INVESTIGATING THE FACTORS FACILITATING (A.O. SAFETY AND SECURITY) COLLABORATION IN THE CHEMICALS SECTOR

G. RENIERS[1,2]
[1]Antwerp Research Group on Safety and Security (ARGoSS), University of Antwerp, Prinsstraat 13, B-2000 Antwerp, Belgium.
[2]Centre for Economics and Sustainable Entrepreneurship (CEDON), HUB, KULeuven, Stormstraat 2, B-1000 Brussels, Belgium.

ABSTRACT

In this paper we investigate the factors influencing collaboration in the industries using chemical substances. The collaboration drivers and the partner features essential for enhancing collaboration initiatives in chemical companies, as well as the possible disadvantages of collaboration arrangements, are investigated. A survey study was carried out to examine which drivers and features make the potential shipping partners complement each other. A suggested collaboration approach is set up. By using the approach, decision makers within chemical companies are able to formulate recommendations for how to initiate and further enhance cooperation understandings, on a horizontal as well as on a vertical level. Such collaborative understandings should lead to more sustainable chemical industrial clusters. Safety and security cooperation within and between corporations using chemicals is very important for the social dimension of true sustainable clusters. Strategic safety and security collaboration arrangements may be initiated and/or enhanced taking the findings of this paper into account.

Keywords: chemicals using industries, safety and security collaboration, survey, sustainable chemical industry.

1 INTRODUCTION

The Antwerp–Rotterdam (AR) chemical cluster region encompasses two European member states (Belgium and the Netherlands) in Northern Europe and has a surface area of approximately 30,000 km^2, housing 580 chemicals and petrochemicals plants. The AR chemical cluster forms – by far – the largest chemical cluster region worldwide in terms of concentration of chemical companies per surface area or the so-called plant-per-surface density (which equals 0.019 in the AR region; remark that the chemical cluster of the 'Greater Houston' region (i.e. the so-called Houston Metropolitan Statistical Area) houses 413 chemical companies in an area of approximately 26,000 km^2, 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 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.

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. Moreover, collaboration leads to more sustainable solutions and ultimately to a sustainable chemical industrial cluster. To obtain an idea of current collaboration perceptions within industrial companies, we investigated cooperation

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

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 on how to enhance cooperation in general and safety and security collaboration in particular within a chemical cluster.

Although cooperative arrangements within the chemical industry have a long and successful tradition, further optimization of these arrangements is very often possible. By augmenting collaborative agreements and relationships and by linking up with other firms on the same level of the market, a company may enjoy options otherwise unavailable to it, such as better access to markets, pooling or swapping of technologies and production volumes, access to specialized competencies, lower risk of research and development, enjoying larger economies of scale, benefiting from economies of scope, etc. [1, 2]. We examine how these collaborative relationships may be extended in a proactive way, i.e. by analyzing the decision makers' perceptions on 'successful collaborative partnerships'. This way, competition-based perceptions and requirements of managers deciding on collaborative agreements are (indirectly) taken into account. We use survey data from the largest chemical cluster region (in terms of concentration of plants per surface area) worldwide for developing a tentative approach for enhancing successful collaboration initiatives.

In this article, we do not focus on considerations concerning mergers, acquisitions and market concentration. Instead we want to investigate how to improve collaborative arrangements (with a non-assimilating nature) between companies active in the chemical industry.

Besides the input for advancing safety and security collaboration and safety and security improvement within chemical clusters, this study on collaboration has four more advantages for the chemicals sector:

1. line organizations in the chemicals sector have identified supply chain collaboration, both vertical and horizontal, as one of the critical drivers for long-term competitiveness of the sector [3, 4];
2. there is a huge potential to be achieved through improved collaboration between producers, customers, suppliers and service providers to drive out waste and cost [5];
3. collaboration in the end may/should lead to sustainable industrial parks, which are characterized with a competitive advantage over non-sustainable industrial clusters;
4. due to the global character of chemical industrial activities, the conclusions of the study (focused on the Antwerp–Rotterdam chemical cluster region) can easily be generalized to collaboration between companies operating in chemicals sectors worldwide.

In this paper, our modus operandi is to theoretically study and empirically test (using survey results) the improvers for (horizontal as well as vertical) cooperation including drivers of collaboration and features of potential partners, both objective ones (such as e.g. service characteristics or financial features) as well as subjective ones (openness, cultural fit between firms, flexibility, etc.) from a chemical organizations' perspective (and thus not from a Logistics Service Providers' point of view). The objective of this paper is to determine an approach for enhancing collaboration in the chemicals sector, based on insights from literature and empirical data on the search process for partners. The approach should encompass at the same time horizontal and vertical collaboration.

The remainder of this article is structured as follows. In the next section, the extensive literature study is discussed. Section 3 describes the research methodology. Section 4 presents the study results and gives an overview and presents the results of an analysis of the horizontal and vertical cooperation drivers and partner features. Section 5 uses the research findings to propose an approach for enhancing multi-corporate collaboration in the chemicals sector. Section 6 summarizes the main findings and concludes this paper.

2 LITERATURE REVIEW

2.1 Types of collaboration

In general, two forms of cooperation can be distinguished: horizontal and vertical cooperation. Chemical companies use actually both collaboration configurations and sometimes also mixed cooperation arrangements. Horizontal collaboration is characterized by cooperation between competitors, i.e. firms operating at the same level in the market. Vertical cooperation can be defined as cooperation between companies that succeed each other in a particular generation process and therefore have different activities [6]. Collaboration, both horizontal and vertical, results in inter-organizational relationships. These associations can range from weak interconnections to complete integration of two or more organizations [7, 8]. Partnerships can differ in duration, strength and closeness. Based on [9], the type of collaboration is determined by three related characteristics of collaboration: scope, objective and horizon. The three cooperation types are operational collaboration, tactical collaboration, and strategic collaboration. During operational collaboration partners deploy activities more efficiently

within the existing organizational structures, at an operational level with a short-term horizon. In tactical collaboration, savings are realized through coordination between partners, exchanging information and planning joint activities with a mid-term horizon. Strategic collaboration leads to structural savings as a result of joint investments (e.g. in structure reorganization) on a long-term horizon.

Both vertical and horizontal cooperation are thus important forces leading to enhanced company competitiveness as well as company sustainability. As [10] puts it, discussions about inter-firm cooperation are likely to be based on misunderstandings stemming from a failure to specify the exact form of cooperation in question.

Although the successes and failures of partnering and forming strategic collaborative arrangements are supported by conceptual and empirical research both within academia and within business [1, 2], real-life situations require analyzing a potential partner's strategic and organizational capabilities (requiring knowledge about its physical as its intangible assets) [11], which makes partner selection a very difficult task. Empirical research [1, 12, 13] is mostly aimed at identifying the benefits and obstacles of cooperation (via success rates or failure rates), rather than understanding the search process for partners.

Verstrepen *et al.* [14] and Cruijssen *et al.* [15] 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 characterized not only by a hard, business economics reality, but also by an emotional or psychological (soft) component. As [16] expound, two basic qualities are sought in a partner: strategic fit and cultural fit. Whereas strategic fit refers to so-called 'hard factor' fit (technology, operations, utilities, etc.), cultural fit refers to the so-called human aspects' or soft factors' synchronization of both partners. Many partners start with a good strategic fit, through which they have the incentive to work on their cultural differences and reduce potential partner feature conflicts. However, their lack of cultural fit will limit their partnering success and will often lead to collaboration failure. The drivers for collaboration (discussed in Section 2.3) and the partner features (discussed in Section 2.4) should thus embody both strategic (hard factor) fit and cultural (soft factor) fit.

2.2 The importance of safety and security collaboration

The development of eco-industrial parks is an emerging concept that is being spread worldwide as a new industrial model that can reconcile the three dimensions of sustainability: social, economic and environmental. However, despite its increased prominence in recent years, sustainable development still faces a number of challenges, and among those challenges is the enhancement of (horizontal as well as vertical) collaboration between companies, leading to, e.g. less environmental strain and to safer and more secured industrial parks. Readers interested in eco-industrial parks are referred to, e.g. Côté and Cohen-Rosenthal [17], Roberts [18], Morose *et al.* [19], and Veiga and Magrini [20].

The environmental aspect of eco-industrial parks has already been subject of a lot of academic and professional research as well as applications and case-studies, and its conceptual importance (which can best be described as 'industrial symbiosis') for both a sustainable and a competitive future is widely known and accepted by the concerned communities. Chertow [21], in her article 'Industrial Symbiosis: literature or taxonomy' defines the concept of industrial symbiosis as '*Industrial symbiosis, as part of the emerging field of industrial ecology, demands resolute attention to the flow of materials and energy through local and regional economies. Industrial symbiosis engages traditionally separate industries in a collective*

approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity.' It is thus obvious that the current emphasis of industrial symbiosis and sustainable industrial parks lies on environmental issues.

Nonetheless, social and economic issues are (and should be) equally important for developing truly sustainable chemical clusters. For the social dimension, and also for the economic dimension, approaching safety and security from a cross-plant viewpoint is the way to achieve more sustainable industrial parks. Especially in the case of *chemical* industrial parks where very often substantial amounts of dangerous chemical substances are being stored, transported, processed and operated, inter-company safety and security are extremely important and relevant for advancing the social dimension of sustainable clusters. Hence, safety and security collaboration arrangements between the companies situated in these industrial parks and also between those companies and Logistics Service Providers (transporting chemical materials), need to be agreed upon.

Some (academic) theories about the practical way to advance cross-company safety and security practices and cross-plant safety and security governance have already been suggested by, e.g. Reniers [22] and Kiranoudis *et al.* [23]. However, these theories assume the existence of collaborative arrangements.

Therefore, to help companies achieving the social dimension of sustainable industrial parks (i.e. having adequate safety and security collaborative arrangements), a theory explaining the parameters considered to be important to enhance those collaborative relationships, needs to be drafted.

2.3 Drivers for collaborative relationships

Clear strategic intent leads to successful collaborative arrangements, and provides focus for the inter-organizational relationship. Following collaboration objectives are identified in literature [8, 13]:

1. *Financial opportunities:* a potential for cost reduction provides a strong incentive to partner. Closer collaboration may, for example, lead to cost reductions in different areas like transportation, handling or development.
2. *Service level enabled through collaboration:* integrating activities in the supply chain through partnerships can often lead to service improvements for customers, e.g. in the form of reduced inventory, shorter cycle time and more timely and accurate information.
3. *Market position:* collaboration can enhance companies' competitive position or market power, provide entry into new markets and access to technology and innovation to stimulate product development.

Low necessary investments for collaboration (with high returns): whereas high collaboration-related investments actively discourage cooperative arrangements, low investments are a strong driver for partnerships.

By achieving profit stability or growth in the collaborative agreement (and avoiding large collaboration-induced investments), a relationship is strengthened, often leading to long-term commitments, reduced variability in sales, joint use of assets, etc. [24].

It needs to be noticed that these literature-based objectives are expressing preferences of Logistics Service Providers. Further empirical verification of chemical companies'

preferences about this topic therefore seems valuable. Nonetheless, the above-mentioned four objectives can be considered the theoretical drivers of cooperative arrangements. It should be noted that the first two drivers, financial opportunities and service level improvements, are in vertical collaboration literature identified as the two key drivers [13, 25, 26].

2.4 Partner features in collaborative relationships

General management literature discusses six variables possibly influencing partnering decisions:

1. *Fit between partners:* refers to which potential partners are suited for collaboration.
2. *Trust and commitment:* implies that the participating partners are loyal and tolerant of each other's deficiencies, true partners do not constantly worry about being replaced [27, 28].
3. *Homogeneity:* internal support is essential and internal targets of different departments may not undermine or conflict with the collaborative objectives [28, 29].
4. *Transparency:* refers to the openness between the cooperating parties in terms of communication and measurability of, e.g. costs, benefits and risks [30, 31].
5. *Gain-sharing:* is defined as the possibility to share collectively in achieved benefits resulting from collaborative relationships [12, 31].
6. *Interpersonal interaction:* [32] stresses the importance of interpersonal emotions in collaborative relationships between organizations. They consider that the collaboration between two organizations is built on the interaction between individual agents of both organizations.

Literature review indicates trust and commitment to be the key parameter in this list [27, 29, 33]. Nevertheless, literature does not explain if collaboration features are valued differently in case of vertical versus horizontal collaboration. On this point further empirical verification is needed.

The above six collaboration influencing variables are only partially taken into account by the suggested collaboration drivers in Section 2.3. To include all six influencing variables from a broad perspective, we propose the following twelve partner features on top of the four collaboration drivers:

1. relative bargaining power;
2. former partnerships and experiences;
3. level of being supplementary/complementary;
4. *trust*;
5. benchmark results concerning potential partner;
6. external willingness to collaborate;
7. external financial position;
8. external knowledge;
9. external innovation potential;
10. external flexibility;
11. cultural fit between companies;
12. openness between companies.

This way, in total 16 (4 collaboration drivers and 12 partner features) unambiguous, tangible and understandable improvers of both horizontal and vertical collaboration are obtained.

2.5 Drawbacks of collaborative relationships

Clearly, besides collaboration improvers, a number of potential disadvantage factors can be linked to collaboration, which often hinder companies to make the decision to start a collaborative relationship. Without the real or perceived drawbacks, firms would be much more inclined to cooperate. Important drawbacks of cooperating or forming an alliance are for example discussed in [1, 34, 35]. The most important reported hindrances for successful collaboration can be summarized by four 'collaboration drawbacks':

1. decreased clarity of governance;
2. increased operational dependence;
3. increased possibility of knowledge unwanted spillovers;
4. decline of social stability.

Decreased clarity of governance implies that gaining insights into the clarity of corporate and internal governance becomes more complicated when collaborating, since collaboration might lead to less transparency and increased difficulties in the determination of which firm is responsible for which results, liabilities, etc. *Increased operational dependence* indicates that collaboration might constrain the autonomy and decision-making authority of the individual collaborating firms due to increased dependencies between the horizontal or vertical partners. The disadvantage of an *increased possibility of knowledge unwanted spillovers* denotes the danger that if know-how, knowledge, information, etc. are made available to a collaborating firm, these can also be leaked to other companies, since the flow of knowledge in collaboration arrangements is often hard to control. The potential problem described as a *decline of social stability* arises, e.g. due to personnel becoming less loyal to their own company as a result of collaboration or due to staff members being worried about their future due to the collaboration arrangement.

3 RESEARCH METHODOLOGY

An extensive literature and internet-based desk research was carried out to identify chemical companies ('shippers') situated in the Antwerp–Rotterdam chemical cluster region. A questionnaire was drafted to evaluate the drivers and features influencing the decision within a chemical plant whether or not to initiate cooperation with a certain partner. The questionnaire was divided into three main sections:

1. vertical collaboration and influencing factors;
2. horizontal collaboration and influencing factors;
3. 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 [36].

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 [32]. 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 representativeness of the results, the characteristics of the participating companies were investigated. The large majority of respondents (83%) have a worldwide turnover of more than 100 million euros yearly. With respect to workforce, 50% of the companies 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), 32% of the companies have a mixed product portfolio. The other companies are well distributed over the different categories.

4 STUDY RESULTS

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:

1. strongly agree;
2. agree;
3. neutral;
4. disagree;
5. strongly disagree.

The comparison of the average scores of both subsets of respondents (i.e. cooperators and non-cooperators) was then investigated. Since categorizing the respondents into a cooperator group and a non-cooperator group is not an ad random exercise, we use the Mann–Whitney U statistic. It seems from our study that the differences in the average scores of cooperators and non-cooperators statistically do not differ at a 95% confidence level. As such, we may conclude that the non-cooperators have a realistic perception of collaboration in general and of partnerships in particular.

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. We resort to the non-parametric Wilcoxon signed-rank test. Table 1 provides these 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

Table 1: Evaluations of collaboration drivers and partner features for vertical and horizontal cooperation.

	Vertical cooperation		Horizontal cooperation			
	Avg.	Std. dev.	Avg.	Std. dev.	z	Asymp. Sig. (2-tailed)
Drivers for cooperation						
Financial opportunities offered	1.62	0.82	1.69	0.82	−1.23	0.219
service level offered	1.63	0.79	1.72	0.64	−1.62	0.106
Internal stakeholder support and commitment	3.02	1.05	2.75	0.98	−2.01	**0.044**
Necessary investments for collaboration	3.02	0.94	2.67	0.81	−2.16	**0.031**
Partner features						
Relative bargaining power	3.08	0.91	3.12	1.02	−0.29	0.773
Former partnerships and experiences	2.40	0.89	2.40	0.97	−0.02	0.983
Level of supplementarity/ complementarity	2.33	0.89	2.10	0.68	−1.29	0.197
Trust	1.81	0.60	1.72	0.64	−0.65	0.518
Benchmark results concerning potential partner	2.58	1.11	2.64	0.94	−0.85	0.396
External willingness to collaborate	2.19	0.99	1.96	0.61	−1.34	0.179
External financial position	2.58	0.94	2.47	0.74	−0.42	0.676
External knowledge	2.54	1.16	2.18	0.80	−1.62	0.106
Eternal innovation potential	2.71	1.07	2.30	0.99	−2.15	**0.031**
External flexibility	1.84	0.81	1.94	0.77	−1.54	0.124
Cultural fit between companies	2.65	0.93	2.31	0.96	−2.28	**0.023**
Openness between companies	2.19	0.86	1.94	0.74	−1.86	0.064

'required investments for cooperation' using a 5% level of significance. These 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.

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 can 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. [37, 38]). Finally, cultural fit could be more an issue if the (competing) chemical plants planning to collaborate are characterized by comparable bargaining power.

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 and security cooperation initiatives between these firms (e.g. concerning cross-company accident prevention measures) have a much higher chance of being successful in the long term. Since establishing prevention measures across neighboring plants might, for example, avoid devastating knock-on accidents, there are huge hypothetical (financial as well as social) benefits.

5 APPROACH FOR ENHANCING COLLABORATION IN THE CHEMICALS SECTOR

Using the findings from our survey, an approach for facilitating the setting up of successful (horizontal and vertical) cooperation initiatives is developed. It is obvious that a distinction can be made between a horizontal collaboration fit and a vertical collaboration fit.

The combination of a horizontal partner features' correspondence and a horizontal collaboration drivers' correspondence between shippers will help them establish stable horizontal partnerships. The same reasoning can be used for stable vertical partnerships.

To draft a workable approach for enhancing collaboration arrangements within chemicals using industries, collaboration drawbacks should be taken into account and should be linked with both types of collaboration improvers (i.e. partner features and collaboration drivers). This exercise was carried out by an expert panel. Figure 2 illustrates for both horizontal and vertical cooperation the existing links between collaboration drawbacks (inner ellipse) and the partner features and collaboration drivers (both outer ellipse).

Figure 2 illustrates in a simple way the balance that has to exist between collaboration enhancement parameters and collaboration hindering parameters. More specifically, several partner features related to one collaboration drawback should be viewed upon as one integral block forming 'counterbalance' against the drawback. Figure 2 can thus be further refined by taking the survey results into consideration: our survey indicates that for establishing long-lasting horizontal partnerships, 'internal stakeholder support' and the 'necessary investments for collaboration' are considered to be more important drivers than for vertical cooperation. Likewise, 'external innovation potential' and 'cultural fit between companies' are considered to be more cardinal partner features in the case of horizontal cooperation.

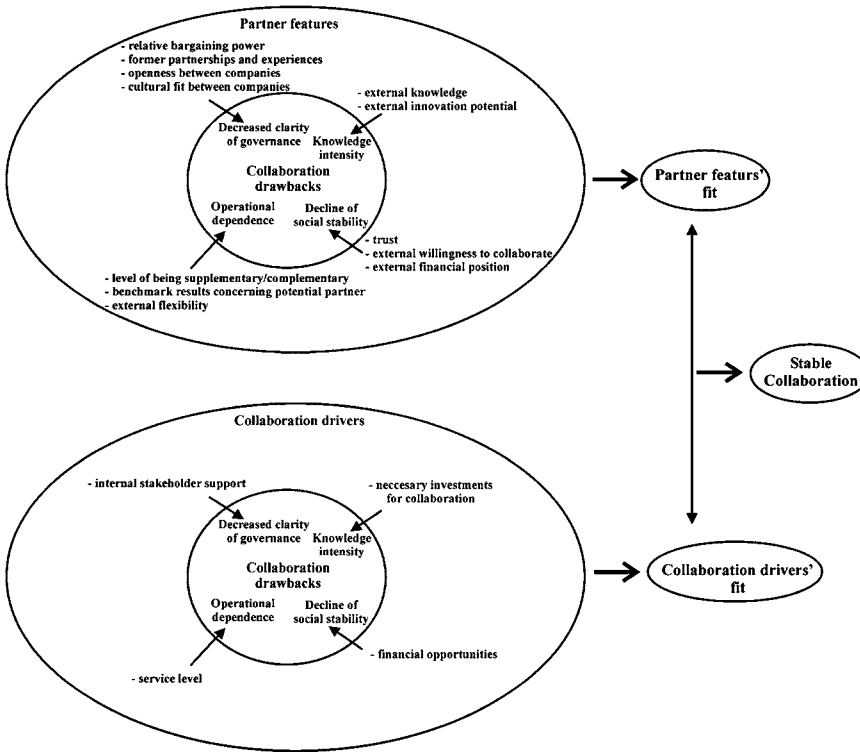

Figure 2: Operational relationships between collaboration drawbacks and collaboration improvers.

Furthermore, literature indicates that 'operational dependence' and its corresponding collaboration driver (service level) and partner features (level of being supplementary/complementary, benchmark results concerning potential partner, external flexibility) are potentially very important drawbacks whereas vertical collaboration is concerned. In addition, the drawback 'decline of social stability', and its corresponding partner features (trust, external willingness to collaborate, and external financial position) and collaboration driver (financial opportunities), is regarded by literature as equally important to both horizontal collaboration and vertical collaboration. Based on these findings, a novel, more refined approach is suggested. Figure 3 illustrates the suggested approach.

It is obvious that not merely one cooperation driver and/or one partner feature is taken into account for a decision to initiate a vertical or horizontal collaborative relationship. In fact, probably in most industrial cases all collaboration improvers are weighed against their potential drawbacks while making a collaboration-related decision. However, the drivers' and the features' importance is unequally perceived by decision-makers. Hence, this 'common sense prioritization' in the minds of decision-makers was employed in this research to elaborate a generalized approach displayed in Fig. 3.

Companies operating in the chemicals sector may use the proposed approach to consider and to investigate partner features and collaboration drivers for their desired type of collaborative understanding. By doing so, the most important drawbacks of the envisioned collaborative arrangement are simultaneously taken into account and the likelihood of a stable horizontal or

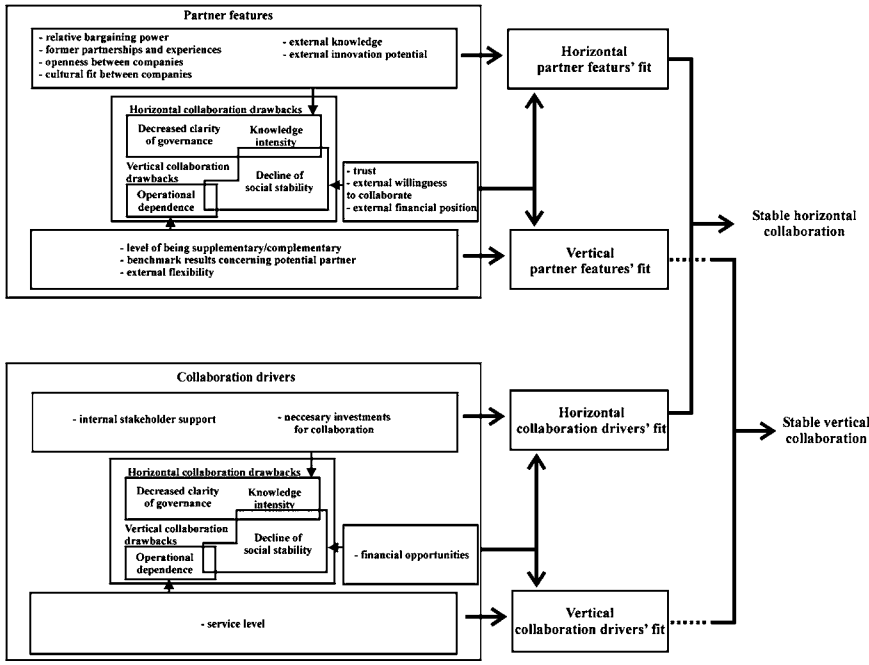

Figure 3: Approach for facilitating successful collaboration initiatives within the chemicals industrial sector.

vertical relationship is enhanced. This simplified approach can evidently not be used for every collaboration situation/decision within the chemicals sector. Nonetheless, it is a tentative model offering a basic understanding on how to set up a successful horizontal or vertical collaborative partnership. Future research will be carried out to further refine and validate this approach.

Applied to the safety and security research field and safety and security management in industrial settings, the suggested approach can be employed as follows. Chemical companies recognize the necessity for improved safety cooperation [39]. 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, e.g. 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 in case of cross-plant accident risks in fact financial optimization opportunities can be realized through more intensified horizontal cooperation. Instead of single companies individually taking cross-plant prevention meas-

ures (and thereby possibly creating economically inefficient precaution redundancies), companies should – including from an economic/financial point of view – cooperate to prevent cross-plant accidents. The same reasoning can be followed in case of security collaboration in the chemicals sector.

By focusing on the right collaboration drivers and partner features for setting up a safety and/or security collaborative partnership, cooperation between horizontal partners and/or between vertical partners can be truly stimulated in a successful way. Furthermore, [40] suggests a methodology for setting up a multi-plant safety and security culture. Companies learn from each other and thereby take existing individual plant safety cultures and potential confidentiality matters into consideration. The process leads to internalized safety and security innovation in the participating plants and to more sustainable chemical industrial parks.

6 CONCLUSIONS

This paper discusses a novel approach to facilitate successful collaborative partnerships in the chemicals sector. To this end, cooperation drivers and partner collaboration characteristics as well as collaboration drawbacks were identified and analyzed. A questionnaire was used to assess the collaboration improvers' 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).

In fact, the importance of the cooperation drivers and the partner features for horizontal and vertical collaboration largely coincide. However, for establishing long-lasting horizontal partnerships, internal stakeholder support and the necessary investments for collaboration are considered to be more important drivers 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. Based on these results, a tentative approach to facilitate flourishing collaboration decision-making was elaborated. Current industrial collaborative safety and security practices indeed indicate the potential willingness of companies to intensify collaborative initiatives concerning jointly taking the preventive and mitigative actions. Using the suggested approach, it is possible for companies to comprehend, to analyze, and if necessary to elaborate the required focus for successful (a.o. safety and security) collaboration arrangements leading to sustainable chemical industrial parks. Future research will be carried out to further refine and validate the suggested approach.

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