

Decision Variables for Inbound Transportation Redesign in a Chemical Manufacturing Supply Chain

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Abstract: With respect to process manufacturing industries, there has been limited research on inbound transportation management in the literature. While some of the methods and strategies developed in the discrete manufacturing industry are easily applicable in the process industries, increasing changes in business environment through emerging technologies and a push for increasing sustainability performance motivates the need for research that addresses the needs of process manufacturers. The purpose of this paper is therefore to provide an overview of current research on key variables to consider when deciding inbound transportation strategy. Those factors are then discussed by looking at the opportunities and challenges they present in the process manufacturing supply chain context, via a case study of a paints and chemicals manufacturing company. Data from the case study was collected during a workshop at the main factory location, and several follow-up interviews. The main opportunities identified are improved sustainability and visibility, while main challenges are increased complexity, and increase in coordination requirements with more collaboration.

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1. INTRODUCTION

Traditionally, all actors in a supply chain are responsible for their own outbound distribution of goods. In many cases, this result in vehicles arriving with raw materials and leaving empty, while at the same time, empty vehicles arrive to pick up the finished goods. This lack of collaboration and visibility between inbound and outbound transportation leads to lost opportunities in taking advantage of the empty vehicles. Empty vehicles are non-value-adding sources to greenhouse gas (GHG) emissions, cost, and driver-time. Montreuil (2011) address this problem, by referring to McKinnon (2007), stating that 27% of truck-kilometres was travelled empty in the UK in 2004. Furthermore, customers are increasingly demanding supply chains that consider environmental issues as well as economic. According to European Commission (2016), in 2014, the transportation sector was responsible for almost 25% of all GHG emissions in Europe, and road transport contributes with over 70% of this. Their goal is to reduce road transport by 60% from 1990 to 2030.

An industry associated with a considerable amount of global transportation is the chemical process industry. The actors are usually positioned in the middle of wider supply chains with many suppliers and customers scattered worldwide (Barbosa-Póvoa, 2012, Shah, 2005). Currently, competition in the chemical process industry has increased and several researchers address the fact that there is a need to reduce both costs, inventories and the time to market.

(Shah, 2005, Papageorgiou, 2009, Barbosa-Póvoa, 2012, Liu and Papageorgiou, 2013). Hence, there is a need for both improved efficiency and responsiveness in the supply chains. Since the chemical industry is such a global industry, the transportation of chemicals corresponds to a large amount of the total transportation of goods world-wide (Erera et al., 2005).

One approach to address this need is the introduction of the factory gate pricing (FGP), a strategy that has had a great success in other industries e.g., in the UK grocery distribution sector. One of UKs largest fashion retailers implemented FGP in the 1970's and have improved their profitability by doing so. Potter et al. (2007) have found that introducing FGP for other sectors of the retail industry as well, with a focus on the grocery sector, could lead to an improved market position. Also, the automotive industry has experienced reduced lead times in the delivery of parts to manufacturers. The FGP strategy concerns the issue where the buyer is in control of the transportation from the supplier. Inspired by the retail industry and the FGP strategy, this research is motivated by the hypothesis that this strategy would benefit also companies in the chemical process industry. The large amount of global transportation in the chemical industry makes this a desirable industry to research.

Therefore, this paper seeks to evaluate the benefit of taking control of the inbound transportation in the chemical process manufacturing industry. The objective of the research is to

establish a body of knowledge to what decision-making areas to consider when changing the inbound transportation strategy. Thereafter, the different areas are assessed and discussed during a workshop by managers at a chemical and paints manufacturing company, to assess possibilities and challenges. There exists, to the authors knowledge, only a limited amount of literature on inbound transportation strategies, and hence, this is the knowledge gap intended to fill. To fulfil this objective, the following research question is addressed: *what opportunities and challenges are expected when planning and control of the inbound transportation shifts from input suppliers to a focal company in the chemical process industry?*

The scope of the study is limited to discussing what different decisions to make, and the possible outcomes of these decisions, when taking over the planning and coordination of inbound transportation, and not to research how a new strategy could be implemented. With this aim, the companies do not necessarily own the vehicle transporting inbound materials themselves. They could choose to hire a carrier or a third-party logistics provider (3PL) to take care of the transport itself, but the important difference is which company that makes this decision. Based on reflections around the findings from the literature study, and findings from the case study, the strategic transportation management decisions are evaluated.

2. RESEARCH METHODOLOGY

The methodology consists of both a systematic literature study and a case study. To study existing literature on the field, a keyword search was done in the databases of Emerald Insight, Science Direct and Web of Science. The articles were limited to the last 20 years, and no articles older than 1998 were included in the study. The articles were sorted by the following criterion: (a) trucking transportation in a supply chain; and (b) the shippers' point of view + not only concerning distribution. This resulted in 42 articles being selected for the study, to identify the key decision-making areas to consider when changing inbound transportation strategy.

In addition, empirical data was collected from a chemical manufacturing company with a large supply network, to figure out if what we found in the literature was relevant in the industry as well. The empirical data was gathered by a workshop, a factory tour and semi-structured interviews with managers in the case company to address their impression of possibilities and challenges with changing the inbound transportation strategy.

3. FINDINGS FROM THE LITERATURE

From the literature study, seven key decision-making areas were identified. These are presented in the following subsections.

3.1 Internal Collaboration and Factory Gate Pricing (FGP)

Internal collaboration refers to the collaboration internally in a company. Stank and Goldsby (2000) focus on internal collaboration in transportation management, and the corporate transportation function in a changing environment. They claim

that a supply chain is no stronger than its weakest element, and that transportation planning managed independently of other value-adding activities, in many cases exemplifies a very weak element. They also state that internal collaboration between inbound and outbound transportation will result in possibilities to combine freight, and milk-runs, as well as better deals with carriers, due to both higher priorities at the carrier and also lower per-unit transportation costs, because of increased shipping volume, giving economies of scale.

It is not new for a manufacturer to take control of and responsibility for the planning and coordination for its inbound transportation. The retail industry and the automotive industry are two examples. The strategy has been presented in the literature under the name of *factory gate pricing* (FGP) strategy. By using the FGP strategy, the inbound transportation becomes a part of the company's supply chain and internal collaboration and coordination between inbound and outbound transportation is possible. (Potter et al., 2007)

Mason et al. (2007) incorporate a case study on the FGP strategy in their paper on freight transport management when combining horizontal and vertical collaboration. From the case, they conclude that introducing the FGP strategy could improve both customer efficiency, asset utilization and customer response. However, work needs to be done before the full potential of this and of collaboration can be achieved. For example, they claim that a holistic viewpoint and a change from a functionally-oriented mentality to a process-oriented mentality is needed.

3.2 Environmental Sustainability

Traditionally, the main focus of operations research (OR) has been to obtain a supply chain economic surplus. In recent years, the environment and social part of the supply chain has gained more attention due to the huge environmental issues the world now faces. It has therefore been a shift of the focus of OR, particularly to include the trade-off between economic and environmental sustainability. Environmental issues are one of the greatest challenges of our world today, and no easy answer yet exists to this complex problem. To improve environmental sustainability of transportation, the most important factors are the load factor, the speed, the transportation network and the transportation mode (Dey et al., 2011; Demir et al., 2014; Mallidis et al., 2014; Christopher et al., 2015). The next sections contain other ways of improving environmental sustainability.

3.3 Transportation Modes

The topic of transportation modes has been highly covered in the literature. The reason for the high focus of changing the mode of transportation is because different modes of transportation emits different amounts of greenhouse gases (GHG), also highlighted by Dey et al. (2011) and Christopher et al. (2015) in the last section. Macharis and Bontekoning (2004) provides a thorough review of the existing operations models used in intermodal transportation. Intermodal transportation concerns transportation of goods by different modes. The goods however, are at all times kept in the same unit and are not treated along the way. This is a subcategory of

multimodal transportation, which is defined as the transportation of goods in a sequence of at least two different modes. Their conclusion is that the decision-making process for multimodal transportation is complex and many actors and stakeholders are involved.

A thorough review of the strategic, tactic and operational levels of multimodal transportation planning is provided by SteadieSeifi et al. (2014). The conclusion is that there is a huge gap in multi-objective transportation planning and the incorporation of backward flows into the planning of forward flows. Harris et al. (2015) review 33 EU framework program projects and conclude that “One of the major constraints is the lack of effective and efficient information connectivity among and between various modes (water, air, road and rail)”. They claim to be the first to combine the technological trends and barriers to technology adaption with multimodal operations.

3.4 Vertical Collaboration

Outsourcing of transportation activities to a third-party logistics provider (3PL) is common. Outsourcing allows companies to focus on the activities they perform well, and paying others, with other specialties to perform other activities in the supply chain (Chopra and Meindl, 2016). When activities have been outsourced, the company also need to determine how close to collaborate with each other.

Mason et al. (2007) highlights combining vertical and horizontal transportation, when being in charge of all transportation management in the logistics flow in addition to focusing on the FGP strategy. They find that when using the FGP strategy, new and innovative technological solutions could improve collaboration, both horizontal and vertical. Roorda et al. (2010) focus on outsourcing of logistics services. They present a framework for modelling the diversity and interactions of actors in an outsourced supply chain. Their findings states supply chains should increase the focus on long-term alliances between suppliers, manufacturers, retailers, carriers and 3PLs to become successful.

3.5 Horizontal Collaboration

A more explored area of research is the collaboration between companies on the same level of the supply chain. This collaboration between competitors is called horizontal collaboration. The main focus of the primary literature on horizontal collaboration has been different approaches on how to allocate the costs between the collaborating shippers (Ozener and Ergun, 2008, Frisk et al., 2010, Yilmaz and Savaseneril, 2012, Lozano et al., 2013).

Defryn and Sørensen (2018) aim to capture the individual partner interests in the logistics optimisation model. They found that the collaboration can be beneficial, even when partners have conflicting objectives. Palmer et al. (2018) quantify environmental and economic benefits of collaboration in the fast-moving consumer goods (FMCG) sector. From their study of collaboration amongst ten FMCG companies, they found 23% cost reduction, with 58% fewer road kilometres travelled and a reduction of CO₂ emissions by 46%. However, the results represented the theoretical maximum, and might not be equally large in the practice.

3.6 Fourth Party Logistics Providers (4PLs)

The main challenge of both vertical and horizontal collaboration is trust between the different collaborating companies. An emerging business originated by the consulting company Accenture is fourth party logistics providers (4PL). The idea behind 4PLs is that they operate as a neutral service provider, implementing data from both the primary client, their partners and their 3PLs to optimise the total supply chain and gain a sustainable end-to-end supply chain, without any of the collaborating companies risking information sharing with one another (Christopher, 2016).

Hingley et al. (2011) research benefits and barriers of 4PLs in horizontal collaboration. Through their research, they found that “managers believed 4PLs could provide key potential benefits, but that it would negatively influence the grocery retailer-supplier dynamics”. Mehmman and Teuteberg (2016) research how a 4PL could be implemented in the transportation planning process. Their findings are that implementing a 4PL could lead to up to 38% cost savings and also the reduction of environmental pollutions.

3.7 Information and Communication Technologies

Some authors also have implemented and analysed the use of information and communication technology (ICT) solutions into transportation management. Only two papers from the literature search had main focus on ICT solutions, being Evans et al. (2015) and Harris et al. (2015). But, many of the other authors mention that emerging track-and-trace technologies and ICT solutions could contribute to improve transportation management even though this is not their primary focus (Stank and Goldsby, 2000; Macharis and Bontekoning, 2004; Wijngaard et al., 2005; Mason et al., 2007; Potter et al., 2007; Norbis and Meixell, 2008; Roorda et al., 2010; Dey et al., 2011; SteadieSeifi et al., 2014; Mehmman and Teuteberg, 2016).

The use of ICT has a directly positive impact on the reduction of CO₂ emissions in road freight transport. However, to be able to utilise the full potential of reducing CO₂ emissions there is a need for collaboration with other companies as well (Evans et al., 2015). The role of ICT in multimodal transportation is key enabler, but the uptake on provisions in Europe and un the UK has been slow (Harris et al., 2015). Wijngaard et al. (2005) claim that the use om real-time information has been implemented in the planning, to improve schedules and routes of transportation. Also, the implementation of the FGP strategy is highly dependent on the use of ICT solutions (Potter et al., 2007). Mason et al. (2007) claims that developments in ICT is one of the main catalysts to improve vertical and horizontal collaboration as well.

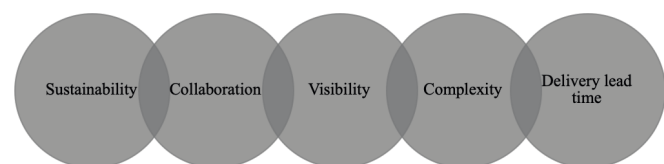


Fig. 1. Key Challenges of Transportation Management

4. DISCUSSION AND CASE INSIGHTS

Even though the core goal of a supply chain is to maximise the company surplus, every supply chain is different, tailor made for its needs. This is what makes supply chain management such an interesting field of study. In recent years, the main focus, and also the core goal has not only been to maximize the surplus, but also to obtain environmental and social sustainability. Also, due to changing customer demands, increased globalisation and emerging technological solutions, supply chains are in constant need of changing. In the literature several potentials have been suggested to obtain successful supply chains.

In Fig. 1. an illustration of the five key challenges of transportation is presented. These five areas are found to be what makes transportation management challenging, and also where there are room for improvements. As illustrated, all the challenges slightly overlap and affect one another. They are based on findings in the literature and the case company, and they all underlie the choices of transportation strategy.

4.1 Factory Gate Pricing (FGP) and Internal Collaboration

Findings from the literature shows that the lack of visibility in supply chains is a challenge. A lack of visibility and mutual trust are the main reasons for why many companies have trouble with collaboration. It is increasingly important to have a good relationship and collaboration with suppliers if a company wish to implement the FGP strategy, because the planning of inbound transportation creates the need for better collaboration on pick up times. In different ways, collaboration is the core element in all papers used in this study. However, the papers often conclude that collaboration have the potential for successful implementation.

Findings from the case company, states that it is usually the complexity of the collaboration that makes it difficult. The case company, whose customers are seven big wholesalers, have a close customer collaboration. While, they find it much more difficult to collaborate close with all of their many suppliers.

4.2 Sustainability

From the literature findings, the load factor has been claimed to be a large contributor when improving the sustainability of the transportation. Findings from the company is that, when ordering raw materials, they do not care about the load factor of their orders, mainly due to a lack of raw material storage space, resulting in a desire to make the orders as small as possible. They order only exactly what they need, and the transportation cost of the order is not visible to the case company. This is one major drawback of the current strategy. It is especially apparent that once the cost of transportation is visible, as it is for outbound transportation, they are keen to fill full containers. On outbound transportation it is also important to reduce transportation costs, since the customers at all times have control of these costs. This is also due to the fact that the customers are large wholesalers that transport the finished

goods to their own storage spaces, and it is assumed that a lack of space is not as big an issue. The load factor therefore becomes a trade-off between economic and environmental sustainability. This affects the sustainability and the visibility challenge in Fig. 1.

4.3 Transportation Modes

Of the key challenges in Fig. 1, the transportation mode covers the trade-off between the sustainability and the delivery time. Norbis and Meixell (2008) highlight the lack of research on security issues and international issues of the different transportation modes, leading to uncertainties in the security and international part of the decisions. Have in mind that a transportation route not necessarily only include one mode of transportation. Multimodal, intermodal and synchromodal transportation are possibilities, but this further increase the complexity of the transportation planning.

For the case company, they have no control of the current inbound transportation modes. This creates possibilities of affecting the choices of transportation mode if they manage the transportation. However, the suitable mode used might not differ at all from the current situation, because, probably the most suitable mode is used already. At least for the short-distance shipments.

4.4 Vertical Collaboration

If the supplier, customer and carrier were to share more of their information with each other, this could contribute to reduce uncertainties. This factor highlights the collaboration and visibility challenge from Fig. 1. It also emphasises a trade-off between collaboration and competitiveness. Increased vertical collaboration leads to increased information sharing between the actors, which again lead to increased visibility in the supply chain. But increased visibility could again result in a lack of negotiation opportunities between the actors. Stank and Goldsby (2000) argues well for why companies should seek to increase collaboration. Their findings match the findings from the case study, where managers also agree that the increased collaboration would benefit flexibility and visibility, cut inventory levels, creating a more seamless supply chain operation and also, reduce uncertainties. Here the issue of complexity is found again. It will be hard to create and obtain a close collaboration in a complex supply network.

4.5 Horizontal Collaboration

Research has shown both economic and environmental saving potentials, increased capacity utilization and increased service level of horizontal collaboration. However, several issues follow this alternative. First and foremost is the issue of privacy being highly relevant for this area. Also, what the majority of researchers in this field have researched, how to distribute joints benefits and costs of this solution in a stable and sustainable way is not an easy task. Ozener and Ergun (2008) highlights that the synergy of the lane network is very relevant and has impact on the collaboration. Suitable companies with synergetic lane networks would have to be

found before deciding to establish this type of collaboration. This appears very challenging, since companies seem unlikely to share supplier and customer locations with each other.

Another important aspect is the legal ramifications of the collaboration, highlighted by Frisk et al. (2010), the collaborating companies must not form cartels, and the coalition must be trustworthy for all collaborating companies. Yilmaz and Savasneril (2012) states that the collaboration might not be as beneficial for large companies with large amount of transportation. While Lozano et al. (2013) points to the limited number of partners that can form the coalition because of complexity and transaction costs. With all these constraints, it might be hard to find suitable companies to collaborate horizontally with. Time and effort must be spent on collaborating and negotiating with the alternative companies. It is also very hard to estimate the possible gains of this alternative, which would make it hard to convince companies to collaborate horizontally.

4.6 Fourth Party Logistics Providers

A 4PL could incorporate information from suppliers, manufacturers, carriers and customers into one system, and thus be able to plan the supply network more efficiently. Providing all the benefits while at the same time bias the challenges of information sharing and trust of horizontal and vertical collaboration. However, their services would most likely be expensive. The cost of hiring a 4PL versus the cost savings of improved efficiency, less coordination and planning in the company has to be deliberated. The managers of the case company did not believe a 4PL to be favourable for their company. The case company already has a planning department and because of the complexity of the planning and coordination, the 4PL would have to be deeply into the organisation. They would also rather keep this competence inside the company than outsource it. This agrees with Hingley et al. (2011), who found that retailers also lack the willingness to collaborate with a 4PL.

4.7 Technologies

Even though ICT solutions have been on the market for quite some time now, it is still constantly need for developments. Many companies still struggle with how to best utilize advantages of the technological trends. Evans et al. (2015) concludes that ICT solutions directly impact the CO₂ emissions positively, however to obtain even further improvements, collaboration and information sharing is needed. When it comes to the visibility, ICT solutions could come in handy. The ICT solutions hence address both visibility and sustainability challenge of Fig. 1. One issue of ICT solutions is that they usually are expensive and comprehensive to implement. However, tracking technologies are becoming cheaper and easier to implement with time.

The authors impression is that ICT has potential in logistics and transportation management. It could help improve visibility and collaboration and reduce complexities. However,

the technologies are relatively new and emerging and evolving on almost a daily basis. The large amount of potentials makes this a very exiting area for further research.

Table 1. Opportunities and challenges in key decision areas

	Opportunities	Challenge
Change Strategy in general	Improved visibility	Increased complexity Unforeseen uncertainties
Environmental Sustainability	Improved environmental sustainability	Economic sustainability
Transportation Mode	Improved environmental sustainability	Increased complexity Delivery lead time
Vertical Collaboration	Improved visibility Improved environmental sustainability	Collaboration
Horizontal Collaboration	Improved environmental sustainability	Collaboration
Fourth Party Logistics Provider	Less complexity Improved environmental sustainability	Collaboration
Technologies	Better Visibility Improved environmental sustainability	Privacy-issues Complexity of implementation

5. CONCLUSION

In this paper, different decision areas concerning inbound transportation management when changing inbound transportation strategy are covered. The findings show that there are several possible advantages of changing inbound transportation strategy to manage the inbound transportation. The general challenges of transportation management, shown in Fig. 1. are possible areas for improvement when changing strategy. Table 1 illustrates which decision-making area could experience which of these improvements. The clearest improvement was of environmental and economic sustainability, as well as improved visibility. The clearest challenge was that of increased complexity and establishing good collaboration with other actors. The collaboration is increasingly difficult with increasingly complex systems. Good collaboration could further improve sustainability and visibility. In sum, this study provides insight to critical possibilities and challenges of inbound transportation management.

The main limitation of this research is that the study is based on only one case study, and the findings are explorative. The assumption of improved environmental sustainability is only based on findings from the literature and are not empirically tested. It has not been possible to estimate, because the characteristics of the current inbound transportation is unknown, due to the fact that suppliers currently are

responsible for this part of the supply chain. Better visibility in the chain is crucial to be able to measure the entire environmental impact of the changes. If the implementation of the new strategy will result in sub-optimising for the case company and their part of the supply chain, but not the entire chain as a whole is also unknown. There is no measure of how these decisions affects other actors in the supply chain. Closer vertical collaboration would however contribute more information in this area.

The topic is rich with opportunities for further research. The empirical implementation of the new strategy should be conducted. Also, the use of multiple cases would improve the credibility of the research. Emerging technologies and digitalisation in the evolution of Industry 4.0 makes it interesting to look into opportunities for the use of track and trace technologies as well as ICT to further improve planning and coordination. Vehicle routing problems occurring when coordinating the trucks and deliveries could be analysed, even if these findings will be case-dependent and non-generalizable.

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