How to increase multi-plant collaboration within a chemical cluster and its impact on external domino effect cooperation initiatives

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Abstract

This paper discusses drivers and partner collaboration characteristics within the Antwerp-Rotterdam chemical cluster, the largest chemical cluster worldwide. A questionnaire was used to assess the characteristics' impact and to evaluate whether respondents give significantly different scores to comparable influencing factors depending on the type of collaboration (i.e., vertical or horizontal). The survey results show that for decision makers within the AR region both the factors 'investments needed for collaboration' and 'internal stakeholder support' turn out to be more essential in the case of horizontal collaboration. Also, the 'fit between the cooperating organizations' and the 'innovation potential of the partner' are deemed to be more cardinal partner characteristics in the case of horizontal collaboration. Since safety cooperation within a chemical cluster is mainly horizontal, strategic multi-plant safety collaboration can be enhanced taking these findings into account, eventually leading to the set up of a cluster safety culture.

Keywords: safety collaboration, horizontal collaboration, chemical cluster.

1 Introduction

The Antwerp-Rotterdam (AR) chemical cluster encompasses two European member states (Belgium and the Netherlands) in Northern Europe and has a surface area of approximately 3,000 km², housing 123 chemicals and petrochemicals plants. The AR chemical cluster forms – by far – the largest

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chemical cluster worldwide in terms of concentration of chemical companies per surface area or the so-called plant-per-surface density (which equals 0.041 in the AR region). (Note that the chemical cluster of "Greater Houston" (i.e., the so-called Houston Metropolitan Statistical Area) houses 413 chemical companies in an area of approximately 26,000 km², representing a plant-per-surface density of 0.016.) Stored, produced and handled materials within this European region include petrochemicals, plastics, oil, gas, fertilizers, biopharmaceuticals, specialty chemicals, etc. The AR area includes seven world-class refineries, three specialty refineries and is known for its dense infrastructure of ports, pipelines, waterways, railways, roads and utilities distribution networks. Figure 1 illustrates a small part of the cluster area.

Figure 1: A part of the Antwerp-Rotterdam chemical cluster.

Chemical companies within the Antwerp-Rotterdam area, handling ever more amounts of dangerous materials, are faced with an ever increasing complexity of their activities. As a result, the need for collaboration between chemical firms ever more increases: congestion may be lowered and the efficiency and effectiveness of safety and security within the area may be increased through collaboration. To obtain an idea of current collaboration perceptions within industrial companies, we investigated drivers and partner characteristics in vertical and horizontal collaboration within the Antwerp-Rotterdam chemical cluster region. If we are able to determine these collaboration drivers and partner features, we can formulate recommendations for how to enhance safety cooperation within a chemical cluster.

2 Vertical versus horizontal collaboration

Supply chain management boasts an abundant amount of academic literature and can be defined as "the set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed in the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements". This definition indicates that supply chain management is aimed at installing beneficial partnerships and seamless linkages between multiple parties operating at different levels of the supply chain to avoid unnecessary logistics costs. As such, supply chain management describes what is known as 'vertical collaboration'.

'Horizontal collaboration' is used to refer to "concerted practices to share private information, facilities or resources to reduce costs or improve service between companies (competing or unrelated) operating at the same level(s) in the market" (The European Union [1]).

In Belgium and the Netherlands, the European logistics centre of gravity, the author is aware of over fifty formally articulated horizontal logistics partnerships. The increased relevance of horizontal collaboration in practice has recently triggered additional research. Cruijssen *et al.* [2] have surveyed Logistics Service Providers in Flanders to map their views on the opportunities and impediments for horizontal collaboration. It was revealed that Logistics Service Providers consider horizontal collaboration a very promising concept to decrease cost, improve service or protect market positions amongst others, although there are some severe impediments that must be tackled before it can prosper on a larger scale. To assess the external validity of these results, the same survey was used to survey Dutch Logistics Service Providers. Formal testing revealed that Flemish and Dutch Logistics Service Providers are equally optimistic about the opportunities of horizontal collaboration and that they identify the same impediments as being crucial. There were no significant differences in the evaluation of the opportunities, but for five of the nine impediments, Flemish Logistics Service Providers appeared to be more reluctant than their Dutch counterparts (Cruijssen and Dullaert [3]).

Although the opportunities and impediments of horizontal collaboration are widely supported by empirical research, real-life situations require analyzing a potential partner's strategic and organizational capabilities, which makes partner selection a difficult task. Recent empirical research (Cruijssen and Dullaert [3] and Cruijssen *et al.* [4]) was aimed at identifying the benefits and obstacles of horizontal collaboration, rather than understanding the search process for partners. In this paper we empirically study the drivers for collaboration including characteristics of potential partners, both objective ones (such as e.g. service characteristics or financial aspects) as well as subjective ones (openness, cultural fit between firms, flexibility, etc.). We surveyed shippers from the chemical industry situated within the Antwerp-Rotterdam region. The chemical industry within the AR chemical cluster has a long tradition of vertical and increasing horizontal collaboration and offers the possibility of studying the

respondents' view on drivers for horizontal and vertical collaboration simultaneously.

In the next section the used research methodology is described. Section 4 presents the empirical study results, offering an overview and a statistical analysis of the horizontal and vertical cooperation drivers. Section 5 summarizes the main findings and concludes this paper.

3 Methodology

An extensive literature and internet-based desk research was carried out to identify chemical companies ('shippers') situated in the Antwerp-Rotterdam chemical cluster. A questionnaire was drafted to evaluate the factors and variables influencing the decision within a chemical plant whether or not to initiating cooperating with a certain partner. To focus ideas, questions on vertical collaboration are limited to the collaboration with Logistics Service Providers. The questionnaire was divided into three main sections: (i) vertical collaboration and influencing factors, (ii) horizontal collaboration and influencing factors, and (iii) general company questions. On average a response rate of approximately 11% was obtained. This is an acceptable rate given the fact that response rates for academic studies have been known to show a general decline in recent years (Griffis *et al.* [5]).

To limit the workload for the respondents and to increase the response rate of the survey, the selected companies were asked to identify a single key informant. Checking his/her function within the company validated the competence of this informant. For more information and suggestions on selecting key informants, we refer to Kumar *et al.* [6]. All respondents can be considered to be sufficiently knowledgeable such that the results are not tainted by informant bias: 57% held a logistics/supply chain management position, 20% belonged to the general management and 9% had another relevant professional background such as finance manager or customer care manager. Finally, 14% of the respondents did not mention their function.

To verify the representativity of the results, the characteristics of the participating companies were investigated. The large majority of respondents (83%) have a worldwide turnover of over more than 100 million euros yearly. With respect to workforce, Figure 2 (left panel) shows that 50% of the companies that responded to the question have more than 1000 employees worldwide, whereas 37% have less than 1000 employees. As regards company activity types (i.e., bulk chemicals, fine chemistry, pharmacy or hybrid), Figure 2 (right panel) illustrates that 32% of the companies have a mixed product portfolio. The other companies are well distributed over the different categories.

4 Drivers and partner characteristics for collaboration

Verstrepen *et al.* [7] suggest that cooperation only has a real chance of success when certain 'chemistry' exists between all sections of the partner companies. Successful cooperative relationships are not only characterized by a hard,

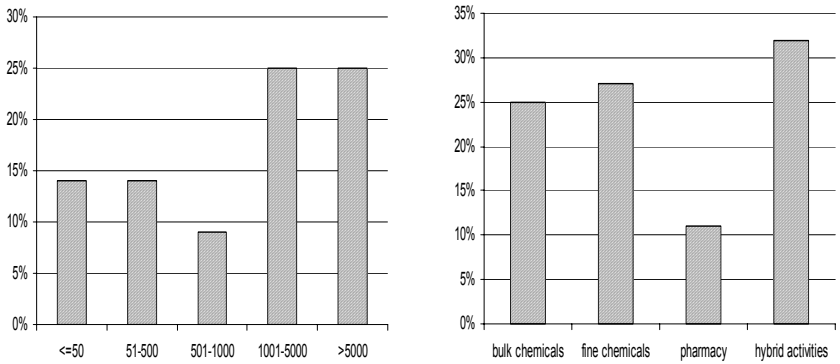

Figure 2: Histogram of global workforce (left panel, in full time equivalent units) and of activity type (right panel) in the sample.

business economics reality, but also by an emotional or psychological (soft) component. Cruijssen *et al.* [2] mention that the potential of (horizontal) collaboration is difficult to judge by merely performing some kind of cost-benefit analysis based on quantitative aspects and that there are many soft factors that may play a crucial role in the success of collaboration.

The questionnaire addressed general company information (activities, location, turnover, manpower) and a set of comparable questions on drivers for cooperation, partner characteristics, nature and practical organization of the collaboration (e.g. use of formal contracts, contract duration) for horizontal and vertical collaboration. Shippers are traditionally involved in vertical collaboration. Those who were not engaged in horizontal collaboration at the time of the research were nevertheless asked to give assessment of the importance of several drivers for collaboration and of features of potential partners. This way, all respondents were asked to complete both sets of questions, cooperators and non-cooperators were explicitly identified, and respondents did fill in both sets of questions in 89% of the cases.

The examined 'drivers for collaboration' and 'partner characteristics' were designed to be comparable between vertical collaboration (part I of the questionnaire) and horizontal collaboration (part II of the questionnaire). Because cooperators and non-cooperators are identified within the survey, this allows comparing the evaluations of both types of respondents. As such we can compare whether the concerns of those who do not cooperate are indeed supported by empirical data from those cooperating horizontally. Respondents were asked to evaluate each driver and partner characteristic by choosing one of the following options: (i) strongly agree, (ii) agree, (iii) neutral, (iv) disagree, (v) strongly disagree.

Table 1 shows the results of the survey. The comparison of the average scores of both subsets of respondents (i.e., cooperators and non-cooperators) is given in columns 2 and 3. Since categorizing the respondents into a cooperator group and

a non-cooperator group is not an ad random exercise, we are not allowed to use a standard *T*-test. Therefore, we use the Mann-Whitney U statistic to test the following hypotheses for each collaboration driver and every characteristic of potential partners:

H_0: Cooperators and non-cooperators are from the same population

H_1: Cooperators and non-cooperators are from different populations

Table 1: Evaluations of drivers and partner characteristics for cooperators and non-cooperators in the case of horizontal collaboration.

	Mann-Whitney U	Asymp. Sig. (2-tailed)
Drivers for cooperation		
Financial opportunities	192.500	0.081
Service level made possible through collaboration	215.000	0.157
Internal sakeholder support and commitment	223.000	0.376
Necessary investments for collaboration	236.000	0.474
Partner features		
Potential for influencing partner	247.500	0.534
Former partnerships and experiences with partner	237.500	0.386
Companies' complementarity	224.000	0.22
Trust in partner	238.000	0.367
Benchmark results concerning the partner	230.500	0.315
Willingness of partner to collaborate	237.000	0.544
Financial position of partner	216.000	0.277
Partner knowledge	255.500	0.638
Innovation potential of partner	232.500	0.343
Flexibility of partner	213.500	0.14
Cultural fit between companies	247.000	0.525
Openness between companies	217.500	0.161

The differences in the average scores of cooperators and non-cooperators statistically do not differ at a 95% confidence level. As such, one can conclude that the non-cooperators have a realistic perception of collaboration in general and of partnerships.

The survey did not only address issues on horizontal collaboration. In fact, the questions on horizontal collaboration were mirrored to match the corresponding drivers and partner features of vertical collaboration as closely as possible. As such, they should allow us to establish whether respondents give a different score to comparable influencing factors depending on the type of collaboration.

To compare the average scores of the variables corresponding to the vertical and horizontal drivers or partner characteristics, a Two-Related-Samples Test is needed. Because the paired samples *T*-test assumes the data to be normally distributed – which is not guaranteed – we resort to the non-parametric Wilcoxon signed-rank test. Table 2 provides the results.

Respondent results concerning the drivers for collaboration point out that in case of horizontal collaboration more importance is given to 'internal stakeholder support' and to the 'required investments for cooperation' (lower scores imply a

higher level of agreement). These empirical outcomes are in line with our a priori expectations, since cooperating with companies that operate at the same level of the market (i.e., collaborating with competitors) concerns a more sensitive matter compared with vertical collaboration. Moreover, in case of vertical collaboration, shipper investments are rather limited.

Table 2: Evaluations of collaboration drivers and partner characteristics for vertical and horizontal collaboration.

	Z	Asymp. Sig. (2-tailed)
Drivers for cooperation		
Financial opportunities offered	-1.23	0.219
Service level offered	-1.62	0.106
Internal stakeholder support and commitment	-2.01	**0.044**
Necessary investments for collaboration	-2.16	**0.031**
Partner features		
Relative bargaining power	-0.29	0.773
Former partnerships and Experiences	-0.02	0.983
Level of supplementarity/complementarity	-1.29	0.197
Trust	-0.65	0.518
Benchmark results concerning potential partner	-0.85	0.396
External willingness to collaborate	-1.34	0.179
External financial position	-0.42	0.676
External knowledge	-1.62	0.106
External innovation potential	-2.15	**0.031**
External flexibility	-1.54	0.124
Cultural fit between companies	-2.28	**0.023**
Openness between companies	-1.86	0.064

The partner features ‘external innovation potential’ and ‘cultural fit between companies’ have mean scores for the corresponding questions, which are statistical significant using a 5% level of significance. These two characteristics are thus judged as more important for successful horizontal partnerships than for successful vertical ones. These findings still need to be researched in detail, but could intuitively be explained as follows. In the chemical industrial sector, the large majority of services is more standardized and is easier vertically outsourced (since these services are not considered to be core activities of the company). Horizontal collaboration is more related to company core activities (in which innovation is considered an important characteristic, see e.g. Busom and Fernández-Ribas [8] and Arranz and de Arroyabe [9]). Finally, cultural fit could be more an issue if the (competing) chemical plants planning to collaborate are characterized by comparable bargaining power. Future research will be aimed at formally validating these claims.

These results indicate that if internal companies’ stakeholders do support cross-company safety departments collaborating, and if the required investments for collaborating are reasonable, then strategic safety cooperation initiatives between these firms (e.g. concerning external domino effects prevention

measures) have a much higher chance of being successful in the long term. Since establishing prevention measures across neighbouring plants might avoid devastating knock-on accidents, there are huge hypothetical (financial as well as social) benefits.

Chemical companies recognize the necessity for improved safety cooperation (Reniers *et al.* [10]). Companies are for example convinced of the safety maximizing synergy effects of cross-company risk analyses, but at the same time openly question the feasibility of more intensive cooperation for several reasons. Companies belonging to an international group with standard safety methods are often obliged to use these methods. The desire to collaborate is often also limited by practical problems, such as the procedure to purchase personal safety equipment or the division of the costs of joint prevention measures, especially where mutual risks are not equally divided over the plants and are difficult to measure. These considerations and the confidentiality of company safety data are some important hurdles for more intensified collaboration in the chemical sector. Current industrial practice indicates that factors driving safety collaboration between companies situated within a chemical cluster include for example fire-fighting, emergency response, crisis management, environmental compliance, safety training, etc. The driving forces behind the latter existing horizontal collaboration initiatives are either major accident risks or financial optimization opportunities. It should be noted that external domino effect risks are in fact major accident risks where financial optimization opportunities can be realized through more intensified horizontal cooperation. Instead of single companies individually taking domino prevention measures (and thereby possibly creating economically inefficient precaution redundancies), companies should – from an economic/financial point of view – cooperate to prevent domino accidents.

Both the drivers resulting from our survey (i.e., 'internal stakeholder support' and 'required investments for collaboration') are therefore likely to be easily realized and accepted as being valid from a domino safety point of view.

Furthermore, potential hurdles concerning the features 'external innovation potential' and 'cultural fit between companies' can also easily be overcome in the Antwerp-Rotterdam chemical cluster by using the frameworks and the schemes proposed by Reniers *et al.* [11], the authors suggesting a method for setting up a multi-plant safety culture, thereby companies learning from each other (i.e., external innovation concerning safety matters) and taking a.o. existing individual plant safety cultures and potential confidentiality matters into consideration. By implementing the suggested approach by Reniers *et al.* the 'lack of openness' - problem (or the 'cultural non-fit' problem) is taken into consideration and solved. Using the proposed cluster approach also leads to safety improvements of companies situated within the same (large) industrial area, but for example not situated close to each other.

5 Conclusions

The contributions of this paper on horizontal and vertical cooperation research in the Antwerp-Rotterdam chemical cluster are twofold. First, non-cooperators

have shown to have a realistic perspective about the drivers and the partner features of partnerships. Second, the drivers for cooperation and the importance of partner features for horizontal and vertical collaboration largely coincide. However, for establishing long-lasting horizontal partnerships, internal stakeholder support and the required investments are considered to be more important drivers than for vertical collaboration. Likewise, external innovation potential and cultural fit between companies are considered to be more important partner features in the case of horizontal collaboration. Therefore, if a successful cluster safety culture is to be established within the Antwerp-Rotterdam area or indeed in any chemical cluster, companies have to be convinced of the hypothetical benefits of cross-company accidents prevention. Current industrial collaborative practices indicate the potential willingness of companies to intensify collaborative initiatives concerning external domino effect risks. Furthermore, the methodology, frameworks and insights suggested by Reniers *et al.* [11] seem to be highly valid for advancing multi-plant safety collaboration improvements within a chemical cluster, eventually leading to a cluster safety culture.

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