a context of various other networks that indirectly might have influence on the logistics network. For instance a logistics service provider like Kuehne & Nagel operates in many different branches and locations throughout the world. Another example is the terminal of Tilburg operating in the different supply chains of large production companies like Sony, FujiFilm, Samsung, Dell Computers and other large retailers using the terminal for shipments of their goods directly to the port of Rotterdam. It is the task of the logistics analyst to find ways to understand the influence of these contexts and perhaps even explore the potential for performing systematic analyses.

In empirical terms the degree of problem solving success depends on the extent and the involvement of targeted individuals and organisations in producing the co-operative effort. The fact that no single actor can either solve a problem alone nor force others to make a choice for specific solutions, underlines the need for an approach of individual actors from the perspective of actor network management.

Actors: Describe the actor perceptions (2b)

The next step is to portray the perceptions of the actors in a network, in terms of relevant factors and actor-specific instruments and goals. For each actor we must understand their perception by identifying the importance of specific factors (i.e. element that can be measured or evaluated; for example emission or competition), their goals (i.e. a factor which is the aim of an actor; for example cost reduction or noise emission reduction) and to what extent specific instruments or measures can influence their goals (i.e. tools or measures that influence a factor or goal; for example usage of low emission equipment or time-windows). The actor perception also contains a representation of the perceived causal relationships between factors, instruments and goals. Describing the perceptions in a qualitative, conceptual language and by additionally performing different types of comparative analysis enables the analyst to hone his or her insight. The information available to an actor constitutes the basis of his appreciation and perception of the problem or problems in which he is involved. This information is incomplete and is generally different from that of other participants. Depending on the information available to him, an actor may not, for example, be aware of one or more other actors that have the capability of influencing the development. Moreover, he may, compared to other actors, have a different perception of the elements that characterize his problem, of the boundaries of his action space, and of the connections between problems. Although the actor's perceptions are always incomplete and necessarily subjective, there is nevertheless a natural tendency to claim that it is based on objective facts and therefore to assume that what one perceives represents the real situation (Radford, 1984). Furthermore, as the context is dynamic and changing, the perceptions of the actors are likely to change over time, depending on their individual abilities to gather information about the new contextual conditions (Radford, 1984).

In order to portray the perceptions we can make use of an actor analysis or use a workbench like Dynamic Actor Network Analysis (DANA; see e.g. Figure 7.2) (Bots et al., 1999; van Duin et al., 1999; Bots et al., 2000; Bots, 2007). The perceptions can be portrayed in 'participatory-model' building-sessions, in which the representatives of each actor simultaneously construct their perception graph by putting it down on paper. The process of model building is assisted by the analyst, and complementary information is gained through an additional guided interview. Finally the analyst builds a qualitative model of the perception. Validation of this model is a continuous activity since the representative of the actor gives continuous feedback during the construction of the model of the perception. Every factor or relation in the actor perception is open for discussion while it is added to the scheme.

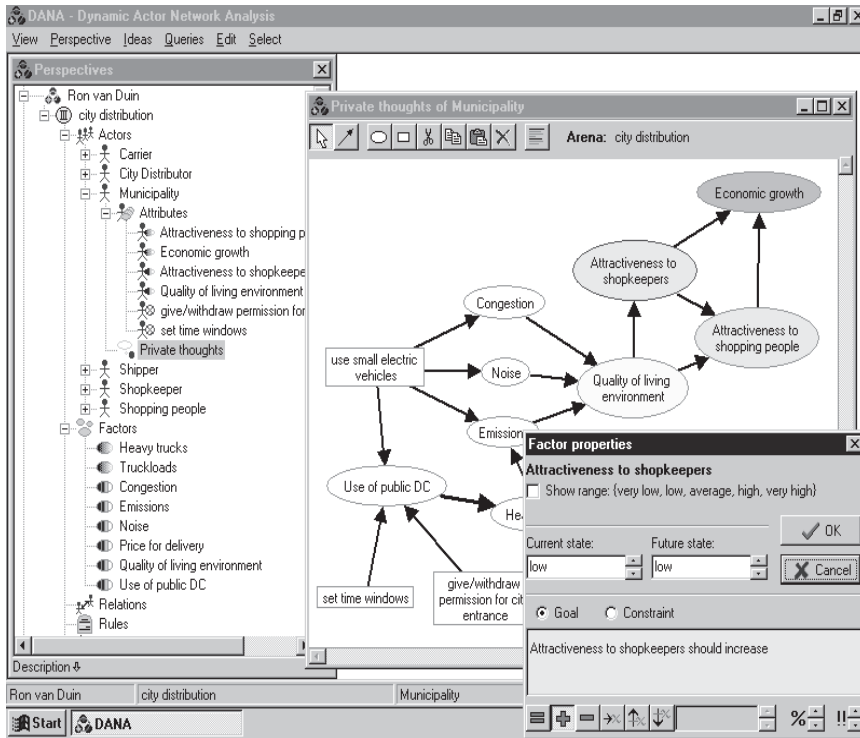


Figure 7.2: Example definition of a goal as part of a Municipal perception, using DANA (van Duin et al., 1999)

The analysis of the actors' perceptions shows similarities with the Multi-Actor-Multi-Criteria-Analysis approach described by Macharis & Ampe (2004; 2007a; 2007b). This so-called MAMCA-methodology makes the objectives of the various relevant stakeholders explicit by specifying the weights of their goals individually. The MAMCA methodology forces the actors to reflect on what they really want and on the rationale behind these desires. The fact that the stakeholders know that they are part of a comprehensive evaluation focuses their thinking and motivates them to make more explicit assessments. The MAMCA methodology shows the essential trade-offs made by all stakeholders, and makes these stakeholders more aware of the conditions and consequences of the societal decision-making process. Involving stakeholders in the analysis takes more time initially but improves the likelihood of acceptance of the proposed solution. DANA differs from the MAMCA methodology since automatic detection of the factors most relevant to a public-private situation, and of (dis)agreement and conflict among stakeholders may help the analyst to obtain convergence in the analysis (Bots et al., 2000; Bots, 2007).

Actors' factors: Analyse the actors' factors (in the perceptions) (3)

We have to be aware that we cannot address all the possible questions related to the key-principles of network analysis. Instead we will concentrate on selecting the basic questions and use these questions, and the answers to these questions, as triggers to more specific questions to use in our workbench in practice. The next basic questions are related to the network theory (Bots *et al.*, 1999):

'Which factors are considered relevant by both actor A and actor B?' and (Question A)
'Which actors have conflicting goals on factor X?' (Question B)

The answers to these question gives us a list of relevant factors (i.e. **actor's factors**), however nothing can yet be said about the degree of criticality of the identified factors. Therefore the goals of the actors have to be weighted and relative distance measurements can be made (see for example Figure 7.2). Bots *et al.* (2000) mention as a first step quantifying the 'socio'-differences between the actors' perceptions. By defining these metrics we are able to apply various techniques related to the field of sociometric analysis, like sociograms (Scott, 1991), sociographs (Lindenberg *et al.*, 1983) and resource dependency (Ostrom, 1990).

Another way of making an inventory of actor perceptions is to create an environment which enables us to identify the critical factors of a logistics concept, is to make use of Group Support Systems (GSS). Group Support Systems is a general term for facilities consisting of people, procedures, hardware, software and virtual facilities that aim to make collaborative group processes more productive in terms of group effectiveness, efficiency, and satisfaction (Nunamaker *et al.*, 1991; Briggs and de Vreede, 1997). Especially, the electronic brainstorming application or 'Topic-generator' has proved its value as a very efficient tool for gathering a lot of information about a specific issue (Dennis *et al.*, 1988). Each actor is asked what factors related to the logistics concept are considered to be most important. Different from the current GroupWare software, our approach structures the collected information according to the definitions of actors and factors. The most ideal situation in view of the suggested approach is to have all the selected actors involved in a brainstorm session. Alternatively one could decide to brainstorm with each actor separately.

Although we have been able to formulate some questions based on the network approach which are found to be relevant for implementing a logistics concept, we have to protect ourselves against too rigid instrumentalism (de Bruijn & ten Heuvelhof, 1995, pp.78-79) and falling back into the traditional logistics thinking. De Bruijn and Ten Heuvelhof (1995) criticise too much emphasis on causal thinking while the reaction of actors with specific measures will bring the actor network in motion causing the creation of new challenges and opportunities. Sometimes the opportunities can be surprisingly different from the expectations of the actors. A second type of criticism concerns the formalisation of the new logistics concept. For some actors the logistics innovation might lead to undesired situations while the adaptations in the network are not reversible or changeable by the control of this actor. A final criticism warns for the effects of a continuous process of network management. While the circumstances continuously change, some actors postpone their decisions and finally develop a sit-and-wait attitude.

Searching the solution space (4)

For a final implementation of a logistics concept the answers to the above formulated two basic questions (*see Question A & B*) are relevant, because they provide us with information regarding the existence of potential blocking power, conflicts and (dis)agreements. If some questions of (dis)agreement or conflict provide us with information which will have negative consequences for the implementation of the logistics concept, we have to make some adaptations in the perceptions of some actors, or the institutional context of the decision processes, or make changes in the logistics concept by (Klijn et al., 2011 p. 439; O'Toole, 1997, p. 50):

- ***Bargaining and Compromise (4a)***: One way to achieve agreement between the actors is to encourage bargaining leading to compromises in which all parties get some result, although not all of their concerns are met in the outcome. The analyst can assist these processes by identifying bargaining issues and potential agreements, as well as by brokering bargaining processes and monitoring to encourage the maintaining of commitments over time.
- ***Changing Perspectives (4b)***: The perceptions and preferences of actors are linked in networked patterns of interdependence; they are not constants but variables. Part of the challenge of network management is to recognise the circumstances in which an apparent deadlock or unproductive compromise can be transformed into a more favourable outcome. Network managers can seek to shift the perceptions of the actors.
- ***Managing the Network-Context/Changing the logistics concept (4c)***: Not only encouraging changes towards a compromise or inducing changes in the perception of the involved actors, but also changing the context of the interaction with actors can help to alter the position of the actors. Sometimes they can re-structure their interdependency by changing the logistics concept to create the possibility of reaching co-operative outcomes where these did not exist before. This is certainly the case when the actor can at least formally fall back on certain unique resources. The trick here is to encourage movement towards new patterns of interaction that are more productive for the network as a whole.

The first two approaches can be dealt with by network management. For each actor one has to investigate his/her instruments of influence and look for actors who can benefit from the use of these instruments. We can also ask actors to reflect on their goals and make suggestions for adjusting some of their goals to create the necessary space for negotiation. However, if no serious solutions can be determined from the analysis of similarities and differences in actors' perceptions, we will continue our approach with dedicated modelling on the actors' factors of the logistics concept.

Modelling: Build dedicated models on actor's factors (5)

All the mentioned techniques searching for solutions require full transparency in the actors' factors. At this stage we play the role of 'independent' analyst building dedicated models to gain more insight. The analyst is responsible for the final selection of factors and actors' instruments which will be embedded in the models. Although at this stage we follow the more conventional modelling approach, we think that the analyst will be more conscious about his/her position and the modelling choices (s)he makes. For some situations it might be helpful to develop a wide range of models which represent the strong links between the most dominant actor perceptions.

The modelling can rely on the long tradition of operations research and simulation, resulting in models which provide good insight into the values of these actors' factors. Operations research has a long tradition in improving operations and especially in reducing costs. For example, in their review paper Dekker et al. (2011) show the contribution operations research has made to green logistics, which involves the integration of environmental aspects in logistics. Simulation also has a strong past performance in logistics studies (Barjis & Verbraeck, 2010). Sensitivity-analysis, meta-analysis and scenario-analysis can be applied to check the validity of the logistics concepts and to show the robustness of the logistics solutions and related solution space. Taguchi's approach (1987) for strategic decision-making in an uncertain world should be mentioned here, originally developed to help Toyota design 'robust' cars (Kleijnen, 2008, 2010).

In general we can conclude that most of the modelling activities follow the modelling process of Sargent (2010, p. 170) showing the processes of developing system theories and models, and relating verification and validation to both of these processes.

Solved: Advice on implementing the logistics concept (6)

The approach continues until a situation of multi-actor acceptance has been established or all options for improvement have been elaborated, but no further actor gain or improvement can be realised (for instance: we reached this stage in case 4 where the demanded volumes for breakeven remained too low). An advice on implementing the logistics concept can then be formulated.

7.9 Analytic generalization of the approach

As we have described in our research approach (Section 1.5) the development of a new construct is based on and determined by the insights provided from multiple cases. In this thesis our cases are used to formulate an approach to achieve convergence between private and public concerns in the design of logistics concepts. Appendix A demonstrates how the different steps of our approach are represented in the cases studies. Based on these insights we can visualise for each case the relative importance of each step into our approach in Table 7.7. The level of importance is displayed in different shades of grey, varying from light grey (less important) to black (very important).

Table 7.7: Contribution of the cases to the approach

	Logistics concept (1)	Actors (2)	Actors' Factors (3)	Searching solution space (4)	Modelling (5)	Solved (6)
<i>E-auction as a concept of UCC</i>						
<i>CO₂-emissions at terminals</i>						
<i>Noise-emissions at terminal Tilburg</i>						
<i>Urban consolidation centre (UCC) in The Hague</i>						
<i>Policy making on intermodal transport</i>						

■ = less important, ■ = important, ■ = more important, ■ = very important.

7.10 Conclusion

This chapter synthesized the approach and findings of the case studies. The case studies together show that understanding the actor perceptions (their clarification and use in negotiation) is critical for successfully filling Gap 1 and Gap 2. The validity of the conclusion of the cases was evaluated. The tools developed produce necessary innovation and insight for the actors involved. The experiences from the cases lead to a process convergence approach. In Chapter 8 we summarize the results and provide recommendations.

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8 Conclusions & recommendations

*I seek not to know the answers,
but to understand the questions
(David Carradine, 1972)*

8.1 Introduction

In line with Crum and Poist (2011) we emphasize that an emerging research area for logistics and SCM is the discipline's potential contribution to the solution of important societal issues. The dynamics and manifestation of societal issues are influenced by both the logistics service industry and public policy makers. Stronger collaboration is needed between on the one hand the institutional bodies, responsible for policy making, financing and investment decisions and on the other hand manufacturing companies, logistics providers, transport operators and managers of transport and logistics nodes, whose decisions and supply chain strategies strongly affect the spatial pattern and the modal split of freight transport. The study described in this book contributes to establishing such links and collaborations by focusing on the analytical and methodological aspects of logistics concept development.

Section 8.2 answers the three main research questions formulated in Chapter 1 of this book and section 8.3 concludes this chapter with some reflections and recommendations for further research.

8.2 Conclusions

Having developed an adapted approach for the ex ante analysis of public logistics concepts we are able to reflect on our initial research questions:

- *In what way can we identify the mutual critical influences of the logistics concept on the public and private actors?*
- *What modelling techniques do we need to analyse the complexity of a logistics concept which supports the joint decision making process between public and private actors?*
- *Will the suggested approach lead to improved implementation of a logistics concept and lead to a greater probability of acceptance by the multi-stakeholders involved?*

In this section each question will be answered separately.

Research question 1: *In what way can we identify mutual critical influences of public and private actors on a logistics concept?*

To answer this question we refer to the detailed actor analysis which is described in the **Actors** and **Actors' factors** steps of our approach. With these activities we identify the main actors involved. For each of them their perception will be reconstructed in terms of relevant factors and actor-specific instruments and pursued goals. This can be done by using structured interviews with actors as we have done in most of our case studies. After specifying the actor perceptions, we superimpose them figuratively and make comparative analyses in terms of: Which factors are considered relevant by both actor A and actor B? Which factors are missing or irrelevant to actor A or actor B? Which actors have conflicting goals regarding factor X? (Bots *et al.*, 1999). Cross-comparison of these perception graphs reveals properties of the multi-actor network, such as factor relevance, resource dependency, conflict, and possible tradeoffs (Bots, 2007).

Based on our experiences the right selection of methods (structured interviews, sociometric analysis, group support systems) to perform the actor analysis heavily depends on the number of actors involved, their willingness and whether they are able (in terms of time and opportunity) to join the analysis. For each new case these conditions are unique.

The scientific value of our study is the overview of and part construction of potential methods to perform the actor analysis adequately and the illustration of some methods by applying them in the case study, showing their added value (*see Table 7.5*).

Research question 2: *What modelling techniques do we need to analyse the complexity of a logistics concept which supports the joint decision making process between public and private actors?*

To answer this question we refer to the **Modelling**-step in our approach. In our opinion the quantitative modelling techniques used are not fundamentally different from other studies on logistics but that the scope of the modelling is due to the multi-actor perspective instead of the traditional mono-actor perspective. Table 8.1 presents an overview of the applied methods.

Table 8.1: Overview of applied methods

	Methods	Tool
Case 1	Simulation+Tabu search	Delphi
Case 2	Heuristic	Excel
Case 3	Simulation	Arena
Case 4	CBA	Excel
Case 5	Linear Programming, Heuristic, Simulation	Aimms, Excel, Arena

Table 8.1 illustrates that the choice of the method is not predetermined. It is the selected (problem) factors that determine which modelling paradigm and method best fits the analytical challenge. In logistics practice simulation is often chosen since the animation and graphical interfaces of most simulation tools are highly suited to supporting the visualisation of the process (Tako & Robinson, 2011; Swain, 2011). On the other hand optimisation packages (for example AIMMS) enable dedicated user-interface development for all kinds of mathematical solution methods and heuristics. The most important issue concerns the capability of the model development to provide transparency in the factors that are relevant for various actors. The modelling support should lead to a conscious and open process assessment of the logistics concept to provide transparency in the main factors of actors' interests. In this study we have shown that, in the end, this approach creates the best and shared support for the outcomes of the analyses.

Research question 3: *Will the suggested approach lead to improved implementation of a logistics concept and lead to a greater probability of acceptance by the multi-stakeholders involved?*

As stated in Chapter 1, this question will be answered by the following evaluation criteria:

Analytic criteria (Geurts & Vennix, 1989)

The approach should leave space for many perspectives. The relevant arguments for logistics concept development should be deduced from a broad, holistic systems approach. The models and techniques applied must be flexible and hybrid (Nutt, 1982). The hybridity of the approach refers to a combination of techniques derived from the hard, formal sciences and the soft, cognitive sciences and should contribute to transparency of the applied methods.

As we have seen in Table 8.1 all the applied methods are derived from both hard and soft operations research and are transparent in terms of (functional) structure and process of application. In all cases the transparency is both theoretically proven by References to other research contributions and practically proven by validation with experts/actors in the problem domain. The methodological transparency is most crucial for reducing what has been labelled as Gap 1: the theoretical public-stakeholder-gap. It should be theoretically and methodologically evident and empirically illustrated that the richness of the multi-actor perspectives can be well incorporated in the ex-ante evaluation of public logistics concepts

and applied in order to improve the processes. We consider this criterion to have been met in our study.

A quality improvement of the logistics concept

This criterion implies that the approach provides transparency with respect to the causal relationships within the logistics concept and its operating environment for all stakeholders involved. The quality improvement can be obtained by a thorough exploration and understanding of the stakeholders' relationships to the logistics concept.

In all of the cases the approach has shown good insight into the factors that really matter. All the developed models, sensitivity analyses and scenario analyses significantly contributed to the mutual insight of the actors involved. Sometimes the logistics concept was improved, as e.g. we have seen in the case of the barge terminal in Tilburg, where sound walls might reduce the noise pollution, and sometimes there was a mutual agreement that no further improvements could be made e.g. as shown in the case of the Urban Consolidation Centre in the Hague.

In terms of the practice public-stakeholder-gap, Gap 2, the transparency in and logical explanation of the outcomes is the most important, which refers immediately back to the quality of the approach. For each actor involved in the public logistics concept it should be made clear what the (financial, economical, environmental, spatial) consequences will be for this actor. In all cases we have managed to provide this transparency in the outcomes of our modelling efforts.

Trust/belief (Rousseau et al., 1998; Hofstede, 2002)

Both the aforementioned criteria are assumed to contribute to the trust and belief in the developed approach. Regarding our cases it is hard to identify for case 1 and case 5 whether our approach contributes to a situation of more trust or belief among the actors. Although practice provides evidence that e-auctions can work (Case 1) and that terminal locations have been appointed before and built in the last years (Case 5), the evidence regarding trust and belief is not a direct result of the case study, but is investigated indirectly. However, cases 2, 3, and 4 provide for direct evidence regarding trust and belief in the approach:

- *Case 2*

The CO₂-footprint method has gained serious interest by a large group of International Terminal Operators EEEG (EU PORT EEIG Environment Group) and FP7-program GREEN-PORTS to use it as a standard for measuring CO₂-emission at terminals.

- *Case 3*

The plans for the new terminal location in Tilburg are being made. The municipality of Tilburg and Barge Terminal Tilburg (BTT) have signed a letter of intent for the construction of a container terminal at Vossenbergh West II. Initially, in December 2010, the Council of State annulled the zoning plan for Vossenbergh West II. However, the Council of State questioned the impact analysis on noise which led to the municipality drafting a new zoning plan, taking into account the concerns of the Council of State. It should be better substantiated that a good living environment remains for the inhabitants of the residences of the Reeshof and the neighbourhood on the North side of the planned business park. Recently (July, 2011) the Mayor and

Aldermen of Tilburg agreed in favour of an environmental permit for the establishment of a Barge Terminal and the construction of the new terminal at Vossenbergh West II has meanwhile already started (Dijkhuizen, 2011).

- *Case 4*

With respect to the UCC in The Hague the former project manager explained that our calculations based on the CBA were considered well and therefore the municipality of The Hague decided not to implement an UCC at the Brinkhorst due to low volumes necessary to operate break even.

Our research has shown evidence that the involvement of public actors in logistics concepts has serious influences on the development of new logistics concepts. In theory we found that analytical approaches to design and evaluation do not sufficiently match the requirements of societal involvement of public actors in logistics. In practice this lack of methodological innovation frequently results in frictions between policy makers working at different policy levels and the operating field of retailers, logistics service providers and transport companies. On the one hand the public actors in practice are not fully satisfied with the outcomes of the research initiatives since their societal goals are not met. On the other hand the private actors involved in logistics services find themselves restricted by the rules and policy measures and often demonstrate their disappointments about the facilitating role of the government. Based on our case research we have been able to develop an approach to support multiple actor decision making on new logistics concepts. The approach enables involved stakeholders to make a choice in favour of a final logistics concept that is better tuned to perceptions of different stakeholders, is well understood and consequently can count on sufficient support for successful implementation.

8.3 Reflection and recommendations

In this section we will provide some reflections on our research and give some recommendations for future research in public logistics.

Process influences in cased base research

In this thesis we have focussed on the ex-ante multi-actor evaluation of the logistics concept and chosen not to include the process of decision making. Doing case studies in logistics practice is crucial for developing new approaches, including underlying methods and methodologies. However, logistics practice sometimes behaves more whimsically due to the time often necessary for political and academic reflection which conflicts with the need from entrepreneurs for a short implementation time. As logistics scientists we strive for openness and transparency with respect to the evaluation of concepts and data. On the other hand we can observe opposition by the initiators of the new concept in practice since they are afraid that the concept will be taken over by competitors or will be available for benchmark experiments by competitors (see for example case 2 where Maersk chose not to supply data on energy consumption). Sometimes it can even lead to anti-scientific sentiments.

Not so explicitly observed and straightforward are the mechanisms that can be found in the logistics business world resulting from policymakers playing political games to increase their influence on the outcomes. For instance in the policy plans to extend the Mainport Schiphol both the actors for and against were creative in moulding the insight into non-acoustic factors

to fit and perpetuate their respective arguments (Kroesen & Huys, 2009). Gils & Klijn (2007) qualify policy games as complex not only because there are many players making unpredictable strategic choices, but also because they are involved in more than one arena, often simultaneously. This is because most problems have different dimensions and thus touch upon different types of policies and actors. The policy game looks like multiple chess games played simultaneously in a number of rounds (Radford, 1977; Teisman, 1992), which makes it extremely difficult to grasp and anticipate what is happening from an analytical perspective.

Recognition of this awareness is represented by the variety of actors we introduce in the *Actors*-step and the understanding of the different arena's they operate in (as we did in case 5 making a distinction between European, national and regional level).

Policy reflection

As argued in Chapter 1 both policy making and logistics decision making are the result of a process of continuous interaction between a variety of stakeholders making a choice to change the system outcomes. In practice it can often be observed that policy making and logistics decision making use their own clocks which are often not synchronised. Synchronisation of the decision making processes leads to improved logistics concepts with a higher chance of success. In practice new public logistics initiatives collapse or encounter serious opposition due to the lack of synchronisation of both decision making processes. Examples of these are for instance the terminal Alpherium, located close to Koudekerk a/d Rijn and the terminal in Wanssum. Both terminals are already operational even though, for example, the problems with noise have not yet been solved. If all relevant actors had been involved from the start the problem of violating the noise constraints might have been foreseen. The case of the UCC in The Hague is a good example of all the actors involved starting at the same time. Even though the initiative failed the lead-time to come to the decision not to implement the project was just 6 months and all actors were strongly involved and supported the decision.

The most striking example is the policy agreement made by the Rotterdam Climate Initiative (RCI) between the Rotterdam local government and the harbour-related companies. The policy agreement resulted in a climate program aiming to reduce CO₂-emissions by 50% by 2025 compared to 1990 levels. However, it is remarkable that these goals have been set even though the real emission levels are not known. We studied the performances of the large container terminals in the Rotterdam area. Most terminal operators do not know how to report their emission footprints, nor do they know how to improve their CO₂-performances. In our opinion RCI (local government) and terminal operators should both have been involved in this program from the beginning and the local government should have worked as a facilitator or knowledge integrator (like the Dinalog organisation).

Towards complex adaptive systems

Future research into logistics will continue with the notions of complex adaptive systems introduced by Checkland (1981), as representative of the so-called "soft systems thinking" tradition. Complex adaptive systems consist of many actors that behave according to some set of rules. These rules require the actors to adjust their behaviours to that of other actors. In other words, actors interact with and adapt to each other and their environment (Stacey, 2003). The complex adaptive systems have an open character and strongly interrelate with other systems of actors. Agent based modelling systems fit these types of systems well

(Weiss, 1999; Wooldridge, 2009). In multi-agent models individual stakeholder behaviour and actions are explicitly modelled. Evidently, changing the set of stakeholders or their individual behaviour will have an effect on the overall outcome of the model. With these models, for example, the effect of price settings by freight carriers on the global outcome can be estimated (Tamagawa et al., 2010; Roorda et al., 2010). Also learning behaviour and reaction time can be included (Watkins & Dayan, 1992). For example, stimulating more interaction between policymakers and initiators of the UCC logistics concept led to dynamic pricing experiments for UCC usage (van Duin et al., 2012). Game theory experiments and other negotiation techniques can also be used to simulate human behaviour (Anand et al., 2010).

Problems of data collection

It is often stated in applied logistics research, especially in public logistics systems, that data collection is a problem (Holguín-Veras & Patil, 2008; Russo & Comi, 2010). In many situations government has no idea where the goods come from, where they go and what type of transport mode has been used. For instance in the field of city logistics it is a science in itself to estimate the origins and destinations of the goods flows by a particular transport mode in an inner city. Freight restocking journeys within urban areas can be stimulated using so-called matrix-calibration approaches which enable us to define freight vehicle Origin-Destination (O-D) matrices. The journeys for restocking urban retail activities are modelled through the definition of the trip-chain order and the choice of the delivery location. Intensive surveys and interviews among truck drivers are carried out to calibrate and validate the trip generation (Nuzzolo et al., 2011).

Such calibrated datasets need to be made available to enable other researchers to benchmark their models and suggestions for policy improvements. As we used an artificial town in our first case study, derived from former studies by Taniguchi from Kyoto University, this data should be further elaborated in terms of data in order to be able to classify specific towns, for example similar to the Solomon problem instances for benchmarking VRP-heuristics and methods (Solomon, 1997).

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9 Epilogue

*'Everything continues,
Everything passes,
Everything continues to pass'
(J.A. Deelder, 2010)*

From environmental awareness towards social responsibility

For multinational companies environmental awareness is becoming common practice in logistics. Strategic perspectives show how businesses could adjust to the new paradigm of green logistics by restructuring logistics systems and supply chains (Harris et al. 2010). Mckinnon (2010) shows that sustainability has become a new priority for logistics managers. Many literature contributions can be found which consider sustainability – green logistics, green port, environmental-friendliness, zero-emissions are keywords in a large number of articles. Green logistics is the study of practices that aim to reduce the environmental externalities of logistics operations, mainly related to greenhouse gas emissions, noise and accidents, therefore developing a sustainable balance between economic, environmental and social objectives (<http://www.greenlogistics.org/>, last accessed on August, 16, 2011). The social objectives try to realise improvements in safety, health, access and equity. Due to some governmental pressure the logistics practice follows this trend to seek for more sustainable solutions with the usage of electric vehicles and more intermodal transport in practice (Woodbrun & Whiteing, 2010). Although the logistics practice seems to be becoming greener, some skeptics should be mentioned here.

According to producers of fast consumer goods governments take no single initiative regarding sustainability. In the food industry new business initiatives for sustainability are growing faster and becoming bigger each time, although the legislation appears to not be able to or unwilling to follow. In principle the industry seems to be the driving force of development and the government follows and facilitates.

At the final stage it is the customer's choice to pay more for sustainable products. As long as the consumer is willing to pay the same or extra for sustainability, companies will concern themselves with sustainable logistics operations. In addition to that we can also observe in business practice that sustainable initiatives go hand in hand with cost reductions which still form the basic focus in logistics. In today's markets large multinational companies often use their green logistics activities as a marketing strategy. By showing their environmental concerns they can strengthen their green image in order to attract more customers and shake off competitors.

Inspired by the White paper 'Social Sustainability Assessment Literature Review' (Benoît & Vickery-Niederman, 2010) there are already forces present in today's society that broaden the scope of environmental awareness towards a societal awareness of companies' operations. Global Reporting Initiative, Corporate Social Responsibility, Social Accountability or Social Sustainability are terms which all have similar meanings in the literature. Corporate Social Responsibility (CSR) is most frequently cited and is defined by the European Commission as a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis. In practice it is a measurement of an organisation's state of being mindful of the emerging social concerns and priorities of internal and external stakeholders. Several frameworks for categorizing social impacts have been developed (Dreyer et al., 2006; Labuschagne & Brent, 2006; Weidema, 2006a, 2006b; UNDSO, 2007; Ceres, 2010; World Bank, 1997). These frameworks can be described as combinations of bottom-up and top-down approaches. The most important framework is the G3 Guidelines set up by the Global Reporting Initiative (www.theglobalreporting.org visited at 9 December 2011).

Nowadays companies can follow standard agreements on these frameworks (ISO 26000 (2010) or OECD Guidelines for multinationals (2000; 2009) on a voluntary basis. In the distant future it will be inevitable that companies have to conform to such a standard. As a good citizen needs a certificate of good behaviour to participate in society, so companies will need in future a conduct of Social Responsibility towards society to do business. By that time the policy circles and the continuing circles of improvement in logistics will be completely synchronised and will show even more overlap (= commonality in factors of concern).

By that time, the author of this dissertation will read this dissertation again with a smile on his face as he pushes his Zimmer frame, and will enjoy the feeling that his predictions have been verified. However, the verification of the work in this dissertation has in some cases already happened in practice since the work underlying this dissertation started almost 18 years ago. Choosing a research topic was never a problem, therefore I end with a quote from my favourite poet:

'Everything continues, everything passes, everything continues to pass'

(in Dutch: *Alles blijft, alles gaat voorbij, alles blijft voorbij gaan*, (Deelder, 2010)

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Summary

*Writing is deleting
(Godfried Bomans)'*

Background

Logistics has become a field of growing interest for public policy making over recent decades. Logistics has a great impact on society. Due to these societal impacts there is a need for a more explicit intervention by governmental policies. This development demonstrates that the growing importance of transition and innovation in logistics concepts is shifting away from the traditional boundaries of these concepts. In this thesis we define a logistics concept as a way of management and control of a series of activities by one or more organisations in order to generate a product or a service for a specific economic market. Logistics concepts nowadays have to serve multiple values (social, economic, environmental) related to the multiple interests of an increasing number of stakeholders. Thus, the development of logistics involves the engagement of all the stakeholders involved. This introduces a challenge for the methodologies/analytical approaches, used to support multiple actor decision-making on new logistics concepts. This study is triggered by the observation that analytical approaches for design and evaluation do not sufficiently match the requirements of societal involvement in logistics. We argue that the design of new logistics concepts demands an improved approach that does meet these requirements. This thesis brings together several case studies carried out and published in the past years, draws lessons from them and provides recommendations to improve a multi-actor approach for logistics concept development.

Scope of the study

Due to the significant changes in logistics we redefine the term logistics as 'Public Logistics' and propose, elaborate and illustrate different approaches to evaluating logistics concept development and implementation. Where the broad definition of logistics emphasizes the

handling of product flows, we add the idea of ‘contextual embeddedness’ in our definition of public logistics:

Public logistics is logistics embedded in an environment where public and private actors take mutually dependent decisions, and consequently broaden the scope of requirements regarding the logistics concepts.

Gaps in public logistics research

Figure A.1 positions the current situation of logistics knowledge in two dimensions: from a strong involvement in theory to a strong involvement in practice on one dimension and from the public nature of the actor to the private nature of the actor on the other dimension. Combining these dimensions results in a field with four corners: strong awareness of public actors in theory development of logistics (analysis and method development) versus public actors that strongly participate in (implementing and facilitating logistics concepts in) practice. These two ends of one axis represent completely different involvements of these public actors. In contrast, the same holds for private companies/actors. The involvement in theory or practice constitutes two ends of the other axis. The diamond in the middle of the playing field represents the present dominating practice of logistics (which implies a relatively strong involvement of private actors in both theory development and practice, and a relatively low involvement of public actors). In this dissertation it is argued that in public logistics the balanced involvement of both types of actors in theory (analysis and method development) as well as practice (implementing and facilitating concepts) should be pursued. The figure therefore indicates the two major “gaps” which need to be filled to reach this balanced situation.

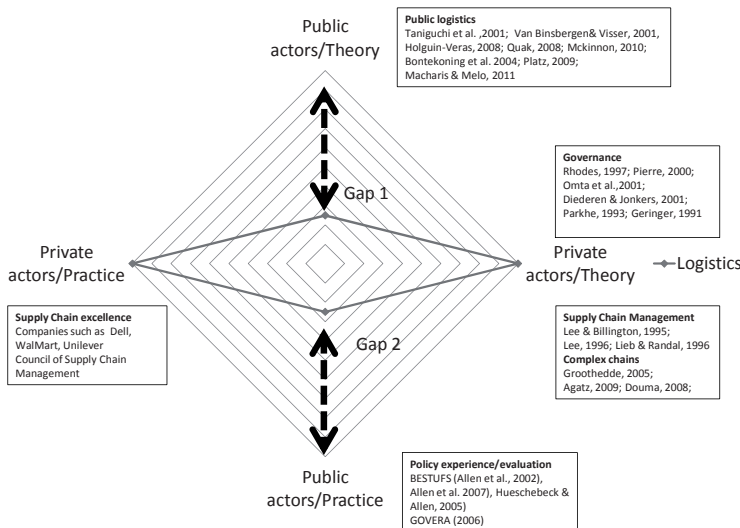


Figure A.1: Positioning of logistics

Nowadays, logistics service providers need to consider the influences of public actors such as the governmental bodies and local communities more. This consideration needs to be

incorporated into both the development of logistics theory as well as the implementation of the concept in practice. However, in both areas at the current time we can observe a lack of attention to the influences, positions and perceptions of all the stakeholders involved. This matches the two research gaps in the field of logistics, indicated as Gap 1 and Gap 2 in Figure A.1, and we call them the theoretical and practice public-stakeholder-gaps.

Some recent studies into logistics, such as on green logistics (Mckinnon *et al.*, 2010), City Logistics (Taniguchi *et al.*, 2001; van Binsbergen & Visser, 2001; Holguin-Veras, 2008; Quak, 2008; Macharis and Melo, 2011) and on intermodal freight networks (Bontekoning *et al.*, 2004; Platz, 2009), show an emerging focus on the integration of sustainable elements and the related actors' behaviours in their search for solutions and concepts. Most of these contributions have shown the importance of public and private actor involvement and the potential influence on the success of the logistics concept. However, none of the contributions has developed an approach for integrating different stakeholder perceptions in a logistics concepts design.

This lack of process innovation frequently results in frictions between policy makers working at different policy levels and industry (retailers, logistics service providers and transport companies). On the one hand the public actors are not fully satisfied with the outcomes of the initiatives since their societal goals are not met, i.e. the practice public actors gap (*see Figure A.1, Gap 2*). On the other hand the private actors involved in logistics services find themselves restricted by the rules and policy measures and are often disappointed in the facilitating role of the government.

Objective of the thesis

This thesis focuses on a stronger methodological integration of stakeholder perceptions and attitudes in the logistics concept design in such a way that the final logistics concept is tuned to perceptions of different stakeholders in order to create sufficient support for successful implementation. Based on this research scope, we formulate the following central research objective:

'To develop an improved approach to support the collaborative analysis of new logistics concepts in a multi-stakeholder context'

Research approach

Research on logistics is complex as the empirical domain includes a variety of business functions and strategic decisions. New and Payne (1995) specify a trade-off between two approaches in research: One can study artificial and abstract problems with the rigour necessary to have fully transparent and generic results, or one can study issues in the unique interaction with their real-world context, but with the risk of getting lost in the extraordinary complexity and ambiguity of the real world. Given our research objective, in this study we chose a research strategy based on case studies. Each case study inquiry dealt with the technically distinctive situation in which there were many more variables of interest than data points, relied on multiple sources of evidence with data which was required to converge in a triangulating fashion, and benefited from the prior development of theoretical propositions to guide data collection and analysis. This description of case study research connects well to the various perspectives of the actors involved.

Our case selection shows a growing complexity in terms of the number of stakeholders, the number of factors to be considered, and the policy levels involved. This is illustrated in Table A.1.

Table A.1: Case complexity

Case	Number of stakeholders	Number of factors	Geographic level	Case type
Case 1 <i>E-auction as a concept of UCC</i> (van Duin et al., 2007)	2 private actors, 1 public actor	Many factors	City level	Laboratory Experiment
Case 2 <i>CO₂-emissions at terminals</i> (van Duin & Geerlings, 2011)	1 private actor, 1 public actor	1 external factor	City level	Real case
Case 3 <i>Noise-emissions at terminal Tilburg</i> (van Duin & van der Heijden, 2012)	1 private actor, 2 public actors	1 external factor	City level	Real case
Case 4 <i>Urban consolidation centre in The Hague</i> (van Duin et al., 2010)	Many private actors, 2 public actors	Many factors	City level	Real case
Case 5 <i>Policy making on intermodal transport</i> (van Duin & van Wee, 2007)	Many private actors, many public actors	Many factors	National, regional, & city level	Real case

Following the idea of analytic generalisation (Yin, 1994) the analysis of the cases gradually sharpened and developed the insights needed to select the most appropriate method for analysis and whilst also testing the validity of the cases. The cases were necessary to develop and apply a tailor-made approach for designing and analysing logistics concepts.

Results

Case 1: E-auction as a concept of UCC (van Duin et al., 2007)

In the freight logistics business, supply chains are under strong pressure to provide customized goods and services. Individualized product deliveries, modifications in product specification, late orders and volume changes need to be accommodated within strict delivery time frames. This uncertainty in demand can only be accommodated by allowing for slack capacity and time in trip planning. This overbooking creates substantial costs, however, so firms will attempt to minimize these costs by further optimizing and re-organizing their distribution channels. This case-study looked at the feasibility of one such solution, a hybrid system of contracting freight carrying services. We tested the effectiveness and efficiency of this contracting system for all the actors involved by means of a simultaneous, real-time

simulation of the execution of planned tours, the auctioning process and the rescheduling of tours. Auctions can help to create more transparent, effective and efficient freight markets, as shippers have more information on (potential) carriers and vice versa. Through the real time and simultaneous auctioning and re-scheduling of deliveries, we were able to study in some detail the dynamics of bidding behaviour of both carriers and shippers. Our study confirmed that an auction system can contribute to a higher degree of consolidation by improving the clustering of routes. The case study also showed that there are benefits for both carriers and shippers. Auction enable carriers to improve the occupancy rate of transport vehicles and shippers can achieve better responsiveness on demanded delivery punctuality and better rates or price conditions. From the policy makers' perspective we observed that the total driving-times and the number of truck kilometres driven were reduced. In addition, the transport market for shippers and carriers became more open and transparent for all parties.

Case 2: CO₂-emissions at terminals (van Duin & Geerlings, 2011)

At present there is an increasing pressure on both governments and industries to come forward with initiatives to reduce CO₂-emissions. This is particularly relevant for the transport sector, as the share of road transportation is still increasing, while other sectors are reducing their CO₂-footprints. The main purpose of the study was to present a method to analyse the CO₂-emissions from container terminals and gain a better understanding of the CO₂-emissions by container terminals in port areas. A better understanding of the CO₂-emissions enables the identification of more effective solutions to reduce CO₂-emissions by container terminals can be identified by terminal operators and (local) government. A simple method was presented to estimate the CO₂-emissions from container port terminals based on fuel and energy-consumption. The developed bottom-up method provides new opportunities for a relatively simple assessment of the CO₂-emissions per terminal, based on macro terminal data. The method can be relatively easily adopted for different terminal configurations. The approach was illustrated for various terminals in practice. Terminal managers have shown a strong interest in this method since local governments demand information on their CO₂-production. For the terminal managers the method appeared to have sufficient precision in estimating the overall CO₂-production at their terminals. The model was validated by applying it to 95% of all the sea and inland container terminals in the Netherlands.

Case 3: Noise-emissions at terminal Tilburg (van Duin & van der Heijden, 2012)

The development of multimodal transport terminals in urban areas generates various serious environmental problems. The available tools for the analyses of the use of such terminals provide insufficient support to decision-making process on location and design of these terminals from the sustainability perspective. This study demonstrated a new approach, triggered by plans for a new Barge Terminal in the Dutch city of Tilburg (BTT). The existing terminal in Tilburg operates at almost full capacity and the construction of a new terminal is considered the best strategy to cope with continuing growth. The main question concerned the optimal design of the new barge terminal to provide high operational performance without exceeding the environmental quality standards, in particular noise. The study presented a computer simulation approach to assist in the process of finding a balance between the operational performance and the noise effects of alternative designs of the new terminal. Based on the 12 busiest days in a year we linked the operational performance of the new terminal, based on a maximum use of cranes, reach stackers and trucks, to its noise

production. This was done assuming different circumstances and noise reduction measures. The noise measures evaluated in the model were: (a) limiting the number of operational reach stackers at the terminal (as it is known that a reach stacker is the noisiest machine in the terminal) and (b) adjusting the working time of the terminal. The resulting insight enabled the terminal operator and the municipal authorities of Tilburg to jointly select the best terminal design option in terms of the balance between logistics performance and noise reduction.

Case 4: Urban consolidation centre in The Hague (van Duin et al., 2010)

The objective of this research was to advise the municipality of The Hague whether, if and under which conditions, the implementation of an Urban Consolidation Centre (UCC) would be possible and desirable. To determine the factors leading to success or failure of UCCs in practice, a survey of 6 cases in Europe was conducted. Summarising the European practices we stated that for the city of The Hague (the case that is studied here), the number of users, the organisation, the type of vehicle and the location are key success factors to consider.

Parts of a Cost-benefit analysis (CBA) were applied in this study. This CBA focused on the costs and benefits of the UCC in €per m³ for different amounts of goods handled per year. The CBA shows that in case the UCC uses medium-sized trucks (38 m³) and the transport demand was a minimum of approximately 150,000 m³ goods per year, the benefits would be higher than the costs. The annual quantity of goods (+/- 150,000 m³) implies participation by approximately 60% of the target group shops. Application of the CBA shows that full participation of all the shops in the target area would lead to a reduction in vehicle kilometres of distribution traffic of 8%. Both consignees and transportation companies would benefit financially from using the UCC. The UCC operator, however, incurs the costs. The municipality would therefore play an important role in the trade-off between costs and benefits.

Case 5: Policy making on intermodal transport (van Duin & van Wee, 2007)

The objective of this case study was to show that all policy levels (European, national (Dutch) and regional) are important in the choice of location of new terminals. We specified a modelling framework for these policy levels to create integrated support for the terminal location choice. We showed how this framework can be used in policymaking processes aiming to select new terminals locations and promote their use. The developed approach is not only a hierarchical top-down one, but also contains feedback-loops from lower to higher spatial scales, allowing to learn from more detailed insights from a lower level to inform the process. Application should lead to the Ministry of Infrastructure and Environment intensifying communication with regional policy makers, contrary to the EU-TEN policy. The focus of terminal development should be on the large (multi-national) companies, since a volume-oriented approach seems to be an accurate and successful selection criterion for the realization of new terminal initiatives. The model results showed good opportunities for inland terminal development with feeder distances shorter than 50 kilometres. At a regional scale we were able to select exact terminal locations. For each selected terminal location its competitiveness regarding road transport was determined precisely. Finally the exact terminal configuration was determined based on volumes from simulations. The developed approach was successfully applied, showing which variables are important for decision making at

different spatial scales with respect to the location of terminals for intermodal transportation, enabling us to identify two promising new terminal locations within the Netherlands.

Synthesis of case studies

Our case research has provided evidence for the addressed research gaps. Table A.2 gives an overview of the identified gaps based on our research cases.

Table A.2: Summary overview of research gaps in the case-studies

Case	Public/private Stakeholder (Theory)	Public/private Stakeholder (Practice)
	Gap 1	Gap 2
<i>E-auction as a concept of UCC</i>	<ul style="list-style-type: none"> ▪ Omission of behavioural aspects of carriers, shippers and government. ▪ Collection principles are not seen from a broad perspective. 	<ul style="list-style-type: none"> ▪ The bundling concept should be made profitable in the long run, since it has potential benefits for carriers, shippers and municipality.
<i>CO₂-emissions at terminals</i>	<ul style="list-style-type: none"> ▪ There is no unique method for calculating CO₂-emission at terminals. 	<ul style="list-style-type: none"> ▪ Terminal operators don't know how to measure/reduce the CO₂-emissions at their terminals. ▪ Policymakers have a pre-perception that terminal operators can reduce their CO₂-emission with 50% according to the Rotterdam Climate Initiative (RCI).
<i>Noise-emissions at terminal Tilburg</i>	<ul style="list-style-type: none"> ▪ External effects can seriously influence the operations at a terminal. No adequate modelling approaches are available showing the consequence of noise limits on terminal performances. 	<ul style="list-style-type: none"> ▪ The terminal operators fail to recognize that the farmers and inhabitants might have an influence on their operations. ▪ Local authorities tend to forget that noise restrictions tend to have serious consequences on the operational performance of a terminal.
<i>Urban consolidation centre (UCC) in The Hague</i>	<ul style="list-style-type: none"> ▪ Other actors might also benefit or have extra costs due to the introduction of a UCC, so other financial models have to be considered. ▪ Theory fails to look at financial feasibility of the UCCs and subsidies are too often the only way to compensate the losses. 	<ul style="list-style-type: none"> ▪ Policy makers fail to look at the success of other UCC initiatives. ▪ Basic principle for the existence of a UCC is to obtain enough bundling volume to achieve break-even.
<i>Policy making on intermodal transport</i>	<ul style="list-style-type: none"> ▪ The location of terminals heavily depends on the cost reduction choice of companies. ▪ It is impossible to formalise the location decision making into one model. 	<ul style="list-style-type: none"> ▪ Decisions on the location of terminals are made at three different policy levels. ▪ Policy makers fail to recognise that companies only choose for intermodal transport on condition that it is cheaper than road transport.

Summarising across all the case studies with respect to the theoretical public-stakeholder gap (Gap 1) we observed corresponding shortcomings with respect to the embedding of different actor perceptions into the developed models. In response to this we applied a case study

protocol to all the cases that explicitly started with an actor perception analysis. This crucial analysis gave us, per case, insight into the critical factors of all the involved actors with respect to the development of new logistics services. In our study it appeared feasible to include many factors of importance for a logistics concept into the applied modelling formalisms and thus enrich the analysis underlying decision making. For the identification of the critical factors of all the involved actors new formalisms can be applied such as Dynamic Actor Network Analysis (DANA) (Bots et al., 1999; van Duin et al., 1999; Bots et al., 2000; Bots, 2007). Based on the modeling experiences in the case studies we conclude that no unique method or modelling formalism is dominant. Each case had its own characteristics and therefore we selected the modelling approach which would provide the best insight into the policy problem field. Application of various validation approaches and scenario analyses gave us good insight into the sensitivity of the factors of importance. Most importantly is the conclusion that all models have contributed to an open process with constructive communication between private and public actors.

With regard to the practice public-stakeholder gap (Gap 2) the cases confirmed the hypothesis that in practice all actors tend to have a restricted view of the logistics concept development. Most actors involved tend to look at the logistics concept from a mono-actor perspective, which is to some degree explained by the fact that the perceptions of the other actors are largely unknown. To understand the complete picture of the logistics concept the perceptions of other actors involved and possible former experiences with the concept need to be considered. Not including actor positions in the design of a new logistics concept will increase the risk of the concept failing or not meeting the performances expected by the stakeholders involved.

Contributions of the thesis

In this thesis we developed an approach that forms a first step in filling the theoretical and practice public-stakeholder-gaps. Table A.3 provides an overview of the theoretical contributions for each case.

Table A.3: Summary overview of theoretical contributions addressed in the case-studies

Case	Contribution to the approach
<i>E-auction as a concept of UCC</i>	The identification of the main stakeholders and the specification of their objectives structures the applied approach. Next, based on the most important factors of interest, we have selected appropriate modelling techniques. The behavioural aspects were formulated and brought into a large simulation model in which the bidding auction-processes, the delivery processes by the trucks and the vehicle-routing planning are dynamically simulated.
<i>Relevance</i>	Adding the behavioural aspects of the actors involved into a simulation model gives a transparent insight into the operational performances of the logistics concept for all the actors involved.
<i>CO₂-emissions at terminals</i>	Terminal operators and local governments have no insight into the CO ₂ emission production at the terminals. A dedicated model was developed to estimate the emissions of the terminals based on their layout, throughput and terminal equipment configurations. The model shows the energy consumption of diesel and electricity and makes clear what the most CO ₂ productive processes/equipments are at the terminal.
<i>Relevance</i>	The development of the model provided insight on the unknown external effect. This insight led to a convergence in the perceptions of the actors and has provided a mutual awareness of

the consequences of this external effect, both for policy and logistics decision making.

Noise-emissions at terminal Tilburg	We developed a modelling approach, based on simulation techniques, to integrate both operational parts of the terminal and the related noise effects for its surroundings and applied this for the new container terminal. With the aid of the simulation model a terminal location assessment was carried out in a very conscious and open process with constructive communication between private and public actors.
<i>Relevance</i>	The development of the model gave insight into the consequences of the unknown external effect on the operational performances. This insight led to a convergence in the perceptions of the actors and has provided a mutual awareness about the consequences of this external effect, both for policy and logistics decision making.
Urban consolidation centre (UCC) in The Hague	As a first step we identified all the actors involved. Identification of their goals and their relationship to the concept gave us clear insight into which factors and interest should be analysed in more depth. In our case the feasibility perspectives (technical, financial and political) reflected well the factors of interest by the actors involved. As a modelling formalism elements of a Cost Benefit Analysis were applied to integrate both technical and financial factors. Based on this analysis we were able to make some recommendations to support political decision making.
<i>Relevance</i>	Identification of the actor perceptions gave insight into the factors of concern with respect to the logistics concept. Scenario-analysis of the model gave insight into the consequences of these factors. As a result convergence of actor perceptions occurred and a joint decision making (between policy makers and logistics actors) was enabled. All actors involved accepted the resulting decision fairly.
Policy making on intermodal transport	As a first step we applied an actor perception analysis which gave us insight into the critical success and failure factors of all the involved actors with respect to the development of intermodal transport services. These identified factors are indicated to be important by the actors at every policy level. Thanks to the recognition of actors in specific arenas we can build dedicated models (a linear programming model, Activity-Based-Cost –model, and a simulation model) for adapting specific factors of concern.
<i>Relevance</i>	The awareness that decision-making on terminal location has attention at three different policy levels. For each of these levels actor-analysis is important and different models are needed to provide insight into the factors of concern. Dependencies between the decision making levels should also be reflected in the development of the models, i.e. output from a model is input for the following model.

In line with this we conclude that this thesis has the following theoretical and practical contributions.

Theoretical contribution

The first theoretical contribution is that the research has developed a serious awareness of multi-actor decision-making in logistics concept development. As a consequence, this study has provided an enriched approach with the focus on stronger methodological integration of stakeholder perceptions and attitudes in the logistics concept design and assessment. The approach enables stakeholders to make a choice in favour of a final logistics concept that is better tuned to the perceptions of different stakeholders and consequently can count on sufficient support for successful implementation. Figure A.2 summarizes an integrative approach. It is based on the idea that policy making and the execution of logistics services simultaneously follow the management cycles. As an initial condition for a successful application of the approach it is important at the start of a development of a new or adapted public logistics concept that the process is synchronized with the policy making process.

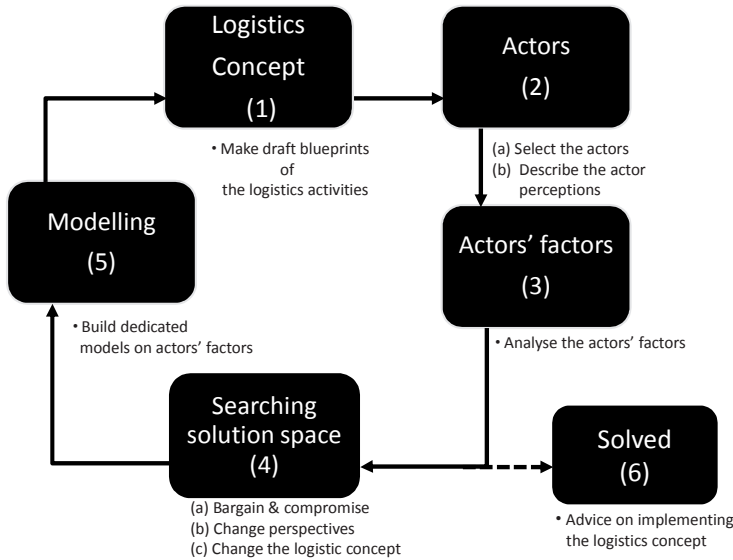


Figure A.2: Integrative approach for public logistics concept design

The approach starts with the identification and description of the logistics processes that are part of the new logistics concept and the selection of all the directly and indirectly-related actors within the arena of this concept (1). The next step is to portray all the actors' perceptions, defining the causal relation schemes of their way of thinking and to specify the relations of actors in the network (2). After all the perceptions have been identified, a network analysis can be performed (3). The network analysis provides us with insight into which factors are considered important by which actors, and which factors receive very different weights or cause conflicts between actors. When actors have conflicting interests and positions their instruments could be studied in order to be able to search for actors who can benefit from the use of these instruments. Identifying actors who potentially benefit from these instruments provides the opportunity for finding solutions by processes of bargaining and compromising or searching for changes in the concept (4). When conflicts or special factors of concern are detected, developing more dedicated models might be more useful to quantify the effects in order to provide more insight for those actors who attach great weights to these issues (5). The outcomes of the dedicated models can clarify or reduce uncertainty with respect to the outcomes. Based on these insights some actors might be willing to change their perception or the logistics concept could be adjusted to more closely meet the perceptions of the actors. If all the actors' factors and their consequences are known then a step towards implementing the concept (6) can be made.

Practical contribution: quality improvement of the logistics concept and higher probability of acceptance by the multi-stakeholders involved

In order to evaluate whether the developed approach will provide an enriched insight for decision making and will also result in an improved design, we refer to the following evaluation criteria:

Analytic criteria (Geurts & Vennix, 1989)

This criterion stresses that the approach should leave space for many perspectives. The relevant arguments for logistics concept development should be deduced from a broad, holistic systems approach. The models and techniques applied must be flexible and hybrid (Nutt, 1982). The hybridity of the approach refers to a combination of techniques derived from the hard, formal sciences and the soft, cognitive sciences and should contribute to the transparency of the applied methods.

Moreover, the criterion stresses the need for methodological transparency. In the context of our study this has been identified as most crucial for reducing what has been labelled as Gap 1: the theoretical public-stakeholder-gap. It should be theoretically and methodologically evident and empirically illustrated that the richness of the multi-actor perspectives can be well incorporated in the ex-ante evaluation of public logistics concepts and applied for processes of their improvement.

In all the case studies in this research we applied methods that are derived from the hard and soft operations research. The development and application of the methods is characterised by a clear transparency. In all cases the transparency is both theoretically proven by References to the approach in other research and practically proven by validation with experts/actors in the problem domain.

Quality improvement of the logistics concept

This criterion implies that the approach should provide transparency with respect to the causal relationships of the logistics concept and its operating environment for all the stakeholders involved. The quality improvement can be obtained by a thorough exploration and understanding of the stakeholders' relationships to the logistics concept.

For filling the practice public-stakeholder-gap, Gap 2, transparency in the outcomes is most important, which immediately goes back to the quality of the approach. For each actor involved in the public logistics concept it should be made clear what the (financial, economical, environmental, spatial) consequences will be for this actor.

In all cases the approach has shown good insight into the factors that really matter. All the developed models, sensitivity analyses and scenario analyses significantly contributed to mutual insight for the actors involved. In all case studies we have managed to provide the required transparency in the outcomes of our modelling efforts.

Trust/belief (Rousseau et al., 1998; Hofstede, 2002)

Both afore-mentioned criteria are assumed to indirectly contribute to trust and the believe in the developed approach. In our case studies we observed that the applied approach created more trust or belief amongst the actors regarding the logistics concept. By seriously integrating the actor perceptions in the applied models, the models themselves played a crucial role in the search for the solution and the role of the logistics concepts in policy, the identification of their boundaries and the transition paths. This confirms the claim frequently expressed in literature that the application of techniques such as scenario analysis and sensitivity analysis significantly contribute to building more trust and belief of the actors in the final results.

Conclusions and recommendations

Our research has provided evidence that the involvement of public actors in logistics concepts has a serious influence on the development of new logistics concepts. In theory we found that analytical approaches for design and evaluation do not sufficiently match the requirements of societal involvement of public actors in logistics. Also in practice this lack of methodological innovation frequently results in frictions between policy makers working at different policy levels and the operating field of retailers, logistics service providers and transport companies. On the one hand the public actors in practice are not fully satisfied with the outcomes of the research initiatives since their societal goals are not met. On the other hand the private actors involved in logistics services find themselves restricted by the rules and policy measures and often demonstrate their disappointment about the facilitating role of the government. Based on our case research we have been able to develop an approach to support multiple actor decision making on new logistics concepts. The approach enables the stakeholders involved to make a choice in favour of a final logistics concept that is better tuned to perceptions and expectations of different stakeholders, is well understood and consequently can rely on sufficient support for successful implementation.

Research into multi-actor decision-making in public logistics concepts will further develop in the direction of the theories and concepts of complex adaptive systems thinking. Complex adaptive systems thinking assumes many actors that behave according to a particular set of rules. These rules describe how actors adjust their behaviours to that of other actors. In other words, actors interact with and adapt to each other and their environment. The complex adaptive systems have an open character and strongly interrelate with other systems of actors. Agent-based-modelling systems fit these types of systems well and all kinds of experiments in terms of actor behaviour (learning experiments & gaming experiments) can be setup to evaluate and improve the decision making in public logistics concepts.

Samenvatting

*‘Schrijven is schrappen’
(Godfried Bomans)*

Achtergrond

In de afgelopen decennia is logistiek uitgegroeid tot een thema met groeiende belangstelling vanuit de overheid. De aan de logistieke sector verbonden activiteiten tezamen hebben veel effect op de samenleving. Als gevolg van deze maatschappelijke effecten is de behoefte aan een meer expliciete tussenkomst van overheidsbeleid geboden. In dit proefschrift definiëren we een logistiek concept als een manier van beheer en controle van een aantal activiteiten door één of meerdere organisaties om een product of een dienst in een specifieke economische markt te zetten. Hedendaagse logistieke concepten dienen meerdere maatschappelijke waarden (sociaal, economisch, milieu) welke gerelateerd zijn aan de diversiteit van belangen van een toenemend aantal belanghebbenden in de private en publieke sector. Derhalve kunnen we concluderen dat de ontwikkeling van de logistiek heeft geleid tot een sociaal engagement van alle betrokken partijen. De uitdaging is om methoden en technieken te ontwikkelen en in te zetten die goed kunnen omgaan met de complexiteit van deze pluriforme besluitvorming tussen betrokken partijen bij de ondersteuning van het ontwikkelen en implementeren van nieuwe logistieke concepten. Deze studie is ontstaan door de observatie dat analytische benaderingen voor ontwerp en de evaluatie van logistieke concepten onvoldoende tegemoet komen aan de eisen van maatschappelijke betrokkenheid. Derhalve kiezen wij de uitdaging dat het ontwerp van nieuwe logistieke concepten vraagt om een verbeterde aanpak die meer aan deze eisen tegemoet komt. Dit proefschrift bundelt een aantal case studies op het gebied van logistieke concept ontwikkeling welke zijn uitgevoerd in de afgelopen vijf jaren. Uit deze case studies worden lessen getrokken die leiden tot een aanpak om de pluriforme besluitvorming met publieke en private partijen met betrekking tot logistieke concept ontwikkeling te kunnen verbeteren.

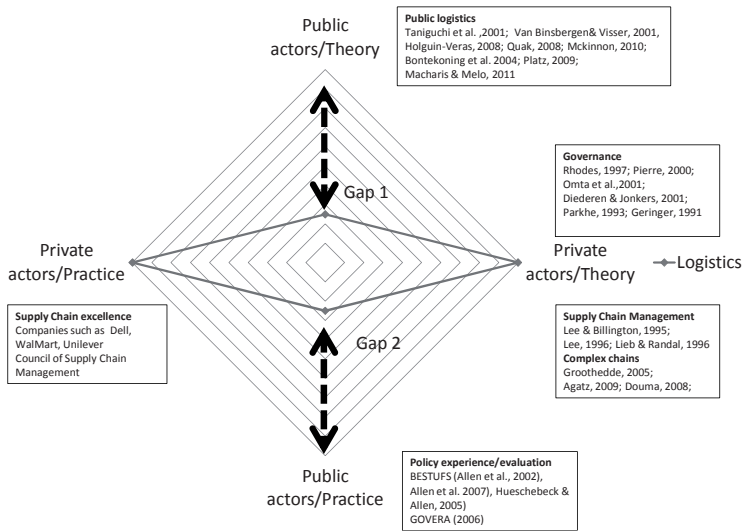
Scope van het onderzoek

Als gevolg van de eerder vermeldde verandering in de logistiek herdefiniëren we het gebied van de logistiek naar ‘publieke logistiek’ en wordt in dit proefschrift dit gebied geschetst, uitgewerkt en geïllustreerd met verschillende evaluatiemethoden ten behoeve van logistiek concept ontwikkeling en implementatie. Waar de algemene definitie van logistiek de afhandeling van productstromen benadrukt, voegen wij het idee van 'contextuele inbedding' toe aan de definitie van publieke logistiek:

Publieke logistiek is logistiek ingebed in een omgeving waar publieke en private actoren wederzijdse afhankelijke beslissingen nemen, waardoor noodzakelijkerwijs een verruiming van eisen en wensen ontstaat ten aanzien van de logistieke concepten.

Lacunes in het onderzoek naar publieke logistiek

Figuur B.1 positioneert de huidige situatie van logistieke kennis in twee dimensies: vanuit enerzijds een sterke betrokkenheid vanuit de theorie naar anderzijds een sterke betrokkenheid vanuit de praktijk, met daaraan toegevoegd de aandacht voor publieke actoren vanuit de overheid en aan de ander kant het private karakter van de betrokken (keten-)actoren. Combinatie van deze dimensies resulteert in een veld met vier hoeken: sterk bewustzijn van de publieke actoren in theorieontwikkeling (analyse en methode ontwikkeling) van de logistiek versus publieke actoren die sterk wensen deel te nemen (aan de uitvoering en faciliteren van logistieke concepten) in de praktijk. Deze twee uiteinden van een as vertegenwoordigen een heel andere betrokkenheid van deze publieke actoren. De betrokkenheid van private partijen in de theorie en/of de praktijk vormen de twee uiteinden van een andere as. De diamant in het midden van het speelveld is representatief voor de huidige dominante praktijk van logistiek (wat impliceert een relatief sterke betrokkenheid van de private actoren in zowel theorievorming en praktijk, en een relatief lage betrokkenheid van de publieke actoren). In dit proefschrift wordt betoogd dat in publieke logistiek een evenwichtige betrokkenheid van beide soorten actoren in theorie (analyse en methodeontwikkeling) en praktijk (het implementeren en faciliteren van concepten) moet worden nagestreefd. Figuur B.1 geeft dus de twee belangrijkste "hiaten" (Gap 1 & Gap 2) aan die gevuld moeten worden om deze evenwichtige betrokkenheid te realiseren.



Figuur B.1: Positionering van de huidige logistiek

Tegenwoordig moeten logistieke dienstverleners steeds meer rekening houden met de invloeden van de publieke actoren zoals de overheden en lokale gemeenschappen. Deze overweging moet worden meegenomen zowel in de logistieke theorie ontwikkeling als ook in de toepassing van het logistieke concept naar de praktijk. Vanuit beide perspectieven ontbreekt op dit moment een gebrek aan aandacht voor de invloeden, standpunten, percepties van alle betrokken partijen. Dit zijn de twee onderzoekshiaten in het onderzoeksgebied van de logistiek, aangeduid als Gap 1 en Gap 2 in Figuur B.1, en definiëren we als de theoretische en de praktische publieke actor-hiaten.

Een aantal recente onderzoeken in de logistiek zoals groene logistiek (Mckinnon et al., 2010.), binnenstadlogistiek (Taniguchi et al., 2001; van Binsbergen & Visser, 2001; Holguin-Veras, 2008; Quak, 2008; Macharis en Melo, 2011) en intermodale goederenvervoer netwerken (Bontekoning et al., 2004; Platz, 2009) laten wel een nieuwe oriëntatie van logistiek zien die gericht is op de integratie van duurzame elementen en gedrag van betrokken actoren bij het zoeken naar oplossingen en nieuwe concepten. De meeste van deze bijdragen erkennen het belang van de betrokkenheid van publieke en private actoren en hun invloed op het succes of falen van nieuwe logistieke concepten. Echter, géén van de bijdragen ontwikkelde een aanpak voor de integratie van verschillende percepties van de belanghebbenden in logistieke concept ontwikkeling.

Dit gebrek aan procesinnovatie resulteert vaak in fricties tussen de beleidsmakers, werkend op verschillende beleidsniveaus, en de logistieke industrie (retailers, logistieke dienstverleners en transportbedrijven). Aan de ene kant zijn de overheidinstanties niet geheel tevreden met de uitkomsten van de initiatieven, omdat de maatschappelijke doelstellingen niet worden gehaald (zie Figuur B.1, Gap 2). Aan de andere kant voelen de private actoren die betrokken zijn in logistieke dienstverlening zich beperkt door de regels en beleidsmaatregelen van de overheid en zijn ze vaak teleurgesteld over het gebrek aan een faciliterende rol van de overheid.

De onderzoeksdoelstelling

Dit proefschrift is gericht op het ontwikkelen van een sterkere methodologische integratie van de actorpercepties en attitudes in het logistieke concept ontwerp op een zodanige wijze dat het uiteindelijke logistiek concept is afgestemd op percepties en belangen van de verschillende belanghebbenden, teneinde voldoende draagvlak voor een succesvolle implementatie te creëren. Gegeven de afbakening van dit onderzoek, formuleren we de volgende centrale onderzoeksdoelstelling:

“Ontwikkeling van een verbeterde aanpak welke een gezamenlijke analyse van nieuwe logistieke concepten vanuit multi-actor context ondersteunt.”

Onderzoeksaanpak

Onderzoek naar logistiek is complex als empirische domein, want zij omvat een groot aantal zakelijke functies en strategische beslissingen. New & Payne (1995) geven een ‘trade-off’ tussen de twee benaderingen in het onderzoek: men kan kunstmatige en abstracte problemen bestuderen met een strengheid die nodig is om volledig transparante en generieke resultaten te genereren, of men kan de problemen bestuderen in hun unieke interactie met de reële wereld (praktijk), maar met een kans op mogelijk verdwalen in de buitengewone complexiteit en ambiguïteit van de echte wereld. In deze studie is gekozen voor de laatste onderzoekstrategie op basis van gevalstudies. Elke gevalstudie kent een unieke situatie waarin vaak meerdere variabelen van belang zijn dan harde meetpunten beschikbaar zijn. In deze situatie worden meerdere bronnen van bewijs met gegevens gebruikt om deze via triangulatie te laten convergeren en te combineren met de eerder bevindingen van theoretische proposities.

De selectie van gekozen gevalstudies vertoont een groeiende complexiteit in termen van het aantal belanghebbenden, het aantal factoren dat wordt beschouwd, en de verschillende (overheid)beleidsniveaus die betrokken zijn (Tabel B.1).

Tabel B.1: Overzicht complexiteit van de uitgevoerde gevalstudies

Gevalstudie	Aantal partijen	Aantal factoren	Geografisch niveau	Gevaltype Studie
Gevalstudie 1 <i>E-veiling als een concept voor stadsdistributie (van Duin et al., 2007)</i>	2 private actoren, 1 publieke actor	Vele factoren	Stad	Laboratorium Experiment
Gevalstudie 2 <i>CO₂-emissies door terminals (van Duin & Geerlings, 2011)</i>	1 private actor, 1 publieke actor	1 externe factor	Stad/regio	Praktijkstudie
Gevalstudie 3 <i>Geluidsemissie door toekomstige terminal Tilburg (van Duin & van der Heijden, 2012)</i>	1 private partij, 2 publieke actoren	1 externe factor	Stad	Praktijkstudie

Gevalstudie 4 <i>Een stadsdistributie-centrum in Den Haag</i> (van Duin et al., 2010)	Vele private partijen, 2 publieke actoren	Vele factoren	Stad	Praktijkstudie
Gevalstudie 5 <i>Beleidsontwikkeling voor intermodaal vervoer</i> (van Duin & van Wee, 2007)	Vele private partijen, vele publieke actoren	Vele factoren	Nationaal, regionaal, & stedelijk niveau	Praktijkstudie

Het protocol van analytische generalisatie (Yin, 1994) volgend is de analyse van de gevalstudies geleidelijk aangescherpt en het inzicht ten aanzien van de juiste aanpak van analyse ontwikkeld, waarbij gelijktijdig de validiteit van de gevalstudies werd getest. We hebben de gevalstudies zodanig opgebouwd, dat een op maat gemaakte ontwikkeling en toepassing van een aanpak voor het ontwerpen en analyseren van publieke logistieke concepten mogelijk werd.

Resultaten

Gevalstudie 1: E-veiling als een concept voor stadsdistributie (van Duin et al., 2007.)

Logistieke bedrijven staan onder sterke druk om op maat gemaakte goederen en diensten op tijd te kunnen leveren. Individuele product leveringen, wijzigingen in productspecificaties, late bestellingen en volume veranderingen zijn klanteisen die vaak moeten worden uitgevoerd binnen strikte tijdvensters. Deze continue veranderingen leiden tot onzekerheden in de transportvraag welke alleen kunnen worden opgevangen door flexibiliteit te garanderen in de vervoerscapaciteit, dan wel in tijd bij het maken van de routeplanning. Aangezien door overboeking aanzienlijke kosten kunnen ontstaan, zullen bedrijven trachten deze te minimaliseren door de verdere optimalisatie en reorganisatie van hun distributiekanaal. In deze gevalstudie hebben we gekeken naar de haalbaarheid van een hybride systeem van aanbesteedde vervoersdiensten. De hybriditeit van dit systeem bestaat uit het feit dat naast een reguliere orderplanning ook een mogelijkheid van veilen wordt aangeboden voor zowel de klant als de vervoerder. We hebben de effectiviteit en efficiëntie van dit systeem voor alle betrokken actoren onderzocht door middel van door middel van een 'real-time'-simulatie van de uitvoering van de geplande ritten, het veilingproces en de herberekening van geplande ritten bij offerte via de veiling. Door toepassing van een 'real-time'-simulatie waren we in staat om de dynamiek van biedgedrag van vervoerders en verladers in detail te bestuderen. Onze studie bevestigt dat een veilingssysteem kan bijdragen aan een hogere mate van consolidatie door een verbeterde clustering van routes. Voor zowel de vervoerders als verladers biedt de veiling gunstige resultaten. Voor de vervoerder kan de veiling worden gezien als een kans om de bezettingsgraad van voertuigen te verbeteren. Verladers kunnen door toepassing van een veiling een betere afstemming op de gewenste punctualiteit verkrijgen en betere tarieven of prijsvoorwaarden kunnen worden onderhandeld. Vanuit het perspectief van de overheid (gemeente) zagen we dat de totale hoeveel gereden tijd en het aantal gereden vrachtwagen kilometers in de binnenstad werden verlaagd. Bijkomstig is het effect dat door toepassing van een veiling meer openheid en transparantie wordt geboden ten aanzien van de vervoerprestaties en prijsontwikkeling voor verladers en vervoerders.

Gevalstudie 2: CO₂-emissies door terminals (van Duin & Geerlings, 2011)

Tegenwoordig is er een toenemende druk vanuit de overheid ten opzichte van de industrie om te komen met initiatieven die de uitstoot van o.a. CO₂ verminderen. Deze druk wordt vooral ervaren in de transportsector waarbij het aandeel van het (weg-)vervoer nog steeds toeneemt. Het doel van deze gevalstudie was om een eenvoudige methode te ontwikkelen om de CO₂-uitstoot van container terminals te kunnen analyseren en een betere vaststelling van de CO₂-uitstoot per container terminals in havengebieden te krijgen. Met een betere vaststelling van de CO₂-uitstoot door de (locale) overheid kunnen effectieve oplossingen worden geïdentificeerd om de totale CO₂-uitstoot van containerterminals te reduceren in overleg met de terminal operators. De ontwikkelde ‘bottom-up’-methode biedt nieuwe mogelijkheden voor een relatief eenvoudige beoordeling van de CO₂-uitstoot per terminal, op basis van macro-terminal gegevens. De methodiek kan relatief eenvoudig worden vastgesteld voor de verschillende terminal configuraties. De aanpak werd geïllustreerd voor verschillende terminals in de praktijk. Terminal managers hebben een sterke interesse in deze methodiek getoond, omdat zij worden gedwongen om inzicht in hun CO₂-productie te bieden door de lokale overheden. Voor de terminal managers bleek de methodiek voldoende nauwkeurig te zijn voor het schatten van de totale CO₂-productie op hun terminals. Het model werd gevalideerd door toepassing op 95% van alle zee-en binnenvaartcontainer terminals in Nederland.

Gevalstudie 3: Geluidsemissie op de toekomstige terminal in Tilburg (van Duin & van der Heijden, 2012)

De ontwikkeling van multimodale terminals in stedelijke gebieden genereert verschillende milieuproblemen. De beschikbare instrumenten voor de analyse van het gebruik van dergelijke terminals bieden vaak onvoldoende steun om de besluitvorming voor locatie en ontwerp van deze terminals vanuit het perspectief van duurzaamheid daadwerkelijk te kunnen ondersteunen. Deze studie toonde een nieuwe aanpak voor het plannen van een nieuwe binnenvaart terminal in een Nederlandse stad (Tilburg (BTT)). De bestaande terminal in Tilburg werkt op vrijwel volledige capaciteit en de bouw van een nieuwe terminal wordt beschouwd als de beste strategie om de aanhoudende groei van containers in deze regio te kunnen faciliteren. De belangrijkste vraag had betrekking op het bepalen van een ontwerp voor de nieuwe binnenvaartterminal op een zodanige manier dat hoge operationele prestaties geleverd kunnen worden zonder de milieukwaliteitsnormen, in dit geval de geluidsnormen, te overschrijden. De studie presenteerde een simulatie-aanpak die een ondersteuning leverde bij het proces van het vinden van een evenwicht tussen de operationele prestaties en het geluidseffecten van alternatieve ontwerpen van de nieuwe terminal. Op basis van de 12 drukste dagen in een jaar hebben we de operationele prestaties van de nieuwe terminal (gebaseerd op een maximaal gebruik van kranen, ‘reachstackers’ en vrachtwagens) gekoppeld aan de geluidsproductie. Daarbij werd gebruik gemaakt van verschillende geluidbeperkende maatregelen. De geluidsreducerende maatregelen die in het model geëvalueerd waren: (a) het aantal operationele ‘reachstackers’ op de terminal (een ‘reachstacker’ is de meest geluidsproducerende equipment op de terminal) en (b) het aanpassen van de werktijden van de terminal. Door de verkregen inzichten met het model konden de terminal operator en het gemeentebestuur van Tilburg in gezamenlijk overleg een keuze maken voor het beste terminal ontwerp in termen van de balans tussen logistieke prestaties en de geluidsproductie.

Gevalstudie 4: Een stadsdistributiecentrum in Den Haag (van Duin et al., 2010)

Het doel van dit onderzoek was om de gemeente Den Haag te adviseren onder welke voorwaarden de implementatie van een stadsdistributiecentrum (SDC) concept mogelijk en/of wenselijk zou zijn. Om de faal- en succesfactoren van een SDC vast te stellen is een zestal Europese ervaringen met SDC's uitvoerig bestudeerd. Samenvattend is uit deze studie naar voren gekomen dat voor de stad Den Haag het aantal gebruikers, de organisatie, het type voertuig en de locatiekeuze belangrijke succesfactoren kunnen zijn. Daarna zijn delen van een kosten-baten analyse (KBA) uitgevoerd (notabene: niet alle factoren werden omgerekend naar kosten). Toepassing van de KBA was gericht het kwantificeren van de kosten en baten van het SDC per m³ voor verschillende hoeveelheden goederen behandeld per jaar. Uit deze studie blijkt dat als het SDC gebruik maakt van middelgrote vrachtwagens (38 m³) en de vervoersvraag een volume van 150.000 m³ producten per jaar overschrijdt, de voordelen groter zijn dan de kosten. Een jaarlijkse hoeveelheid goederen van (+/-)150.000 m³ impliceert een deelname van ongeveer 60% van de doelgroep winkels. De berekeningen laten zien dat een volledige deelname van alle winkels in het doelgebied zou leiden tot een vermindering van de gereden voertuigkilometers van het goederenvervoer met 8%. Zowel de ontvangers (winkeliers) en de transport bedrijven zouden financieel profiteren van het gebruik van het SDC. De SDC exploitant draait echter op voor de kosten. De gemeente zou daarom een belangrijke rol spelen in een evenwichtige verdeling van de kosten en baten.

Gevalstudie 5: Beleidsontwikkeling voor intermodaal vervoer (van Duin & van Wee, 2007)

Het doel van deze gevalstudie was aan te tonen dat alle beleidsniveaus (Europees, nationaal en regionaal) van belang zijn bij de keuze van de locatie van nieuwe terminals. We hebben een raamwerk van modellen ontwikkeld voor al deze beleidsniveaus om een geïntegreerde ondersteuning voor terminallocatiekeuze te kunnen maken. We hebben laten zien hoe dit raamwerk kan worden gebruikt ter ondersteuning van de beleidsvorming processen gericht op het selecteren van potentiële terminals locaties. Het ontwikkelde raamwerk kent niet alleen een hiërarchische 'top-down'-benadering, maar bevat ook 'feedback-loops' van een lager ruimtelijk schaalniveau naar een hoger ruimtelijke schaalniveau die het mogelijk maken om te leren van meer gedetailleerde inzichten van het lagere niveau. Toepassing van het raamwerk dient te leiden tot intensivering van de communicatie tussen het ministerie van Infrastructuur en Milieu en de regionale beleidsmakers (dit is in tegenstelling tot het EU-TEN-beleid). De focus van terminal ontwikkeling dient te liggen op de grote (multi-nationale) bedrijven, omdat een volume-gerichte aanpak een accurate en succesvolle selectiecriteria lijkt te zijn voor de realisatie van de nieuwe terminal initiatieven. De modelresultaten gaven goede mogelijkheden voor de binnenvaart terminal voor ontwikkeling met vaarafstanden korter dan 50 kilometer. Op regionale schaal waren we in staat om exacte terminal locaties te selecteren. Voor elke geselecteerde terminal locatie kon de concurrentiepositie ten opzichte van het wegvervoer nauwkeurig worden bepaald. Tenslotte werd de exacte terminal configuratie bepaald op basis van volumes met behulp van simulaties. De ontwikkelde methodologie werd met succes toegepast, daarbij aangevend welke variabelen van belang zijn voor de besluitvorming op de verschillende ruimtelijke niveaus. Met behulp van het raamwerk zijn we in staat geweest om twee veelbelovende nieuwe terminal locaties te identificeren binnen Nederland.

Synthese van de gevalstudies

Onderzoek van de gevalstudies onderzoek hebben bewijs geleverd voor gevonden hiaten in het logistieke onderzoek. Tabel B.2 geeft een overzicht van de geïdentificeerde hiaten in het onderzoek voor de toegepaste gevalstudies meer specifiek.

Tabel B.2: Overzicht van de gevonden onderzoekshiaten in de gevalstudies

Gevalstudie	Publieke/private Actoren (Theorie)	Publiek/private Actoren (Praktijk)
	Gap 1	Gap 2
<i>E-veiling als een concept voor SDC</i>	<ul style="list-style-type: none"> ▪ Omissie van gedragsaspecten van vervoerders, verladers en gemeente. ▪ Het collectiebeginsel wordt niet bestudeerd vanuit een breed perspectief. 	<ul style="list-style-type: none"> ▪ Het concept van bundeling kan voor de lange termijn winstgevend zijn, want het heeft voordelen voor vervoerders, verladers en gemeente.
<i>CO₂-uitstoot op terminals</i>	<ul style="list-style-type: none"> ▪ Er bestaat geen methode voor het berekenen van CO₂-uitstoot op terminals. 	<ul style="list-style-type: none"> ▪ Terminal operators hebben geen idee hoe zij CO₂-emissies kunnen meten, laat staan reduceren. ▪ Beleidsmakers hebben het idee dat terminal operators hun CO₂-uitstoot met 50% kunnen reduceren volgens het Rotterdam Klimaat Initiatief (RCI).
<i>Geluidsemissie op terminal Tilburg</i>	<ul style="list-style-type: none"> ▪ Externe effecten kunnen de operaties op een terminal sterk beïnvloeden. Er is geen geschikte modelleeraanpak beschikbaar die de gevolgen van geluidsmaatregelen laten zien in relatie tot terminal prestaties. 	<ul style="list-style-type: none"> ▪ Terminal operators vergeten vaak dat omwonende inwoners en boeren een invloed kunnen hebben op de prestaties van hun terminal processen. ▪ Locale autoriteiten realiseren zich niet altijd dat geluidsbeperkende maatregelen vaak directe gevolgen kunnen hebben voor de operationele prestaties van een terminal.
<i>Stads Distributie Centrum (SDC) in Den Haag</i>	<ul style="list-style-type: none"> ▪ Andere actoren kunnen mogelijk ook profijt hebben of extra kosten hebben als gevolg van de introductie van een SDC. Hierdoor dienen andere financiële modellen beschouwd te worden. ▪ De theorie gaat vaak voorbij aan de financiële haalbaarheid van een SDC. Het verstrekken van subsidies wordt dan als enige mogelijkheid aangedragen om de verliezen te compenseren. 	<ul style="list-style-type: none"> ▪ Beleidsmakers vergeten kritisch te kijken naar succesvolle implementaties van SDC initiatieven. ▪ Basis principe voor het bestaan van een SDC is het aantrekken van voldoende (gebundeld) volume om uiteindelijk uit de kosten te geraken.
<i>Beleidsontwikkeling voor intermodaal vervoer</i>	<ul style="list-style-type: none"> ▪ De locatie van terminals hangt sterk af de kostenreductiemogelijkheden van bedrijven. ▪ Het is onmogelijk om de bepaling van locaties van terminals te formaliseren in één model. 	<ul style="list-style-type: none"> ▪ Beslissingen ten aanzien van locaties voor terminals worden op drie verschillende beleidsniveaus genomen. ▪ Beleidsmakers vergeten te erkennen dat bedrijven alleen voor intermodaal vervoer kiezen als het goedkoper is dan wegtransport.

Samenvattend over alle gevalstudies kunnen we met betrekking tot de theoretische omissie voor het ontbreken van publieke actoren (Gap 1) enige tekortkomingen constateren met betrekking tot de inbedding van de verschillende actorpercepties in de ontwikkelde modellen. In antwoord op deze omissie hebben wij gebruik gemaakt van een gevalstudie protocol waarbij in alle gevalstudies uitdrukkelijk begonnen werd met een actorenperceptie-analyse. Deze cruciale analyse gaf ons duidelijk inzicht in de kritische factoren van alle betrokken actoren ten aanzien van de ontwikkeling van de nieuwe logistieke concepten. In het gehele onderzoek bleek het haalbaar te zijn om een groot aantal factoren van belang voor het logistiek concept te integreren in de toegepaste formalisatie. Op deze wijze ontstond een duidelijk verrijking in de analyse van het besluitvormingsproces.

Voor de identificatie van de kritische factoren van alle betrokken actoren kan een nieuwe formalisatie worden toegepast, zoals Dynamic Actor Network Analysis (Dana) (Bots et al., 1999; van Duin et al., 1999; Bots et al., 2000; Bots, 2007). Op basis van de model-(bouw)ervaringen uit de gevalstudies kunnen we concluderen dat er geen unieke methode of modelformalisme dominant is. Elk gevalstudie had zijn eigen kenmerken en daarom hebben we in iedere studie gekozen voor die modelleringsaanpak die het beste inzicht zou geven in het (beleids-)logistieke probleemveld. Toepassing van verschillende validatietechnieken en scenarioverkenningen gaf ons een goed inzicht in de gevoeligheid van de factoren die van belang zijn. Belangrijker is vast te stellen dat alle modellen hebben bijgedragen aan een open proces met constructieve communicatie tussen private en publieke actoren.

Ten aanzien de praktische omissie om de houding van publieke actoren te integreren (Gap 2) bevestigden gevalstudies de hypothese dat in de praktijk alle betrokken actoren meestal een beperkt zicht hebben op de logistiek concept ontwikkeling. De meeste betrokken partijen hebben de neiging om het logistieke concept waar te nemen vanuit een 'mono-actor'-perspectief. Dat is tot op zekere hoogte te verklaren door het feit dat de perceptie van de andere actoren grotendeels onbekend zijn. Om een volledig beeld van het logistieke concept te krijgen, dienen de percepties van andere betrokken actoren gekend te worden en indien mogelijke eerdere ervaringen met het concept bestudeerd te worden. Het niet meenemen van de actorpercepties ten aanzien het nieuwe concept zal het afbreukrisico van het concept verhogen of mogelijk leiden tot het niet kunnen voldoen aan de verwachte prestaties van de betrokken actoren.

Bijdragen van dit proefschrift

In dit proefschrift hebben we een methodologische benadering ontwikkeld die een eerste stap vormt voor het vullen van de geconstateerde theoretische en praktische hiaten om het publieke actoren perspectief meer te integreren in de logistiek concept ontwikkeling. Tabel B.3 geeft een overzicht van de theoretische bijdragen voortkomend uit elke gevalstudie.

Tabel B.3: Samenvattend overzicht van de theoretische bijdragen in de gevalstudies

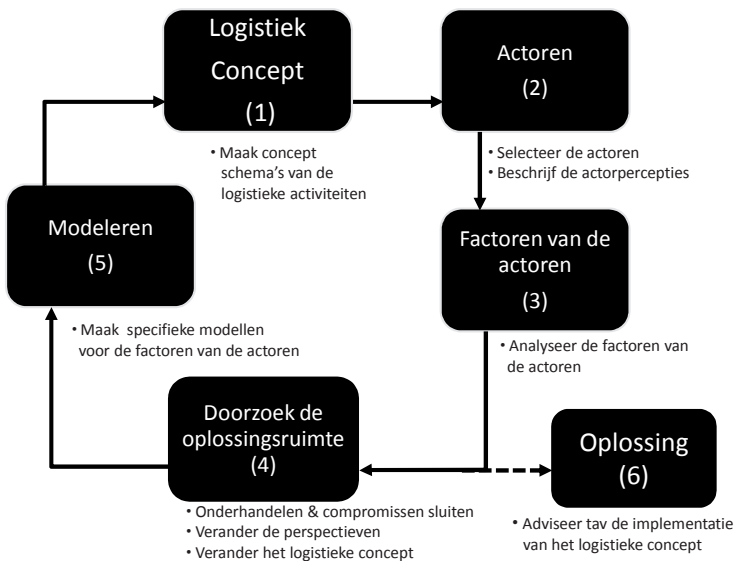
Gevalstudie	Bijdrage aan de methodologische aanpak
<i>E-veiling als een concept voor SDC</i>	De identificatie van de belangrijkste actoren en de specificatie van hun doelstellingen structureert de toegepaste methodologie. Na vaststelling van de belangrijkste factoren van belang, hebben we gekozen voor de meest geschikte modelleringstechnieken. De gedragsaspecten werden geformuleerd en ingebracht in een simulatiemodel waarin het bieden in de veilingprocessen, de levering processen door de vrachtwagens en het 'real-time

	route plannen van elk voertuig dynamisch gesimuleerd zijn.
<i>Relevantie</i>	Het toevoegen van gedragsaspecten van betrokken actoren in een simulatiemodel geeft een transparant inzicht in de operationele prestaties van het logistiek concept voor alle betrokken actoren.
<i>CO₂-emissies op terminals</i>	Terminal operators en lokale overheden hebben geen inzicht in de CO ₂ -uitstoot als gevolg van de processen op de terminals. Een speciaal model werd ontwikkeld om de emissies van de terminals op basis van hun lay-out en equipment te kunnen schatten. Het model toont het energieverbruik van diesel en elektriciteit en maakt duidelijk wat de meest CO ₂ -productieve processen / apparatuur zijn op de terminal.
<i>Relevantie</i>	De ontwikkeling van het model gaf inzicht ten aanzien van het onbekende externe effect CO ₂ . Dit inzicht heeft geleid tot een convergentie in de percepties van de actoren en heeft geleid tot een wederzijds kennis over het CO ₂ -gedrag van de terminalprocessen voor zowel het beleid als ook de logistieke besluitvorming.
<i>Geluidsemissie op terminal in Tilburg</i>	We hebben een model ontwikkeld, op basis van simulatietechnieken, met als doel om zowel de operationele processen van de terminal te integreren en de daaraan verbonden geluidsoverlast effecten voor de omgeving te kunnen vast stellen voor de nieuwe containerterminal. Met behulp van het ontwikkelde simulatiemodel zijn simulatie-experimenten uitgevoerd ter evaluatie van de terminal locatie. Dit leidde tot een zeer open proces met constructieve communicatie tussen private en publieke actoren.
<i>Relevantie</i>	De ontwikkeling van het simulatiemodel heeft inzicht gegeven in de gevolgen van het externe effect (geluid) op de operationele prestaties van de terminal. Dit verkregen inzicht heeft geleid tot een convergentie in de percepties van de actoren en heeft geleid tot wederzijds begrip en kennis van de gevolgen van dit externe effect zowel voor het ontwikkelen van beleid als de vertaling naar de logistieke operaties op de terminal.
<i>Stads-Distributie-Centrum (SDC) in Den Haag</i>	Als eerste stap in deze gevalstudie zijn alle betrokken actoren geïdentificeerd. De identificatie van hun doelen en hun relatie met het concept gaf ons een duidelijk inzicht in welke factoren en belangen meer in detail geanalyseerd moesten worden. In dit geval representeerden de haalbaarheid perspectieven (technisch, financieel en politiek) de factoren van belang goed. Het model is geformaliseerd door elementen van een kosten-batenanalyse toe te passen waarbij zowel technische als financiële factoren in worden meegenomen. Op basis van deze analyse konden we een aantal aanbevelingen voor de politieke besluitvorming leveren.
<i>Relevantie</i>	De actorenanalyse gaf inzicht in de factoren die van belang zijn voor het logistieke concept. Een scenarioanalyse met het model gaf inzicht in de gevolgen van deze factoren. Op basis van deze analyse heeft convergentie in de actorpercepties plaatsgevonden, waardoor een gezamenlijke besluitvorming (tussen beleidsmakers en logistiek actoren) mogelijk werd. Alle betrokken partijen hebben uiteindelijk vrij ingestemd met de daaruit voortvloeiende beslissing.
<i>Beleidsontwikkeling voor intermodaal transport</i>	Als eerste stap hebben wij een actorenanalyse toegepast welke ons inzicht in de kritische (succes-en faalfactoren) factoren van alle betrokken actoren met betrekking tot de (beleids-) ontwikkeling van het intermodaal vervoer. Deze geïdentificeerde factoren zijn gespecificeerd voor elk beleidsniveau. Dankzij de erkenning van de actoren in specifieke arena's zijn speciale modellen (een lineaire programmering model, Activity-Based-Cost-model, en een simulatie model) ontwikkeld voor de specifieke factoren van belang.
<i>Relevantie</i>	Het beseft dat de besluitvorming voor een terminallocatie op drie verschillende beleidsniveaus plaatsvindt, is relevant. Voor elk van deze niveaus is een actor-analyse van belang en de verschillende modellen zijn nodig om inzicht te geven in de factoren van belang. Afhankelijkheden tussen de het besluitvormingsproces moet ook worden weerspiegeld in de ontwikkeling van de modellen, dat wil zeggen de uitkomsten van het ene model vormen de invoer voor het volgende model.

Op basis van de verkregen inzichten kunnen we concluderen dat dit proefschrift de volgende theoretische en praktische bijdragen heeft:

Theoretische bijdrage

De eerste theoretische bijdrage is dat het onderzoek bijdraagt aan een serieuze bewustzijn van multi-actor besluitvorming bij de ontwikkeling van een logistiek concept. Als gevolg hiervan heeft deze studie opgeleverd een verrijkte methodologische aanpak met de focus op een sterkere methodologische integratie van actorpercepties in het logistieke concept ontwerp en de evaluatie hiervan. De aanpak stelt belanghebbenden in staat om keuzes te maken ten gunste van een definitieve logistiek concept welke beter is afgestemd op de percepties van de verschillende belanghebbenden, en dus mogelijk kan rekenen op voldoende steun voor een succesvolle implementatie. Figuur B.2 geeft een overzicht een integrale aanpak. Het is gebaseerd op het idee dat beleidsvorming en de ontwikkeling van het logistieke concept tegelijkertijd dezelfde management cycli volgen. Als een eerste voorwaarde voor een succesvolle toepassing van de aanpak is het belangrijk dat aan het begin van een ontwikkeling van een nieuwe of aangepaste openbare logistieke concept dat het proces wordt gesynchroniseerd met het beleidsvormingsproces.



Figuur B.2: Integrale aanpak voor het ontwikkelen van een publiek logistiek concept.

De aanpak begint met het identificeren en beschrijven van de logistieke processen die deel uitmaken van het nieuwe logistieke concept en daaraan gerelateerd de selectie van alle directe en indirecte actoren binnen de arena van dit concept (1). De volgende stap is het in kaart brengen van alle actorpercepties, het definiëren van de causale relatie schema's teneinde van hun manier van denken af te beelden en het specificeren van de relaties tussen de actoren (2). Nadat alle percepties zijn opgesteld, kan een actornetwerk-analyse worden uitgevoerd (3). Deze actornetwerk-analyse geeft ons inzicht in welke factoren belangrijk gevonden door

welke partijen, en welke factoren verschillende gewichten ontvangen of zorgen voor een mogelijke conflictsituatie tussen actoren. Wanneer actoren tegenstrijdige belangen en posities hebben, kunnen hun instrumenten worden bestudeerd om te zoeken naar actoren die mogelijk profijt kunnen hebben van deze instrumenten. Het identificeren van actoren die mogelijk baat hebben bij deze instrumenten, biedt de mogelijkheid voor het vinden van oplossingen voor onderhandelingsprocessen en het sluiten van compromissen of mogelijkheden biedt voor verandering of aanpassing van het concept (4). Als conflicten of bijzondere factoren van belang worden vastgesteld, kan de ontwikkeling van meer specifieke modellen nuttig zijn om de effecten te kwantificeren en meer inzicht te geven aan de actoren die grote gewichten aan deze factoren hechten (5). De uitkomsten van de speciaal ontwikkelde modellen voor deze factoren kunnen het inzicht verduidelijken of onzekerheid verminderen met betrekking tot de resultaten. Op basis van de verkregen inzichten kunnen actoren hun percepties aanpassen of het logistieke concept kan worden aangepast om beter te voldoen aan de percepties van de actoren. Als voor alle actoren de factoren en de gevolgen daarvan inzichtelijk zijn gemaakt, kan een stap worden gemaakt naar een mogelijke implementatie van het concept (6).

Praktische bijdrage: verbetering van de kwaliteit van het logistieke concept en een hogere kans op acceptatie door de betrokken actoren

Om te kunnen beoordelen of de ontwikkelde methodiek een verrijkt inzicht levert voor de besluitvorming en mogelijk ook kan bijdragen aan een verbeterd logistiek ontwerp, gebruiken we de volgende criteria ter evaluatie:

Analytische criteria (Geurts & Vennix, 1989)

Dit criterium benadrukt dat de methodologie ruimte moet laten voor veel perspectieven. De relevante argumenten voor logistiek concept ontwikkeling moet worden afgeleid vanuit een brede, holistische systeembenadering. De modellen en technieken die worden toegepast moeten flexibel en hybride zijn (Nutt, 1982). De hybriditeit van de methodologie heeft betrekking op een combinatie van technieken afgeleid van de harde, formele wetenschappen en de zachte, cognitieve wetenschappen en moet bijdragen aan transparantie van de toegepaste methoden. In het kader van onze studie is dit de meest cruciale opgave om het theoretische publieke-actoren-hiaat te reduceren. Het moet theoretisch en methodologisch duidelijk zijn en empirisch worden aangetoond dat de rijkheid van het de multi-actor perspectief kan worden geïntegreerd in ex-ante evaluatie van de publieke logistieke concepten en kan worden toegepast voor verbetering van de processen.

In alle gevalstudies in dit onderzoek zijn de toegepaste methoden afgeleid vanuit de harde formele wetenschappen en de zachte, cognitieve wetenschappen. De ontwikkeling en toepassing van de methoden wordt gekenmerkt door transparantie. In alle gevallen is de transparantie theoretisch plausibel gemaakt door verwijzingen naar de aanpakken in andere onderzoeksdomeinen en praktisch onderbouwd door validatie met deskundigen/actoren in het probleemdomein.

Kwaliteitsverbetering van het logistieke concept

Dit criterium houdt in dat de methodologie transparantie moet laten zien met betrekking tot de causale relaties van het logistieke concept en de operationele omgeving voor alle betrokken actoren. De kwaliteitsverbetering kan worden verkregen door een grondig onderzoek en exploratie van de actor-relaties met het logistieke concept.

Voor het dichtten van de praktijk hiaat, Gap 2, is transparantie in de resultaten van groot belang. Dit is één op één verbonden met de kwaliteit van de methodologie. De methodologie moet voor elke betrokken actor bij het publieke logistieke concept duidelijk maken wat de (financiële, economische, milieu-, ruimtelijke) gevolgen zullen zijn voor deze actor.

In alle gevalstudies heeft de aanpak goed inzicht gegeven in de factoren die er echt toe doen. Alle ontwikkelde modellen, gevoeligheidsanalyses en scenarioanalyses hebben in belangrijke mate bijgedragen tot wederzijds inzicht voor de betrokken actoren. In alle case studies zijn we erin geslaagd om de gewenste transparantie in de uitkomsten van onze modellen te leveren.

Vertrouwen/geloof (Rousseau et al., 1998; Hofstede, 2002)

Beide, hiervoor genoemde criteria worden verondersteld indirect bij te dragen aan vertrouwen en het geloof in de ontwikkelde methodiek. In de gevalstudies stellen we vast dat de toegepaste methodische aanpak heeft bijgedragen tot meer vertrouwen of geloof onder de actoren in het logistieke concept. Door het expliciet integreren van de actorpercepties in de toegepaste modellen hebben de modellen zelf een cruciale rol gespeeld in de zoektocht naar het zoeken naar oplossingen, de rol van de logistieke concepten in het beleid duidelijk gemaakt, de identificatie van hun grenzen mogelijk gemaakt en de transitiepaden geëxpliciteerd. Dit bevestigt de claim, veelvuldig genoemd in de literatuur, dat de toepassing van technieken zoals scenarioanalyse en gevoeligheidsanalyse belangrijke bijdrage leveren aan het bouwen van meer vertrouwen en geloof van de actoren in de eindresultaten.

Conclusies en aanbevelingen

Ons onderzoek heeft aangetoond dat de betrokkenheid van publieke actoren in de logistieke concepten een belangrijke invloed heeft op de ontwikkeling van nieuwe logistieke concepten. In theorie vonden we dat analytische benaderingen voor het ontwerp en de evaluatie van logistieke concepten echter onvoldoende afgestemd zijn op de eisen van de betrokkenheid van de publieke actoren. Ook in de praktijk resulteert dit gebrek aan methodologische innovatie vaak in fricties tussen de beleidsmakers, werkend op verschillende beleidsniveaus, en de partijen die actief zijn in het operationele logistieke werkveld van de retailers, logistieke dienstverleners en transportbedrijven. De publieke actoren in de praktijk zijn vaak niet volledig tevreden over de uitkomsten van de onderzoeksinitiatieven, omdat hun maatschappelijke doelstellingen niet worden gehaald. De private actoren die betrokken zijn in logistieke dienstverlening voelen zich vaak beperkt door de regels en beleidsmaatregelen en tonen vaak hun teleurstelling over het gebrek aan faciliterende rol van de overheid. Door toepassing van gevalstudie-onderzoek zijn we in staat geweest om een innovatieve methodologische aanpak te ontwikkelen voor de ondersteuning van het multi-actor besluitvormingsproces rondom de ontwikkeling van nieuwe logistieke concepten. Door de aanpak zijn de betrokken actoren beter in staat om gezamenlijke keuzes te maken voor de invulling van het finale logistieke concept. De ontwikkelde aanpak is beter afgestemd op percepties en verwachtingen van de verschillende belanghebbenden, geeft een beter beeld van de relevante gevolgen van het logistieke concept en draagt daarmee bij aan de keuze voor concepten die kunnen rekenen op brede steun voor een succesvolle implementatie.

In de toekomst zal het onderzoek naar multi-actor besluitvorming in publieke logistieke concepten zich verder ontwikkelen in de richting van de theorieën en concepten afkomstig uit het complexe adaptieve systeem denken. Complex adaptief systeemdenken gaat ervan uit dat vele actoren die zich gedragen volgens een bepaalde set van regels. Deze regels geven aan dat

de actoren hun gedrag gaan aanpassen aan dat van andere actoren (met andere woorden, de actoren interacteren en passen zich voortdurend aan, aan elkaar en hun omgeving). Complexe adaptieve systemen hebben een open karakter en staan sterk in verband met elkaar en met andere systemen van actoren. 'Agent'-systemen sluiten goed aan bij dit soort systemen en verschillende soorten van experimenten in termen van actorgedrag (het leren van experimenten en 'gaming'-experimenten) kunnen worden gemodelleerd om de evaluatie en verbeteringen van de besluitvormingsprocessen van publieke logistieke concepten mogelijk te maken.

About the author

Ron van Duin was born on the 18th of June 1963, in Rotterdam. In 1982, Ron started his study for a master's degree in econometrics at the Erasmus University Rotterdam. During his graduation project he developed a decision support tool for the (slit-)planning of coils at VBF Tubes in Oosterhout. After his graduation in 1988 he worked at the Operation Research division of FEL-TNO. In this period Ron developed decision support- and simulation tools for all kinds of logistics problems at the National Defence Organisation. In 1992 Ron started as an entrepreneur building advanced simulation models for train operations (Dutch Railways) and production processes, lecturing educational courses in logistics and simulation (ISW education center and Euroforum), and implementing logistics information systems (SAP/R3). Since 1994 Ron has been working as an assistant professor at the Faculty of Technology, Policy and Management doing research and lecturing logistics in multi-actor environments. City logistics, Intermodal freight transport and policy making in multi-actor environments have his main research interest. He has published more than 100 articles, book sections, research reports and conference papers.

List of Abbreviations

BESTUFS	Best Urban Freight Solutions
CBA	Cost Benefit Analysis
CSR	Corporate Social Responsibility
DANA	Dynamic Actor Network Analysis
DINALOG	Dutch Institute for Advanced Logistics
ECMT	European Conference of Ministers of Transport
GOVERA	Goederen Vervoer Randstad (Freight transport Randstad)
IDEF	Integration DEFinition for Function
ISO	International Organization for Standardization
KAN	Knooppunt Arnhem Nijmegen (Modal node Arnhem Nijmegen)
MAMCA	Multi-Actor Multi-Criteria Analysis
NP-Hard	Non-deterministic Polynomial-time hard
OECD	Organisation for Economic Co-operation and Development
RCI	Rotterdam Climate Initiative
RFID	Radio-frequency identification
SCM	Supply Chain Management
TEN-T	Trans-European Transport Network
TEIT	Trans European Inland Terminal
TLN	Transport & Logistics Netherlands
UCC	Urban Consolidation Centre

Appendix A – Summary detailed case description

For all case studies we show in detail which research activities were carried out for each defined step in our approach.

Table A.I: E-auction as a concept of UCC

Research activities in the design approach	Contents
Logistics concept (1)	Description of the contracting system; Routing from depots briefly described.
Actors (2)	Carrier, shipper, society (<i>briefly</i>).
Actors' factors (3)	Shipper: costs, pickup time, responsiveness, transport speed, punctuality/reliability of carrier. Carrier: profit (bonus/discount), responsiveness, punctuality. Society: total driving time, truck kilometres, transparent freight market.
Searching solution space (4)	Specification of different carrier behaviours
Modelling (5)	Simulation (& route-optimisation) for different carrier-behaviour scenarios.
Solved (6)	Insight in the behavioural aspects of actors on the operational performances of the e-auction concept.

Table: A.II: CO₂-emissions at terminals

Research activities in the design approach	Contents
Logistics concept (1)	Description of the terminal activities.
Actors (2)	Terminal operator, policy maker (RCI).
Actors' factors (3)	Terminal operator: CO ₂ -emission, Energy-consumption (Diesel, Electricity) Policymaker: CO ₂ -emission
Searching solution space (4)	Estimation of energy consumption and CO ₂ -emission for many terminals. different carrier behaviours
Modelling (5)	Deterministic model to estimate the energy consumption at a terminal based on equipment, modal split, activities and distances (design) of the terminal.
Solved (6)	Clear insight in the emission behaviour of terminals with respect to the design, activities and equipment.

Table: A.III: Noise-emissions at terminal Tilburg

Research activities in the design approach	Contents
Logistics concept (1)	Description of the terminal activities.
Actors (2)	Terminal operator, municipality Tilburg, residents & farmers living in the neighbourhood
Actors' factors (3)	Terminal operator: terminal performances, throughput, costs, utilisation of equipment Municipality: quality of living environment (i.e. noise), economic importance of the terminal. Residents and farmers: quality of living environment (i.e. noise).
Searching solution space (4)	Scenarios with growth of throughput volume at terminal with different number of reachstackers, adjustment of working time of the terminal and noise reduction with container walls or green belts.
Modelling (5)	Simulation model to show the terminal performances for the specific scenarios in the solution space. activities and distances (design) of the terminal.
Solved (6)	The insight enabled the terminal operator and the municipal authorities of Tilburg to jointly select the best terminal option in terms of the balance between logistics performance and noise reduction.

Table: A.IV: Urban consolidation centre (UCC) in The Hague

Research activities in the design approach	Contents
Logistics concept (1)	Description and analysis of European urban consolidation centres.
Actors (2)	UCC-operator, Municipality The Hague, Shopkeepers
Actors' factors (3)	UCC-operator: profit, volume, load factor Municipality The Hague: Vehicle kilometres in the inner city, sufficient load factor of entering vehicles, minimal subsidies Shopkeepers: Good delivery service, low costs for delivery and receipt of goods
Searching solution space (4)	Scenarios with different percentages of shopkeeper participation combined with different of vehicles.
Modelling (5)	Deterministic cost model to quantify the cost and benefits for the specific scenarios.
Solved (6)	The actor perceptions of the municipality, UCC-operator and shopkeepers converged and joint decision making not to start a UCC.

Table: A.V: Policy making on intermodal transport

Research activities in the design approach	Contents
Logistics concept (1)	Description of intermodal transport. Description of TEN-T at European level. Description of TEIT at national level.
Actors (2)	European Ministers of Transport, Shippers, road carriers, intermodal agents, intermodal carriers, Ministry of Transport, Ministry of Environmental Affairs, Ministry of Economic Affairs, Local government, Terminal Operators.
Actors' factors (3)	<i>A long list of actors' factor, see Table 6.2</i>
Searching solution space (4)	Scenarios with different network configurations for intermodal transport.
Modelling (5)	Linear Programming model to identify the best network in terms of costs. Spreadsheet-model to search the best terminal location in a specific region. Simulation model to define the best terminal configuration.
Solved (6)	The actor perceptions vary at each level of policymaking. Based on these insights we have identified two potential terminal initiatives in practice.

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