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# Port supply chain integration: analyzing biofuel supply chains

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This paper focuses on port supply chain integration to strengthen operational and business performance. We provide a structured and comprehensive method to enable port supply chain integration and demonstrate its applicability to the biofuel supply chain. We define the value proposition, role, activities, resources, and characteristics that a port needs to integrate in the biofuel supply chain and incorporate them in an 'integration matrix'. Port authorities can achieve integration in the biofuel supply chain by extending their role and (1) facilitating flows, (2) attracting new flows, (3) executing value-adding activities, (4) developing a bio-industry cluster, and (5) acting as a knowledge center. A roundtable and two single case studies on the Port of Rotterdam and the northern Dutch port cluster have validated the content and applicability of our findings.

**Keywords:** ports; logistics; sustainability; terminals; risk; policy

## 1. Introduction

Ports play an important role in the context of supply chain management (Robinson 2002). Port supply chain integration highly contributes to create a flexible and robust supply chain that delivers value for the final consumer (Notteboom and Rodrigue 2005; Pettit and Beresford 2009). Despite the identified importance of port supply chain integration for ports, port users and other members of the supply chain, empirical investigation in this area is needed (Tongzon, Chang, and Lee 2009). Also, the few studies that have been conducted, mostly elaborated on the importance and results of port supply chain integration, while neglecting how ports can actually integrate in a supply chain. Our goal is to define how port supply chain integration can be achieved. We aim to design a method to explicate the changing value proposition of ports in supply chains and define the roles, activities, resources, and characteristics needed to fulfill this proposition.

We develop this method through qualitatively investigating the role of ports in the biofuel supply chain. The choice for this specific supply chain is manifold: (1) the biofuel supply chain is new, complex, and dynamic and has only limited been academically researched; (2) global biofuel demand and supply are dislocated, which hypothetically makes ports vital parts of the chain; and (3) we hypothesize it as a chain which could significantly benefit from supply chain integration.

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With this qualitative and explorative research we aim to:

(1) Provide an overview of the composition and developments of the biofuel supply chain.
(2) Define the value proposition, role, activities, resources, and characteristics that a port needs to integrate in the biofuel supply chain and incorporate them in an 'integration matrix'.

We include an important validation and a generalization stage with two single case studies and a roundtable.

We start this paper with the presentation of the conceptual framework. In Section 3, we discuss our research methodology. Next, we provide an overview of the biofuel supply chain. In Section 5, we translate the conceptual framework in the integration matrix for port integration in the biofuel supply chain and validate its contents. The sixth section describes the practical validation of the integration matrix. Finally, some conclusions and suggestions for further research are provided.

## 2. Port supply chain integration: a conceptual framework

We look at two types of seaports: ports with a focus on throughput and ports with a focus on industrial development. Since ports are regarded as vital nodes in supply chains (Demirbas, Flint, and Bennett 2014), their value proposition should be targeted at serving the needs of the final customer. Specific types of needs can be distinguished for users in selecting a port. Some examples include service, costs, location, infrastructure, and timeliness (Kim 2014). Port authorities can facilitate those needs and take the initiative to improve the port area. However, cooperation between neighboring port authorities in establishing those needs can also assist in attracting specific types of customers to a region (e.g., Dooms, Van Der Lugt, and De Langen 2013). Port orientation in the supply chains is a prerequisite to deliver value creation (Tongzon, Chang, and Lee 2009; Demirbas, Flint, and Bennett 2014). We define port supply chain integration as the extent to which a port authority plans, organizes, and coordinates activities, processes, and procedures related to physical, information, and financial flows beyond its own gates along the supply chain and monitors performance in such activities (Bichou and Gray 2004; Panayides and Song 2009). The extended gate concept is an example of how port authorities take responsibility beyond their own gates and coordinate activities in a broader sense. In this case, network integration can be achieved by extending their seaport terminal into, for example, inland terminals in the hinterland (e.g., Veenstra, Zuidwijk, and Van Asperen 2012). Literature has identified linkages between port integration practices and significant improvements in terms of productivity, cost reduction, delivery quality, and shorter cycle time and the effectiveness of the supply chain as a whole (Panayides and Song 2008; Woo, Pettit, and Beresford 2013). In our knowledge, however, hardly any research has developed a structured and comprehensive understanding of how ports can achieve supply chain integration.

Port supply chain integration starts with the development of the ports value proposition as it 'could be'. Traditionally, ports solely served as an interface between land and water transportation. The value proposition of ports should rise from the level of cargo handling to a more strategic level of logistics in the entire supply chain (Carbone and De Martino 2003). Ports started to have a broader range of functions and are acting as transport, industrial, and commercial service centers that are increasingly offering value-added activities and services (UNCTAD 1999; Bichou and Gray 2004; Pettit and Beresford 2009).

Port authorities must take a holistic approach to strategically align themselves into supply chain and determine the roles and value-added activities that the supply chain needs (De Martino and Morvillo 2008; Demirbas, Flint, and Bennett 2014) An analysis of the physical, information, and financial flows through the different channels (e.g. supply, trade, and logistics channels) of a port provides insights in what these potential value-adding activities are (Bichou and Gray 2004; Mangan, Lalwani, and Fynes 2008; Panayides and Song 2009). To undertake these value-adding activities, specific port resources and characteristics are needed (De Martino and Morvillo 2008).

In summary, our conceptual framework, functioning as the first step in our research, describes the concept of port supply chain integration through a changing value proposition and the factors that should be analyzed and changed to align with this new value proposition and achieve supply chain integration, namely the port's roles, activities, resources, and characteristics. The actual value proposition, roles, activities, characteristics, and resources that a port needs may differ for diverse supply chains.

## 3. Methodology

The first phase of our research (see Figure 1) consists of the overview of the biofuel supply chain. Its application to the presented conceptual framework and the resulting integration matrix are based on (1) a content analysis of industry reports and documents; (2) review of academic literature; (3) direct observations and field trips; and (4) the first round of interviews with stakeholders. In the second phase, we iteratively completed the integration matrix and validated its content and applicability of research findings through two case studies and the roundtable. The findings of all research steps taken will be summarized in Sections 4 and 5. Based on the finding presented, Section 4 will show the biofuel supply chain. After that, we translated all findings into a long list of all important port activities. Section 5 shows an integration matrix in which we order and categorize the elements of this long list showing the roles, activities, and characteristics for port integration in the biofuel supply chain.

### 3.1. *Interview and roundtable methodology*

The first round of interviews consisted of mainly face-to-face interviews conducted by a single investigator. We conducted those interviews between September and December 2011. A total of 59 experts from 47 organizations, including businesses, port authorities, (non) governmental organizations, and (academic) research institutes, participated in the research (see Appendix). The interviews were conducted with single interviewees at the interviewees' organization, to allow maximized observation and field visits where possible. The focused interviews of approximately 1.5 h each were semi-structured and guided by open-ended questions to gain a thorough understanding of the biofuel supply chain, the products, locations, and organizations involved in the different process steps and the relationships between the parties of the supply chain.

We choose to ask questions that helped us analyze the organization of different flows through the port and the activities executed in the port area, in order to identify possible value-adding activities along the supply chain that can be executed in the port area. Also,

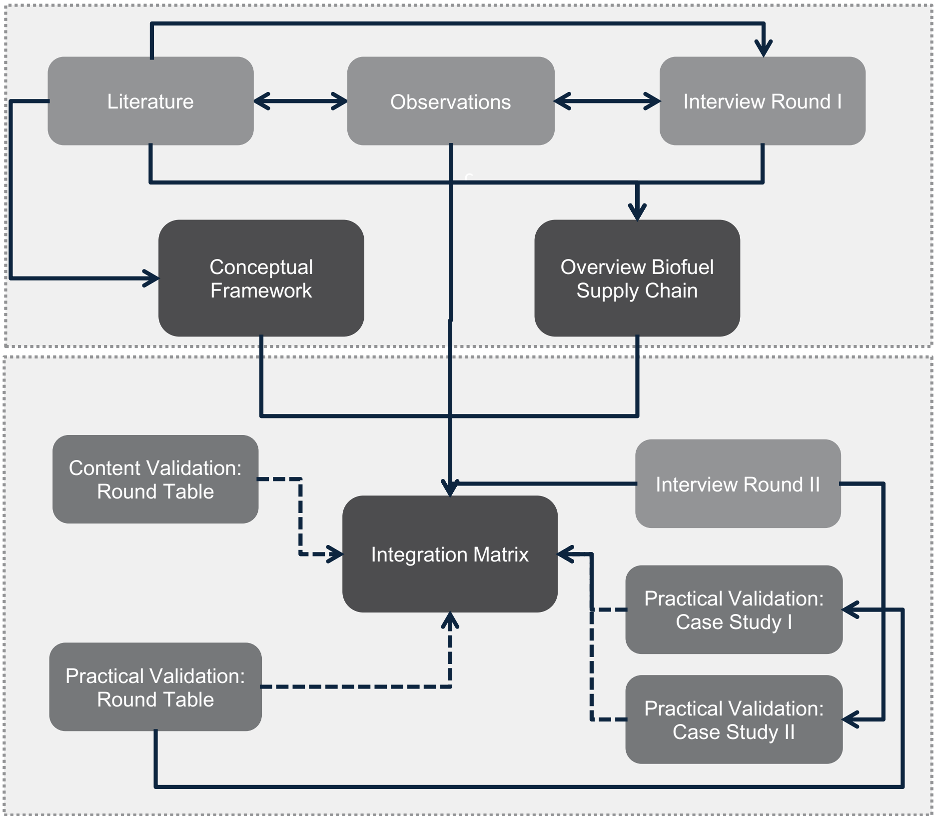



**Figure 1. Research methodology.**

we directly asked interviewees which opportunities they saw for (further) cooperation with port authorities and within the port area.

We used minutes of the interviews combined with other material collected in the field to document the data gathered in an interview narrative. We consolidated the gathered information into categories using the coding scheme suggested by Strauss and Corbin (1990). We used two broad categories: biofuels and ports. The first category consisted of information gathered on the biofuel supply chain. Within this category, we used sub-categories to group information on the different flows of the biofuel supply chain. In the second category, we grouped the gathered information into roles, activities, resources, and characteristics. Next, we analyzed the data in two steps (Voss, Frohlich, and Tsikriktsis 2009); analysis within each interview and searching for patters across interviews. This resulted in (1) the overview of the biofuel supply chain (as presented in Section 4) and (2) a preliminary integration matrix (as included in Section 5) with the roles, activities, and some resources for ports in the biofuel supply chain. We sent this preliminary matrix via email to the participants as a preparation for the second round of interviews. Subsequently, the matrix was validated during the second round of interviews.

This second round of interviews was largely conducted in the period January–May 2012 through telephone conversations, some face-to-face interviews, as well as some specific validation questions by email. Based on the information needed, and the available time of the interviewees, we included 28 of the 59 participants in the second round of interviews. We aimed at confirming the overview of the biofuel supply chain; testing contradicting statements found in the first interview round; testing and confirming the preliminary integration matrix; and asking follow-up questions to complete the matrix. Because of restricted time and the iterative nature of our research, we used one single interview for 10 participants to ask the interview questions of both the first and second rounds.

The research output is based on our interpretation and analysis of the opinions of the interviewees. To enable sharing thoughts amongst interviewees and reduce the risks of observer bias, we have organized a roundtable in January 2012, where direct interaction between the participants was facilitated. At this roundtable, 21 research participants accepted the opportunity to discuss the research findings and discuss their implications. Also, some new research participants that had not been interviewed were added to ensure a broad and objective validation. The roundtable contained several rounds of presentations with different research findings, each of which was followed by a round of discussion. We fueled these discussions with statements containing discrepancies from the interviews or preliminary research conclusions. These rounds of discussions helped us to reach consensus on rival statements and interpretations between the different interviewees.

### 3.2. *Case study protocol*

We validated the applicability of research findings through two single case studies. We decided to select atypical or extreme cases, because these can reveal more information (Flyvbjerg 2006). We conducted the two single case studies sequentially, which allowed us to confirm the analysis of the first case with a different type of port. We expect that our polar cases (Voss, Frohlich, and Tsikriktsis 2009) will generate a broad range of results, since they have a different focus (namely throughput and industrial development).

In the first case study, we selected the port that was expected to be the most advanced in biofuel operations in Europe and thus potentially provided most of the activities of the integration matrix. Within the European Union, the Port of Rotterdam (PoR) is the largest seaport with a large (petrochemical) industrial cluster. The PoR has a focus on throughput. Besides high biofuel throughput, the PoR has several production, storage, and blending facilities and therewith was found suitable as the first case of this research.

For the second case study, we sought a case port that could confirm the findings of the first case study and further demonstrate the broad applicability of the integration matrix. Therefore, we altered one factor in the second case study, namely the type of port, while keeping the other factors constant. This translated into the need for a port with a focus on industrial development, but within the Netherlands to assure the same legislation, hinterland, etc. We found the ports of Delfzijl and Eemshaven, administrated by the authority of Groningen Seaports (GSP), to be suitable for the second case study. GSP (with which we from now on indicate the two ports and the authority) is a smaller and developing port which is very focused on its industry cluster. The background of this industry and nature for their growth is the energy and chemical sector, which is yet another differentiation of the PoR, which is built on the petrochemical cluster.

The case study process followed the same general process: plan, collect data, analyze data, and disseminate findings (see Section 3.1). We collected the data for the case studies through content analysis of documents, direct observations and field trips, by asking specific port-related questions in the second round of interviews, and during the roundtable.

## 4. The biofuel supply chain

This section presents an overview of all findings on the biofuel supply chain obtained by carrying out the research steps as described in Section 3. Existing work has shown the potential of biofuels and has shed light on the biofuel supply chain and its challenges (e.g. Huang, Chen, and Fan 2010; Dal-Mas et al. 2011). However, most papers discuss biofuels on an operational level and do not link their overview to supply chain management and logistics of biofuels. Our strategic overview of the biofuel supply chain is based on industry reports and the information gathered from stakeholders during the first round of interviews. In Section 5, we connect our overview of the biofuel supply chain to ports, when we apply the conceptual framework presented in Section 2 to the biofuel supply chain.

Biofuels are fuels, mainly used for transportation, which are derived from some sort of biomass. The most commonly used biofuels are ethanol and biodiesel. Ethanol is used as a substitute for conventional -fossil- gasoline and biodiesel for fossil diesel. Figure 2 shows the biofuel supply chain, which consists of several process steps, or nodes: feedstock production and processing; feedstock trading and transportation; biofuel production; biofuel trading, blending and distribution; and biofuel retail and consumption. The different types of flows identified in Section 2 are acknowledged in the biofuel supply chain.

The biofuel that is consumed in the EU is produced all over the world from feedstock that is cultivated globally. Upstream, the feedstock production and processing is dominated by the agricultural industry and independent farmers through their existing value chain. The downstream blending, distribution, and retail of biofuels follow the conventional fossil fuel chain, where the process steps are executed by national and international oil companies. The agricultural industry, farmer cooperatives, oil businesses as well as independent parties get involved in biofuel production. Since the biofuel market is immature and constantly developing, the types of products, locations, and organizations involved in this physical flow are likely to change in the future.

The flow of information accompanying the physical product plays an increasingly important role in the biofuel supply chain. Certification on the sustainability (e.g. greenhouse gas reduction, and the assurance of biofuels not pressing on food availability and biodiversity) of the biofuel and feedstock is becoming more and more important. The registration of the fulfillment of biofuel blending-obligations is another major administrative load in this information flow.

The financial flows in the biofuel supply chain are complex. Nations have different, sometimes opposing, agendas which result in un-harmonized legislations, such as differences between subsidies, import tariffs, and blending targets. Furthermore, it is important to realize that biofuel itself is not yet price-competitive with fossil fuels; it is produced

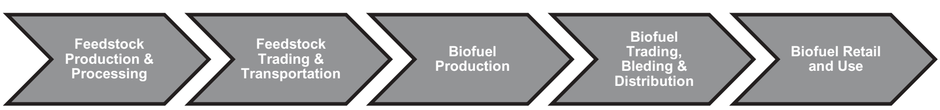



**Figure 2. Overview of the biofuel supply chain.**

because of EU mandates. Also, access to capital is essential, but found difficult, in this developing industry where capital-intensive large-scale facilities need to be built.

Together with the stakeholders, we conclude that the biofuel supply chain, the flows in it, and its strategic environment are complex with an uncertain future. To cope with this uncertainty and to be able to respond to changes and market opportunities, the biofuel supply chain requires flexibility, resilience, and focus on both effectiveness and efficiency. Companies of the industries across the supply chain should cooperate, and take a holistic approach to supply chain management: supply chain integration. We have identified several integration activities in the biofuel supply chain and expect increased integration. Current examples were named during the interviews, such as the upstream involvement of several international oil companies in feedstock and biofuel production and the downstream integration of agricultural industry and commodity houses into biofuel production.

Despite these first integration activities, a constructive approach to managing the biofuel supply as a whole appears to be lacking. Interviewees see opportunities to improve the physical flows, increase the transparency of the industry by enhancing the information flow and attracting capital flows to further develop the biofuel industry.

We conclude that an international biofuel market and supply chain are developing, as supply and demand are dislocated. As the biofuel supply chain is immature, physical, information, and financial flows are not harmonized. Ports already are a vital part of the biofuel supply chain due to the large volumes of biofuel and feedstock that are shipped from supplying to demanding areas and port authorities would be a logical actor to drive further integration of the biofuel supply chain.

## 5. Ports in the biofuel supply chain: design of the integration matrix

The integration matrix provides a method for port integration in the biofuel supply chain, as presented in Figure 3. This section presents the findings of the literature study, first round of interviews, and direct observations as well as the second round of interviews. The findings were ordered and categorized, enabling the construction of the integration matrix. Consequently, the content of the integration matrix presented is based on literature, the first round of interviews and direct observations, as described in Figure 1.

During the second round of interviews and the roundtable, we validated the content of the integration matrix. Interviewees confirm that the integration matrix gives a comprehensive and structured overview of the value proposition, roles, activities, resources, and characteristics for port integration in the biofuel supply chain. The resources and characteristics are identified as being essential for offering the identified activities. The relation between activities and roles was also confirmed. No significant differences in answers with regard to vision and priorities among the representatives from the various types of organizations were found in the interviews nor during the roundtable.

The identified changing value proposition of ports as identified in literature is confirmed for the biofuel supply chain. Port authorities indeed have a broader range of tasks to perform that enables them to deliver more value than a simple interface between land and sea. The value proposition of a port in the biofuel supply chain can develop from a transshipment point, toward a logistics hub for biofuel and feedstock flows and/or a bio-based industrial cluster.

From a practitioner perspective, the first and most straightforward role of port authorities is to support physical flows: efficient and effective loading, unloading, storage and

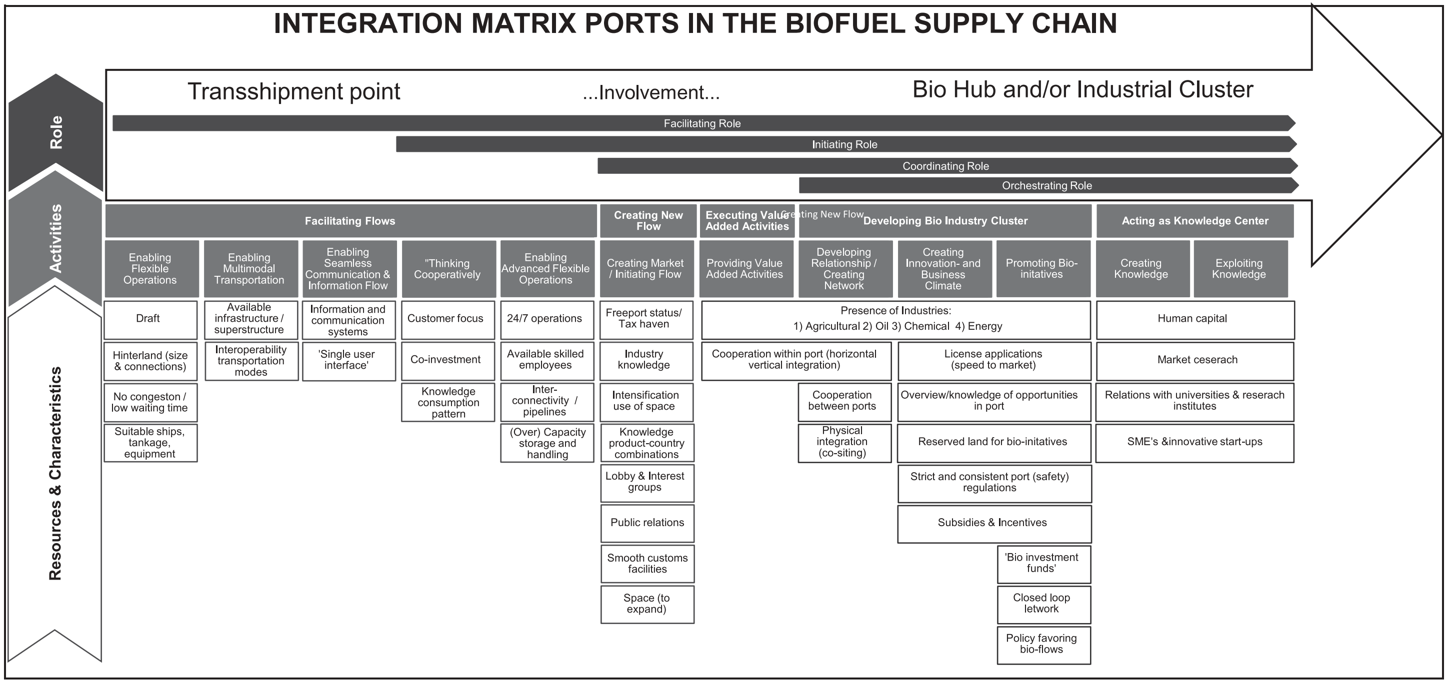



**Figure 3. Integration matrix for ports in the biofuel supply chain.**

handling of biofuel and feedstock. In this matter, the role of port authorities is clearly to *facilitate*, by creating circumstances for smooth operations (e.g. Panayides and Song 2008). Second, port authorities can take an active approach in facilitating flows. They can execute their vision and value proposition more decisively by taking the *initiative* to search for possible operational improvements in the port area. This can lead to enhanced logistics and operations of biofuel flows. The role of port authorities can be further extended toward a more *coordinating* nature (e.g. De Souza, Beresford, and Pettit 2003), when the port authority takes a comprehensive approach to optimize the biofuel supply chain as a whole. Finally, port authorities can have an *orchestrating* role. This orchestrating can encompass the actual organization of biofuel flows and the (logistics) expertise in doing so. This may include cross chain orchestrating, through searching synergies of biofuel flows with other (liquid) bulk flows. Another form of orchestrating is developing a bio-industrial cluster. A port authority has the opportunity to connect businesses and orchestrate a bio-network in the port area. In short, based on the literature study presented in Section 2 and our practical research, we state that ports can have facilitating, initiating, coordinating, and orchestrating roles. These four roles may not be exclusive, and no strict boundaries exist between them. Each role can be performed by executing a range of activities. We found that in practical situations, it might be difficult to determine whether an activity is purely initiative or coordinative in nature. The activities, and as such the roles are not strictly sequential but be regarded as 'organically evolving' and sometimes iterative. For example, the attraction of new flows can result in the need for infrastructure investments, which is part of facilitating flows.

On an aggregated level, port authorities should fulfill several goals to achieve their new value proposition and perform the activities.

(A) Facilitating flows;
(B) Attracting new flows;
(C) Executing value-added activities of the biofuel supply chain in the port area;
(D) Developing and promoting a bio-industry cluster; and
(E) Acting and attracting a knowledge center.

### 5.1. *Facilitating flows*

A port authority should execute activities that create operational flexibility for port users. This includes basic port characteristics, such as draft, hinterland size, connections (e.g. Cetin and Cerit 2010), low congestion and enough capacity for ships, tankage, and handling equipment. For more advanced ports, this also includes available skilled employees, interconnectivity through pipelines, and the possibility to operate 24 hours a day, 7 days a week.

Multimodal transportation that enables port users to transfer all sorts of product over sea, inland waterways, rail, and road is becoming increasingly important in all supply chains (e.g. Mangan, Lalwani, and Fynes 2008), including the biofuel supply chain. The uncertain and changing demand (volumes and locations) of biofuels requires a flexible infrastructure with the possibility to use different transport modes interoperable.

Seamless communication and information flows are becoming more and more essential for all supply chains (e.g. Panayides and Song 2009). Information and communication flows are additionally critical for the biofuel supply chain in specific, because of the need to certify the sustainability of the product. Information flows are facilitated by advanced information and communication technologies systems and could benefit from integration with customs or other administrative systems, to create a single information interface for port users.

Port authorities can actively facilitate flows through thinking cooperatively with the port users. With a customer focus, good contacts with businesses, and knowledge of business consumption patterns, port authorities can initiate and co-invest in projects to improve biofuel operations in the port area.

### 5.2. *Attracting new flows*

Port authorities can actively try to attract biofuel flows to their port. In order to do so, industry knowledge as well as a strong public relations capability is needed. Furthermore, a so-called Freeport or tax Haven status and smooth customs facilities can significantly help in attracting new physical flows (Notteboom and Winkelmans 2001).

The port authority can lobby for the biofuel industry to stimulate the use of biofuels and increase their biofuel throughput. This also demands a deep understanding of the market, as well as actively taking part in lobby and interest groups. Lobbying for harmonized legislation that facilitates the financial flows of the biofuel supply chain may stimulate the physical volumes through the port. Of course, in order to facilitate these larger throughput volumes, enough capacity and space to expand are needed.

### 5.3. *Executing value-adding activities*

We define value adding activities as the process steps along the supply chain that add value to the product or service (e.g. Bichou and Gray 2004). When analyzing the outcomes of Section 4, we see that both feedstock processors and biofuel producers see advantages in being physically located in the port area. Agricultural businesses often have their processing facilities, or at least their storage, in the port area. This gives producers the possibility to source directly from their neighbors. On the demand side, oil companies represent possible buyers in the port to whom the produced biofuel can be sold directly.

If these direct buyers and suppliers are not available in the port area, or for some reason have no interest in doing business, being located in the port area provides another way of flexibility; the access to both sea, inland waterways, rail and road modalities gives producers the opportunity to source and sell their large volumes of product from and to multiple (overseas) locations. Ports can thus facilitate the scale that the biofuel supply chain is looking for.

Besides industry presence, cooperation between different organizations within the port is essential. A port authority can initiate, coordinate, and even orchestrate this cooperation and stimulate both horizontal and vertical integration in the port area.

### 5.4. *Developing and promoting a bio-industry cluster*

A port (industrial) cluster can be defined as a set of interdependent firms in a port area which are engaged in port-related activities, possibly with similar strategies, to create competitive advantage (e.g. De Langen 2002). To develop a bio-industry cluster, cooperation within the port is needed and relationships (Notteboom and Rodrigue 2005) and a network should be developed. This cooperation can also result in physical integration of facilities in the port area, co-siting, and sharing of utilities. Ultimately, a closed-loop network can be pursued, in which no waste flows exist. This means that all residue flows from industrial plants in the port cluster have found a purposeful destination and are used as feedstock for another organization. Besides collaboration within the port area, cooperation between port authorities should be sought, and port networks can be created (Paixão and Marlow 2003).

To become an attractive facility location for businesses, port authorities should create a beneficial innovation and business climate. This includes clear and fast license applications to facilitate the speed to market and consistent port safety and environmental regulations. Port authorities can help businesses to get access to capital by developing some sort of 'bio-investment fund' and through subsidies and incentives. A port authority can reserve land for bio-initiatives or introduce policies that physically favor bio-flows or ships that run on biofuels.

### 5.5. *Acting as a knowledge center*

Knowledge management activities in activities 1–4 are an important condition and typically solely encompass importing critical knowledge to enable execution of the activities. In the fifth activity, we consider knowledge, as an objective and activity in itself, being key to innovate the cluster (activity 4) and to enable export of knowledge created.

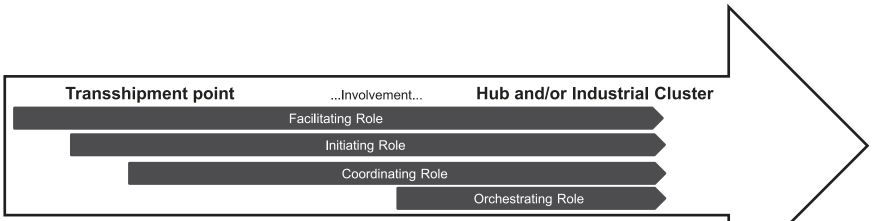
Port authorities can act as a knowledge center by creating and exploiting their industrial and logistics knowledge (e.g. Meier, Humphreys, and Williams 1998). Port authorities can identify new markets and opportunities for the application of biomass and should develop the capabilities to anticipate changes so that the bio-industry cluster in the port can continuously innovate They can do this through market research and through building close relations with universities and research institutes. Port authorities can exploit their created and acquired knowledge not only within, but also outside the port area. The latter can include selling intellectual property or taking a stake in new developing ports.

Innovative start-up companies and small- and medium-sized enterprises can be attracted to the port. The establishment of such parties in the port area can enhance the development of knowledge and increase the chance of this knowledge becoming incorporated in the existing industry, which can stimulate the maturing of the biofuel industry. The presence of state-of-the-art knowledge—beyond merely physical qualities of the port—will make a port an attractive location for new businesses. Human capital is essential for ports to become a knowledge center, and thus represents a hard-to-imitate competency.

Although the research was set up to determine the roles that port authorities can have, all types of interviewees, and especially port authorities, perceive the integration matrix as having normative value as well, in describing what a port authority should do.

## 6. Practical validation integration matrix

We have demonstrated the practical value and applicability of the integration matrix through an extensive validation stage with two single case studies, using the case study protocol explained in Section 3.2. By determining the resources, characteristics, and activities for the PoR and GSP, we are able to identify their role and value proposition in the biofuel supply chain. We explain the case study findings through discussing the five aggregated activities and the integration matrix, see Figure 4. We rank the presence of the activities on the second round of interviews, roundtable outcomes, and industry reports (see Section 3.1). This ranking is done on a five-point scale from ++ (very high presence)




| | Facilitating Flows | Creating New Flow | Executing Value Added Activities | Developing Bio Industry Cluster | Acting as Knowledge Center |
|---|---|---|---|---|---|
| PoR | ++ | ++ | + | + | +/- |
| GSP | +/- | +/- | - | - | - |

**Figure 4. Case study output: scores of PoR and GSP**.

to –- (not at all present). It should be noted that this scaling does not allow quantitative comparison between the different activities and that these scores are neither relative to each other within each case, nor across cases. When discussing the ports' potential of becoming a bio-industry cluster, we not only focus on biofuels for transportation, but also on biomass for energy and chemicals.

### 6.1. *Output case studies*

The PoR is the largest seaport of Europe with a yearly throughput of 434 million ton (2011), consisting of 286 million tons of liquid bulk, 87 million tons of dry bulk, and 11 million TEU. The PoR covers an area of 12 440 hectares and has a large industrial cluster in which established parties of the petrochemical, agricultural, and energy sectors are well-presented.

In 2011, GSP had a throughput of over 8 million tons. GSP manages an area totaling approximately 2600 hectares, which includes a large chemical cluster in its port in Delfzijl. Several power plants are currently built in the Eemshaven port.

We conclude that the PoR is considerably integrated in the biofuel supply chain. The more 'traditional' activities related to facilitating existing biofuel flows are very well represented in the PoR. This may be seen as no surprise, since the PoR is an established, advanced, and modern port with extensive experience on facilitating liquid bulk. Also, the scores on attracting new flows are considerably good. This is consistent with the focus and strengths of the PoR on throughput. The PoR has several value-adding activities in the port area, puts effort in developing a bio-industry cluster and the development and exploitation of knowledge. The strength of the PoR as a logistical hub, presence of 'conventional' industries, and the explicit 'bio-vision' strengthens the opportunity to further become a bio-port. Still, the PoR authority can and should take further steps to integrate in the biofuel supply chain, and invest in the necessary resources and characteristics.

GSP, on the other hand, has limited biofuel operations. However, they intent to significantly increase their involvement in the biofuel supply chain. The GSP authority is becoming more focused in its development, and clearly wishes to become a value-adding industrial cluster. They acknowledge the limited opportunities for (biofuel) throughput, and see their hub-function and logistic activities as support for the industrial cluster. Current examples of biofuel throughput and activities are limited,

**Table 1. Case study output: maturity, intentions, and SWOT of PoR and GSP.**

| | Port of Rotterdam | GSP |
|---|---|---|
| Maturity | • Very mature port<br>• High biofuel + biomass throughput<br>• Many value-added activities in port area (feedstock processing; biofuel production; storage; blending; and co-firing in energy plants) | • Developing port<br>• Very little biofuel + biomass throughput<br>• Few value-adding activities (biofuel production and planned co-firing of biomass in energy plants) |
| Intentions | • Become a main global biofuel hub (high throughput)<br>• Develop a bio-based cluster with chemicals, fuels, and energy | • Less focus on becoming a throughput port<br>• Develop a bio-based cluster with biomass for energy and (perhaps) chemicals |
| Strengths/opportunities | • Available and reserved space to expand<br>• Strong geographic position<br>• Benefit of experience and reputation<br>• Industries present to develop cluster (with bio-energy; -fuel; -chemical)<br>• Large port authority with increasing knowledge base | • Available space to expand<br>• Profitable business environment (direct contact with authorities and local government) |
| Weaknesses/threats | • Congested port<br>• Industry dominated by 'traditional parties' (which may make integration difficult) | • Limited depth<br>• Less favorable geographic position<br>• Depopulation area (human capital difficult to attract)<br>• 'Fuels' are missing for the development of bio-cluster<br>• Small port authority with limited knowledge base (but developing) |

but in the near-term, several large power plants in the port intent to start co-firing biomass. This may result in enormous volumes of incoming biomass, which represents opportunities for spin-off activities and a bio-based cluster. Still, creating a critical mass of cooperating organizations that can enable the transition from co-firing to higher value-utilization of biomass represents a huge challenge.

We found that the direct comparison between the PoR and GSP requires some nuancing because of the ports' stages of maturity, biofuel operations, and strengths, opportunities, weaknesses, and threats to become a bio-hub and industrial cluster, which we provide in Table 1.

## 6.2. *Implications*

The practical validation is confirmed by the stakeholders of both ports, who perceive the applied integration matrix as very insightful and comprehensive and as a tool that can provide a holistic view to individual parties and that can guide their strategic (investment) decisions.

The case studies demonstrate that our distinction between a hub and industrial cluster is a correct one, and that port authorities indeed have the opportunity to select either one of them, or both, as their aspired value proposition. The PoR authority clearly focuses on further developing both, while the GSP authority wants to grow a bio-industry cluster, in which facilitating flows (their hub function) plays a subordinate role.

We see that both case ports score better on the resources and characteristics on the left hand (facilitating flows) of the matrix and that the right side (developing industrial cluster and acting as a knowledge center) is more developing. Facilitating flows seems to be a precondition for the development of an industrial cluster. We therefore conclude from the case studies that the integration matrix visualized some sort of growth path. When ports mature and integrate in the biofuel supply chain, we find that facilitating flows always remains important. In both advanced (PoR) and developing (GSP) ports, draft, hinterland connections, and multimodal infrastructure remain important characteristics, since they are the raisons d'être for ports.

## 7. Conclusion

We have developed a general conceptualization of port supply chain integration and used it to build an integration matrix for port integration in the biofuel supply chain. Port authorities can achieve integration in the biofuel supply chain by creating a clear vision and by extending their role from facilitating to more initiating, coordinating, and even orchestrating and strive for (1) facilitating flows; (2) creating new flows; (3) executing value-added activities of the biofuel supply chain in the port area; (4) developing a bio-industry cluster that utilizes biomass for chemicals, biofuels, and energy; and (5) acting as a knowledge center.

These roles and activities represent a growth path for ports in the biofuel supply chain and the resources and characteristics related to facilitating flows remain important, even for more developed ports. We have validated the applicability and possible generalization of the integration matrix through two case studies, on the PoR and GSP.

From a practical perspective, the concept and method of the integration matrix provide port authorities and port actors hands-on directions in 'what to do' and can guide investment decisions. Also, the case study results were highly appreciated by the stakeholders of both ports, by providing a holistic view and giving insights into the current situation and possibilities for further development.

Since the conceptual framework of port supply chain integration is developed from general port and supply chain literature, it should be generally applicable for different types of ports and different supply chains. The integration matrix presented in this article is suitable for European seaports with either an industry or throughput focus in the biofuel supply chain. Still, the value proposition and most of the roles, activities, resources, and characteristics are not exclusively used for biofuels. This intuitively leads to the rationalization that a more general application of the matrix is possible. Further research should indicate if the integration matrix indeed provides insights for seaports in other geographical regions, other types of ports (inland ports and airports), and other supply chains (liquid bulk, dry bulk, containers, or general cargo).

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## References

Bichou, K., and R. Gray. 2004. "A Logistics and Supply Chain Management Approach to Port Performance Measurement." *Maritime Policy & Management* 31 (1): 47–67. doi:10.1080/0308883032000174454.

Carbone, V., and M. De Martino. 2003. "The Changing Role of Ports in Supply-Chain Management: An Empirical Analysis." *Maritime Policy & Management* 30 (4): 305–332. doi:10.1080/0308883032000145618.

Cetin, C., and A. Cerit. 2010. "Organizational Effectiveness at Seaports: A Systems Approach." *Maritime Policy & Management* 37 (3): 195–219. doi:10.1080/03088831003700611.

Dal-Mas, M., S. Giarola, A. Zamboni, and F. Bezzo. 2011. "Strategic Design and Investment Capacity Planning of the Ethanol Supply Chain under Price Uncertainty." *Biomass and Bioenergy* 35: 2059–2071. doi:10.1016/j.biombioe.2011.01.060.

De Langen, P. 2002. "Clustering and Performance: The Case of Maritime Clustering in the Netherlands." *Maritime Policy & Management* 29: 209–221. doi:10.1080/03088830210132605.

De Martino, M., and A. Morvillo. 2008. "Activities, Resources and Inter-Organizational Relationships: Key Factors in Port Competitiveness." *Maritime Policy & Management* 35 (6): 571–589. doi:10.1080/03088830802469477.

De Souza, G. A., A. K. C. Beresford, and S. J. Pettit. 2003. "Liner Shipping Companies and Terminal Operators: Internationalisation or Globalisation?" *Maritime Economics & Logistics* 5: 393–412. doi:10.1057/palgrave.mel.9100088.

Demirbas, D., H. Flint, and D. Bennett. 2014. "Supply Chain Interfaces between a Port Utilizing Organisation and Port Operator." *Supply Chain Management: An International Journal* 19 (1): 79–97. doi:10.1108/SCM-04-2013-0137.

Dooms, M., L. Van Der Lugt, and P. W. De Langen. 2013. "International Strategies of Port Authorities: The Case of the Port of Rotterdam Authority." *Research in Transportation Business & Management* 8: 148–157. doi:10.1016/j.rtbm.2013.06.004.

Flyvbjerg, B. 2006. "Five Misunderstandings about Case Study Research." *Qualitative Inquiry* 12 (2): 219–245. doi:10.1177/1077800405284363.

Huang, Y., C.-W. Chen, and Y. Fan. 2010. "Multistage Optimization of the Supply Chains of Biofuels." *Transportation Research Part E: Logistics and Transportation Review* 46: 820–830. doi:10.1016/j.tre.2010.03.002.

Kim, J.-Y. 2014. "Port User Typology and Representations of Port Choice Behavior: A Q-Methodological Study." *Maritime Economics & Logistics* 16 (2): 165–187. doi:10.1057/mel.2013.26.

Mangan, J., C. Lalwani, and B. Fynes. 2008. "Port-Centric Logistics." *The International Journal of Logistics Management* 19 (1): 29–41. doi:10.1108/09574090810872587.

Meier, R. L., M. A. Humphreys, and M. R. Williams. 1998. "The Role of Purchasing in the Agile Enterprise." *Journal of Supply Chain Management* 34 (4): 39–45.

Notteboom, T. E., and J. Rodrigue. 2005. "Port Regionalization: Towards a New Phase in Port Development." *Maritime Policy & Management* 32 (3): 297–313. doi:10.1080/03088830500139885.

Notteboom, T. E., and W. Winkelmans. 2001. "Structural Changes in Logistics: How Will Port Authorities Face the Challenge?" *Maritime Policy & Management* 28 (1): 71–89. doi:10.1080/03088830119197.

Paixão, A. C., and P. B. Marlow. 2003. "Fourth Generation Ports: A Question of Agility?" *International Journal of Physical Distribution & Logistics Management* 33 (4): 355–376. doi:10.1108/09600030310478810.

Panayides, P. M., and D.-W. Song. 2008. "Evaluating the Integration of Seaport Container Terminals in Supply Chains." *International Journal of Physical Distribution & Logistics Management* 38 (7): 562–584. doi:10.1108/09600030810900969.

Panayides, P. M., and D.-W. Song. 2009. "Port Integration in Global Supply Chains: Measures and Implications for Maritime Logistics." *International Journal of Logistics Research and Applications* 12 (2): 133–145. doi:10.1080/13675560902749407.
Pettit, S. J., and A. K. C. Beresford. 2009. "Port Development: From Gateways to Logistics Hubs." *Maritime Policy & Management* 36 (3): 253–267. doi:10.1080/03088830902861144.
Robinson, R. 2002. "Ports as Elements in Value-Driven Chain Systems: The New Paradigm." *Maritime Policy & Management* 29 (3): 241–255. doi:10.1080/03088830210132623.
Strauss, A., and J. Corbin. 1990. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. Newbury Park, CA: Sage Publications.
Tongzon, J., Y.-T. Chang, and S.-Y. Lee. 2009. "How Supply Chain Oriented Is the Port Sector?" *International Journal of Production Economics* 122: 21–34. doi:10.1016/j.ijpe.2009.03.017.
UNCTAD. 1999. "The Fourth Generation Port." *UNCTAD Ports Newsletter* 19: 9–12.
Veenstra, A. W., R. A. Zuidwijk, and E. Van Asperen. 2012. "The Extended Gate Concept for Container Terminals: Expanding the Notion of Dry Ports." *Maritime Economics & Logistics* 14 (1): 14–32. doi:10.1057/mel.2011.15.
Voss, C. A., M. Frohlich, and N. Tsikriktsis. 2009. "Case Research in Operations Management." In *Researching Operations Management*, edited by C. Karlsson, 162–195. New York: Routledge.
Woo, S.-H., S. J. Pettit, and A. K. C. Beresford. 2013. "An Assessment of the Integration of Seaports into Supply Chains Using a Structural Equation Model." *Supply Chain Management: An International Journal* 18 (3): 235–252. doi:10.1108/SCM-09-2011-0264.

## Appendix. Research participants

| | (Academic) Research institutes | | |
|---|---|---|---|
| Organization | Department/description | Interviewee | Participation |
| Delft Technical University | Dry bulk transport & storage | Assistant professor | Interview rounds I + II |
| Delft Technical University | Center of for Port Innovation | Director | Roundtable |
| Dinalog (Dutch Institute of Advanced Logistics) | | Program manager | Interview rounds I + II |
| ECN (Energy Center the Netherlands) | Energy from biomass, bio-based economy | Coordinator | Interview rounds I + II |
| Energy Delta Institute | | Professor/scientific director | Interview round I |
| Energy Valley | | Program manager Innovative biomass applications | Interview round I |
| Rotterdam School of Management/ SmartPort | | Business director | Interview rounds I + II |
| Rotterdam School of Management/ SmartPort | | Senior port and transport economist | Roundtable |
| Agrotechnology & Food Sciences Group | Agrotechnology & food sciences | Professor | Interview rounds I + II |
| Utrecht University/ Copernicus Institute | Energy & resources | Assistant professor | Interview round I |

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| | (Academic) Research institutes | | |
|---|---|---|---|
| Organization | Department/description | Interviewee | Participation |
| Utrecht University/ Copernicus Institute | Energy & resources | Junior researcher | Roundtable |
| Port authorities | | | |
| GSP | | Marketing research manager | Interview rounds I + II |
| GSP | | Account manager Logistics | Interview round I |
| Port of Amsterdam | | Commercial manager Bulk Logistics | Interview rounds I + II Roundtable |
| Port of Ghent | | Commercial director | Interview rounds I + II |
| Port of Rotterdam | | Business developer Bulk Cargo and Shipping | Interview rounds I + II Roundtable |
| Practitioners | | | |
| Abengoa | Biofuel (ethanol) producer | Logistics manager | Interview rounds I + II |
| Accenture | Consulting firm—energy strategy | Global Lead Clean Energy | Interview rounds I + II |
| Accenture | Consulting firm—energy strategy | European Lead Biofuels | Interview rounds I + II Roundtable |
| Argos | Oil company & biofuel producer | Business development manager (bio) technology | Interview round I Roundtable |
| BioMCN | Biofuel (methanol) producer | Product sales manager | Interview round I Roundtable |
| BioPetrol | Biofuel (biodiesel) producer | CEO | Interview rounds I + II Roundtable |
| BP | Oil company | Biofuels manager Benelux | Interview round I |
| BTG BioLiquids BV | Biofuel (pyrolysis) Technology Developer | Managing director | Interview rounds I + II |
| CEFIC | European Chemical Industry Council | Executive director Industry policy | Interview round I |
| ED&F Man | Biodiesel & vegetable oil trader | Managing director Biofuels | Interview round I |
| ED&F Man | Biodiesel & vegetable oil trader | Operations manager Biofuels | Roundtable |
| EFOA | European Fuel Oxygenates Association | Director | Interview round I |
| Eneco | Energy company | Developer International Projects Biomass | Interview round I |
| Koole | Storage provider | Managing director | Interview rounds I + II |

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| Organization | (Academic) Research institutes | | |
|---|---|---|---|
| | Department/description | Interviewee | Participation |
| LyondellBasell | Chemicals & biofuel (ETBE) producer | Biofuel business developer | Interview rounds I + II Roundtable |
| LyondellBasell | Chemicals & biofuel (ETBE) producer | Supply chain manager | Interview round I |
| Neste Oil | Biofuel (NExBTL) Producer | Managing director | Interview round I Roundtable |
| Nidera | Biofuel + feedstock trader | Jr. biodiesel trader | Interview round I |
| North Sea Group | Downstream oil distributer | Director Biofuels | Interview rounds I + II Roundtable |
| Odfjell | Storage provider | Sales | Interview round I |
| Orange Blue Terminals | Storage provider | Director | Interview round I |
| Productschap MVO | Association for vegetable oils & fats biofuel feedstock) | | Interview round I Roundtable |
| Q8 | Oil company | Supply chain manager | Interview round I |
| Qlyte | Subcoal® plant | Director | Interview round I |
| Raizen (JV Shell & Cosan) | Feedstock (sugarcane) & biofuel (ethanol) production | Agriculture manager | Interview round I |
| RWE/Essent | Energy company | Manager, Biofuel Logistics | Interview round I |
| Shell | Oil company | Rhine Biofuels Project Lead | Interview rounds I + II Roundtable |
| Strategy Works | Consulting firm | Strategy consultant | Interview round I |
| Vopak | Storage provider | Global Director Vegetable Oils and Biofuels | |
| (Non) Governmental institutes | | | |
| Agentsc hap NL | GAVE Biofuels Program | Coordinator | Interview round I |
| Agentschap NL | | Senior expert Bioenergy | Roundtable |
| BioRenewables Platform | Biobased economy & biofuels | Secretary & expert | Interview round I |
| Deltalinqs | Association Businesses Port of Rotterdam | Policy adviser Innovation | Interview round I |
| Dutch Emission Authority (NEA) | Responsible for Dutch Biofuel Mandate & Ticket control | Program manager Register and Enforcement Biofuels | Interview round I |
| EemsDeltaGreen | | Program manager | Interview round I |
| Ministry of Infrastructure & Environment | Responsible for Biofuel Legislation | Biofuels policy coordinator | Interview round I |
| Ministry of Economic Affairs, Agriculture & Innovation | Interdepartmental Program Biobased Economy | Policy advisor | Interview round I Roundtable |
| Ministry of Economic Affairs, Agriculture & Innovation | Interdepartmental Program Biobased Economy | Policy advisor | Roundtable |

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**Continued.**

| | (Academic) Research institutes | | |
|---|---|---|---|
| Organization | Department/description | Interviewee | Participation |
| Ministry of Economic Affairs, Agriculture & Innovation | Interdepartmental Program Biobased Economy | Senior policy officer | Interview round I |
| NOM | | Program manager | Interview round I |
| Rotterdam Climate Initiative | | Chairman Council | Interview rounds I + II |
| Rotterdam Climate Initiative | | Project Director Port | Interview rounds I + II Roundtable |
| Rotterdam Climate Initiative | | Senior communication advisor | Interview round I |

Note: ETBE, ethyl-tert-butylether.