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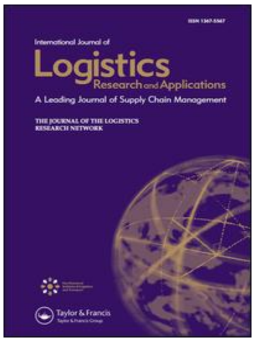
DOI
10.1080/13675567.2021.1885634

Publication date
2021

Document Version
Final published version

Published in
International Journal of Logistics Research and Applications



International Journal of Logistics Research and Applications
A Leading Journal of Supply Chain Management

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cjol20

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To cite this article: Fuqi Liang , Kyle Verhoeven , Matteo Brunelli & Jafar Rezaei (2021): Inland terminal location selection using the multi-stakeholder best-worst method, International Journal of Logistics Research and Applications, DOI: 10.1080/13675567.2021.1885634

To link to this article: https://doi.org/10.1080/13675567.2021.1885634

Published online: 11 Feb 2021.

INTERNATIONAL JOURNAL OF LOGISTICS: RESEARCH AND APPLICATIONS
https://doi.org/10.1080/13675567.2021.1885634

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ABSTRACT
The aim of this study is to develop an inland terminal location selection methodology. This methodology is viewed from the perspective of the shipping line designing the inland transport chain while also taking the objectives of multiple other stakeholders into account. To that end, we develop a consensus model for a group Best-Worst Method (BWM) in order to aggregate the evaluations of the various stakeholders. The proposed method is applied to a real-life case study involving the Maersk shipping line, in which nine experts representing three different types of stakeholders assess six possible locations. After the evaluation, the market volume potential is identified as one of the most important criteria. Furthermore, a sensitivity analysis indicates that a varying influx of the container volume has no impact on the most desirable location.

ARTICLE HISTORY
Received 18 July 2020
Accepted 1 February 2021

KEYWORDS
Inland terminal location selection; shipping line; best-worst method; consensus

1. Introduction

Over the last three decades, the shipping industry has evolved from a highly segmented sector into a more integrated sector (Franc and Van der Horst 2010). Traditionally shipping lines were merely involved with maritime transport between seaports across the globe, but they are increasingly trying to integrate their ocean transport setups with connecting inland transport services to provide door-to-door business propositions to their customers (Frémont 2009; Franc and Van der Horst 2010). This is known as vertical integration, which allows shipping lines to improve the coordination of container flows and inland repositioning tactics (Song and Dong 2011; Van den Berg and De Langen 2015a; Wan, Basso, and Zhang 2016). Vertical integration helps increase the (cost) efficiency of the provided hinterland operations, which in turn attracts customers and increases the shipping lines' market share in, and control over, the hinterland.

With regard to the cost efficiency of the inland transport chain, intermodal transport has significant economic advantages due to the possibility of putting multiple containers on larger vehicles and reducing the costs per transported container (Simina, Patrick, and Radu 2012). A major component of intermodal transport is the inland terminal, where containers are transshipped between trucks and intermodal vehicles, or vice versa (Teye, Bell, and Bliemer 2017, 2018). Because of the necessity of transshipment operations for intermodal transport, inland terminals have a considerable impact on the cost efficiency of the broader inland transport chain (Rodrigue and Notteboom 2009). Therefore, active engagement with inland terminals by shipping lines enables them to effectively use these facilities in their inland transport configurations (Van den Berg and De Langen

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2015b). Because a number of competing stakeholders also use these facilities (e.g. freight forwarders, logistics service providers and competing shipping lines), setting up an inland terminal dedicated to the needs of the shipping line and its (potential) customers makes it possible to create an inland transport chain (Franc and Van der Horst 2010; Tan et al. 2018).

The location of an inland terminal is a crucial factor due to its ability to contribute to the effectiveness of the inland transport chain, mainly because that location determines the distances for container movements in the main haulage and pre-/end-haulage legs (Pekin 2010; Tsao and Thanh 2019). As such, selecting the inland terminal location is an essential task for the shipping line when designing the inland transport chain in which the terminal has to contribute to its efficiency and effectiveness (Van Nguyen et al. 2020). Although numerous studies have examined location selection (Bontekoning, Macharis, and Trip 2004; Alumur and Kara 2008; Teye, Bell, and Bliemer 2017, 2018), so far few have approached the issue from the perspective of shipping lines, which is exactly what this study is intended to remedy.

Moreover, because the operations of the inland terminal business are not conducted by the shipping line alone but also by other companies in the inland transport chain, multiple stakeholders play a role in selecting the best location (Franc and Van der Horst 2010; Rodrigue et al. 2010; Wilmsmeier, Monios, and Lambert 2011; Monios and Wilmsmeier 2012; De Langen, Fransoo, and van Rooy 2013), which is why the problem definition with regard to the shipping line is approached by taking the different objectives of those stakeholders into account. In addition to the objectives of the shipping line itself are the objectives of terminal operators and the transport companies that use the terminal for their operations. Accordingly, to select a desirable location we need to find a compromise between the different objectives. The stakeholders involved are very likely to apply different sets of criteria when evaluating the location problem, next to the transportation cost (Limbourg and Jourquin 2009). To date, few studies have attempted to aggregate the preferences of a heterogeneous group with different sets of criteria. To remedy that state of affairs, we propose a consensus framework based on the Best-Worst Method (BWM) (Rezaei 2015).

This study offers a methodological contribution along with a real-case application. That is, we formalize the inland terminal location selection problem from the scope of a shipping line and develop a group consensus decision-making method using different sets of criteria. First, this study adds to the existing literature regarding inland terminals from the perspective of the inland transport chain by approaching the specific inland terminal location selection problem from the perspective of the shipping line. Various researchers have studied the components, activities, and dynamics of container port hinterlands (Lee and Yang 2018). Multiple studies include analyses involving container transport markets (e.g. De Langen, Fransoo, and van Rooy 2013; Rodrigue and Notteboom 2013) and the optimisation of hinterland transport efficiency (e.g. Caris, Macharis, and Janssens 2012; Notteboom and Rodrigue 2017). However, few studies adopt the point of view of the shipping line as a leading stakeholder in that context, mostly because this is a relatively new development, both professionally and academically, especially with regard to studies involving inland terminals and inland terminal location selection, where shipping lines were originally not the main stakeholders involved. Where the studies of Franc and Van der Horst (2010) and Van den Berg and De Langen (2015b) touched upon the relationship between inland service integration and inland terminals, this study adds to contemporary literature and follows up on their notions by focusing on the development and operation of inland terminals from the perspective of the shipping line as a key stakeholder, with the main purpose of improving the shipping line's inland transport chain services offered to its customers. In addition, this research contributes to the current literature on vertical integration in hinterland container transport markets by obtaining insights into the differently valued criteria involved in inland terminal location decisions from the perspective of the shipping lines themselves and of other companies involved in the inland transport chains.

Second, this study adds to the existing literature on Group Multi-Criteria Decision-Making (GMCDM) problems by considering the varying preferences for individually relevant criteria stemming from the distinct objective(s) of each involved stakeholder. In most primary studies on

GMCDM, the views of the multiple stakeholders involved in the research are taken into account by having them evaluate all the criteria that are considered to be relevant within a fixed set of criteria (e.g. Kayikci 2010; Regmi and Hanaoka 2013; Roso, Brnjac, and Abramovic 2015). Based on the evaluations of the stakeholders, criteria weights are then calculated and used for a further assessment. The basic requirement of this approach is that the calculated weights and the resulting values need to stem from the same fixed set of criteria so they can be compared to one another. However, it has been argued that decision-making criteria (which are originally stored in one fixed set) are not necessarily relevant to the particular objectives of all the involved stakeholders, which implies that criteria that are *irrelevant* to certain stakeholders are subjected to their assessment, while not actually being the right criteria to be used to reflect their preferences (Macharis, Turcksin, and Lebeau 2012). In fact, in real-life situations different stakeholders are likely to use different sets of criteria. The aim of this study is to develop a method to compare the weights of the criteria of different stakeholders in a meaningful way.

In the remainder of this study, the theoretical framework for the transportation system under investigation is defined in Section 2, in addition to a review of the relevant literature regarding inland terminal evaluation factors. Next, the methodology used in this study is presented in Section 3, while Section 4 discusses the application of the location selection methodology to a case study involving the Maersk shipping line. Based on the results of the case study, the conclusions and discussion are presented in Section 5, including practical implications and recommendations for further research.

2. Theoretical background

This section starts with a review of the four-layer framework: the relevant stakeholders are identified from the literature, and the factors considered in inland terminal location selection studies are reviewed.

2.1. Stakeholders in the inland terminal location selection system

The research system of the inland terminal location is viewed as a component of the broader container port hinterland, which is a structure consisting of multiple layers. By using an adapted four-

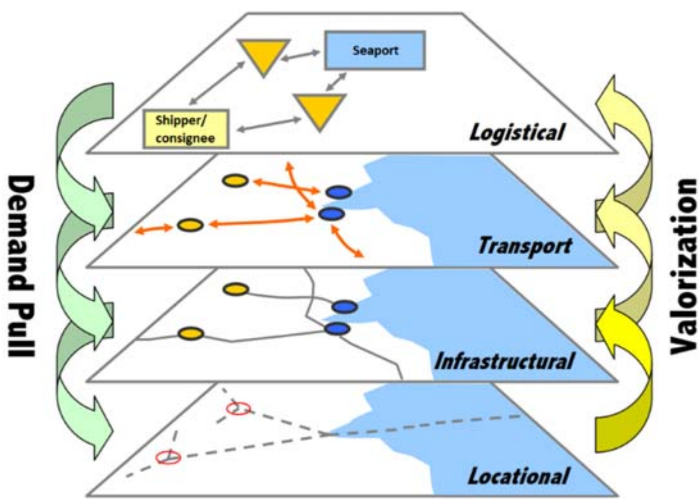


Figure 1. Four-layer framework expanding the structure of the container port hinterland (adapted from Notteboom and Rodrigue 2017).

layer framework[1] from the study by Notteboom and Rodrigue (2017), which is applicable to the container port hinterland, it is possible to identify the logistical layer, the transport layer, the infrastructural layer and the locational layer (see Figure 1), all of which are considered to be important for assessing the container port hinterland due to *demand pull effects* from a higher layer in relation to the layer below and the *valorisation effects* from a lower layer towards the layer above. From each layer, components, activities, and related stakeholders relevant to the evaluation and selection of the inland terminal location can be extracted. Regarding the stakeholders, a distinction can be drawn between *key stakeholders* and *contextual stakeholders*. Key stakeholders are directly involved in the main activities within the respective layers, while contextual stakeholders (including the government) are associated with but not actively involved in those activities (at least within the scope of this research). The latter are therefore not included as stakeholders in the remainder of the study.

The **logistical layer** contains the organisation of the supply and transport chains, which were originally designed mostly by freight forwarders or other third parties for shippers/consignees in so-called third-party logistics (Douma 2008; De Langen, Fransoo, and van Rooy 2013; Van den Berg and De Langen 2015a). However, in recent times shipping lines have increasingly tended to expand their scope and take greater control of the design of transport chains (which is the basis of this research), with the aim of increasing the *Carrier Haulage* setups (compared to *Merchant Haulage* setups) in the hinterlands, which in turn increases their scope from port-to-port to door-to-door transport (Frémont 2009; Franc and Van der Horst 2010). A way to encourage this development is through an active engagement of inland terminals in the hinterland transport network, which would facilitate the transport and transshipment operations contributing to the effectiveness of the inland transport chains (Franc and Van der Horst 2010). Hence, with regard to the shipping line's design objectives for its inland transport chains in the logistical layer, the shipping line is considered to be a key stakeholder, while freight forwarders and shippers/consignees are viewed as contextual stakeholders (as competitors and customers, respectively).

The **transport layer** contains the transport and transshipment operations that realize the designed transport chain services described above. The main haulage, in the form of either a rail or barge transport, is performed via intermodal transport operators, while pre-/end-haulage activities are conducted by truck transport operators (De Langen, Fransoo, and van Rooy 2013). Since these transport operators actively use inland terminals in their operations, they are seen as key stakeholders in regard to selecting the best inland terminal location. Transshipment operations are performed at inland terminals by inland terminal operators, which are regarded as key stakeholders in the transport layer. In addition to basic logistics services, value-added services, which involve extra services aimed at improving the (cost) efficiency of the broader transport chain, can also be provided (Rodrigue et al. 2010).

The **infrastructural layer** contains the transport and transshipment infrastructure used to facilitate the transport and transshipment operations described above. Transport infrastructure (e.g. roads, railways, and inland waterways) is usually developed and owned by government stakeholders based on maintaining and increasing public wellbeing in a larger sense than merely in relation to inland terminals (De Langen, Fransoo, and van Rooy 2013). As such, the decisions made regarding the development of transport infrastructure are considered to fall outside of the scope of this research. However, the availability of transport infrastructure is taken into account because it does affect the selection of an inland terminal location. Thus, in this research the government is not considered to be a key stakeholder with regard to infrastructure. Node infrastructures, such as inland terminals, are usually owned by private or public-private entities (Bergqvist and Monios 2014). With regard to inland terminals, the key stakeholders are the organisations that own and operate the inland terminals, implying their presence in the transport as well as the infrastructural layer (Bergqvist et al. 2015). Whereas inland terminal operators are key stakeholders, public (government) stakeholders are not involved in inland terminal ownership because of their relatively nonexecutive roles. With regard to the infrastructural function of the inland terminal within the inland transport chain, the load centre that facilitates integrated transport and transshipment solutions close to the locations of shippers/consignees is the most applicable to the shipping line, which aims at setting up the facility as a component of the inland services it provides.

The **locational layer** contains the geographical locations of the infrastructural components discussed above within the economic space of the container port hinterland. These infrastructure locations are relative to the container volume (the number of containers imported and/or exported from a certain area). Generating/attracting points in this economic space define the distances between these locations and the actual infrastructure and consequently the relative effectiveness of the infrastructure. Accordingly, the location of infrastructure can contribute to, as well as be dependent on, the economic space (Rodrigue et al. 2010). The selection of infrastructure locations is shaped by these relationships as well (Rodrigue and Notteboom 2009). The infrastructure operator is a key stakeholder in selecting the location of the infrastructure and is involved in the actual provision and operation of the infrastructure. Since this study is aimed at selecting a location for an inland terminal infrastructure to be used specifically within the inland transport chain designed by the shipping line, the latter is also a key stakeholder in the location selection process.

An overview of the contents of the container port hinterland layer applicable to this study, including the key activities and the stakeholders making the (final) decisions with regard to these activities, are shown in Table 1.

The information from the container port hinterland structure review is used as the system input in the remainder of this study. Based on the outcomes of that review, the inland terminal location selection process discussed in this study can be configured as follows:

- The stakeholders making the actual decisions with regard to the selection of the location of the inland terminal are the **shipping line** and the inland **terminal operator**.
  - The shipping line evaluates an inland terminal location and decides to select it based on the objective of *incorporating the terminal into the designed inland transport chain*.
  - The terminal operator evaluates an inland terminal location and decides to select it based on the objective of *ensuring the profitability of transshipment operations at the site*.
- Although the transport operators, i.e. the **terminal users**, are not actually involved in the decision-making process regarding the location of the terminal, they are *affected* by the decision because the eventual location of the terminal determines the locations in the broader network transport, between which operations have to be conducted. As such, the fit of the selected location within the transport operation scheme of the terminal user affects the (cost) efficiency of the transport operations and, ultimately, of the entire inland transport chain. Accordingly, the evaluation of the inland terminal location by the transport operators is based on the objective of *using the inland terminal to optimise their transport operations*. This evaluation is ultimately important in terms of selecting a location that is beneficial to these transport operations and ultimately to the designed inland transport chain.

Figure 2 shows the graphical configuration of this study. Note that there is a clear distinction between the stakeholders evaluating and ultimately selecting the inland terminal location and the stakeholders that only *evaluate* the location. The dotted line indicates the importance of the evaluation by the terminal user on top of the evaluations by the stakeholders that ultimately select the location.

Table 1. The corresponding key activities and stakeholders from the container port hinterland layers.

Layer	Key activity	Key stakeholder
Logistical	Organize inland transport chains	Shipping line
Transport	Transport containers	Intermodal transport operator, truck transport operator
	Transship containers	Inland terminal operator
Infrastructural	Provide transshipment infrastructure	Inland terminal operator
Locational	Select infrastructure location	Shipping line, inland terminal operator

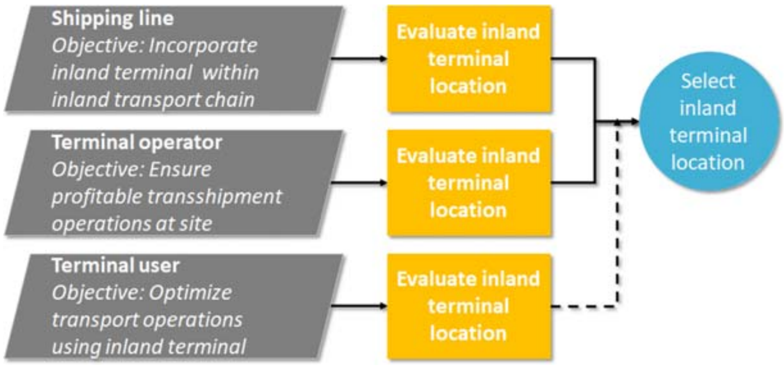


Figure 2. Inland terminal location selection configuration.

2.2. Factors (or criteria) considered in inland terminal location selection studies

The selection of a suitable location for an inland terminal involves multiple factors related to the different interrelated features of the container port hinterland. Both quantitative and qualitative factors are often used in location studies (Notteboom 2011). In MCDM studies these factors are referred to as criteria, and their evaluations by stakeholders ultimately determine the outcomes of decision-making models. This section describes the most commonly used criteria with regard to the location-related decision-making problem for inland terminals. The review was carried out using Scopus[2] as a primary academic database and Google Scholar[3] as an additional bibliographic search engine. As such, literature specifically concerned with the location selection of inland terminals was considered. Since the terminology used to denote inland terminal facilities often varies, attention was also paid to location selection studies involving *dry ports* and *freight villages*. Although these terms and definitions may vary, what the referenced location selection studies have in common is the fact that the studies in question all focus on inland intermodal transshipment of *containerised cargo,* which ensures that the reviewed factors are appropriate for the aim of this study.

The literature reviewed in this study consists of MCDM studies specifically focused on inland terminal location selection. Not all the criteria are included in the remainder of this study, first of all for practical reasons: it is not desirable to have an overly long list of criteria because that implies (time-)intensive data gathering and criteria-weighting processes. In addition, as the (combinations of) stakeholders, (geographical) scopes and methods each study uses vary, so too do the criteria. As such, not all the factors mentioned in the reviewed studies are considered eligible for this particular research. To include only the most suitable factors, *the observed criteria are prioritised*, and the factors that are not relevant to the scope of our study are filtered out. These include:

- Factors that are not generically applicable because they are location-specific (e.g. criteria aimed at particular local legislation).
- Factors indicating *existing* properties/performances of a facility, not applicable because this study is specifically aimed at identifying a location for a *new* inland terminal.
- Factors considered with conditions that are preliminarily considered when selecting alternative locations, and thus are not relevant to assess (e.g. connection to infrastructure network).
- Factors concerned with certain terminal functionalities not applicable to the considered *load centre* terminal type.

The prioritised criteria are further examined in the remainder of this section and structured according to the container port hinterland layer structure. The factors are assigned to the logistical layer, the transport layer, the infrastructural layer, and the locational layer.

2.2.1. Logistical layer factors

Logistical factors used for the selection of an inland terminal location are mostly connected to local market characteristics and related indicators, which affect the decisions involved in the organisation of transport chains (at those locations). One of the most frequently observed factors in this regard is *market volume potential*, which relates to the entities in a certain area generating and/or attracting freight volumes and is often expressed as *demand* (Regmi and Hanaoka 2013; Nguyen and Notteboom 2016), usually as the freight volume (e.g. TEU (twenty-foot equivalent units)) moved to/from an area in a certain time unit (e.g. Roso, Brnjac, and Abramovic 2015; Rožić, Ogrizović, and Galić 2016). Other frequently proposed economic factors related to organising inland transport chains are the *labour market,* as a resource for conducting inland facility operations (e.g. Long and Grasman 2012; Karaşan and Kahraman 2019), as well as the more general *socioeconomic development* of an area, often indicated by such indicators as the area's per capita GRP (Gross Regional Product) (e.g. Kayikci 2010; Li, Shi, and Hu 2011). Multiple factors are used to indicate a local investment climate. At a market level, *transport and logistics competition* is used to indicate the number of potential competitors offering inland facility services (Long and Grasman 2012; Karaşan and Kahraman 2019). At an administrative level, *government policy-related* factors are proposed to indicate the local/regional/national regulatory and/or political stances on the development of inland facilities at certain locations (e.g. Ka 2011; Roso, Brnjac, and Abramovic 2015). These factors indicate the broad perspectives being used in most inland facility location studies, ranging from factors that focus explicitly on transport and/or logistics (e.g. *market volume potential*) to factors describing more general market indicators (e.g. *socioeconomic development*). In this regard, the number of criteria related to the logistical layer is relatively high because multiple characteristics from several types of market(-related) components/developments may affect the decisions being made regarding the organisation of the transport chain. An overview of all prioritised logistical layer factors included in this study is presented in Table 2.

2.2.2. Transport layer factors

Factors used for the selection of inland facility locations in connection to the transport layer are directly related to the operational activities at and around the inland facility. These can be *conditions* under which these operations (have to) take place but also, for instance, the effects of such operations. Operational costs are often used, including *costs for transport* (e.g. Ka 2011; Regmi and Hanaoka 2013) and *costs for operating the inland facility* (Ka 2011; Nguyen and Notteboom 2016). Furthermore, local traffic characteristics that affect transport operations are also

Table 2. Logistical layer criteria observed in the literature.

Factor	Explanation	Observations in the literature
Market volume potential	Amount of container volumes predicted to be generated in and/or attracted to the area	Ka (2011); Kayikci (2010); Nguyen and Notteboom (2016); Roso, Brnjac, and Abramovic (2015); Rožić, Ogrizović, and Galić (2016); Wei, Sun, and Zhuang (2010); Li, Shi, and Hu (2011); Komchornrit (2017); Regmi and Hanaoka (2013)
Local labour market	Local supply of sufficiently skilled labour for inland terminal-related activities	Karaşan and Kahraman (2019); Rožić, Ogrizović, and Galić (2016); Long and Grasman (2012); Nguyen and Notteboom (2016)
Regional economic development	Local/regional socio-economic characteristics indicating the development of population and economy	Ka (2011); Kayikci (2010); Roso, Brnjac, and Abramovic (2015)
Regional transport/ logistics competition	Number of companies involved in inland terminal (-related) activities in the area	Karaşan and Kahraman (2019); Long and Grasman (2012); Regmi and Hanaoka (2013)
Government policy	Local/regional political, administrational, and regulatory circumstances with regards to the inland terminal(-related) developments/ activities	Ka (2011); Karaşan and Kahraman (2019); Nguyen and Notteboom (2016); Long and Grasman (2012); Li, Shi, and Hu (2011); Roso, Brnjac, and Abramovic (2015)

mentioned, mostly in terms of *traffic congestion* indicators (e.g. Wei, Sun, and Zhuang 2010; Li, Shi, and Hu 2011), which can sometimes be translated directly into *delivery times* (Karaşan and Kahraman 2019). In addition, the environmental effects of the operations are also included. Whereas it is sometimes indicated whether those effects take place on a local scale (e.g. Nguyen and Notteboom 2016; Özceylan et al. 2016) or on a global scale (Kayikci 2010), this is not always the case.[4] Other transport- and transshipment-related factors in this context are *noise pollution*, which can be viewed as a local effect (e.g. Roso, Brnjac, and Abramovic 2015), and *energy consumption*, which can be approximated by the indirect increase or reduction of emissions as a result of the energy used in the transport and transshipment operations at or near a site (Kayikci 2010). An overview of all the transport layer-related factors included in this study is presented in Table 3.

2.2.3. Infrastructural layer factors

The factors that are used for the selection of an inland facility location selection and that are related to the infrastructural layer are first connected to the local infrastructure and its characteristics. In this sense, *local transport infrastructure* metrics (e.g. Rožić, Ogrizović, and Galić 2016; Komchornrit 2017) are used to indicate the properties of the infrastructure in relation to (potential) inland facilities in the area. Criteria concerning the *development/construction* of the infrastructure are also frequently mentioned, which are associated with the infrastructural layer, since that also involves the *provision* of the infrastructures. The involved factors refer to the investments needed to set up an inland facility, which are usually subdivided into *costs for land* (e.g. Yıldırım and Önder 2014; Özceylan et al. 2016), *costs for construction* (e.g. Regmi and Hanaoka 2013; Karaşan and Kahraman 2019) and *other types of investment costs* (Ka 2011; Nguyen and Notteboom 2016), which are grouped under the overarching inland terminal CAPEX (CAPital EXpenditure) in the criteria selection survey we sent to the stakeholders in the transport chain. In addition to monetary factors, the resource availability factor of *expansion possibilities* indicates the ability to develop more inland facility infrastructure if necessary/desirable (e.g. Roso, Brnjac, and Abramovic 2015; Özceylan et al. 2016). In this regard, the *spatial development* criterion is also included to indicate potentially unfavourable land-use types close to the (potential) inland facility (e.g. Kayikci 2010; Komchornrit 2017). An overview of all the infrastructural factors included in this study is presented in Table 4.

2.2.4. Locational layer factors

Factors used for the selection of an inland facility location and related to locational aspects only play a role with regard to *proximity* measures, such as the distance between a given inland facility location and various other objects in the economic space of the container port hinterland represented by the locational layer. The most frequently mentioned factor in the literature, which is also the most applicable to this study, is *market proximity*, i.e. the distance between the inland facility and locations in the area at/to which a certain amount of container volumes are generated/attracted (Long and Grasman 2012; Yıldırım and Önder 2014; Roso, Brnjac, and Abramovic

Table 3. Transport layer criteria observed in the literature.

Factor	Explanation	Observations in the literature
Total inland transport costs	Overall costs for inland transport, including (if applicable) trucking costs, rail/barge costs and inland terminal handling costs.	Nguyen and Notteboom (2016); Kayikci (2010); Ka (2011); Regmi and Hanaoka (2013); Wei, Sun, and Zhuang (2010)
Traffic congestion	Local congested infrastructure causing delays in transport flows.	Nguyen and Notteboom (2016); Karaşan and Kahraman (2019); Long and Grasman (2012); Kayikci (2010); Wei, Sun, and Zhuang (2010)
Environmental effects	Effects of inland terminal(-related) operations on the environment, e.g. release of hazardous materials or emissions in surroundings.	Nguyen and Notteboom (2016); Kayikci (2010); Regmi and Hanaoka (2013); Özceylan et al. (2016)
Inland terminal operational costs	Costs for operating inland terminal and related activities (e.g. handling).	Nguyen and Notteboom (2016); Ka (2011)

Table 4. Infrastructure layer criteria observed in the literature.

Factor	Explanation	Observations in the literature
Transport infrastructure network in area	Characteristics of a transport infrastructure network (e.g. lengths, density) in the area	Kayikci (2010); Ka (2011); Regmi and Hanaoka (2013); Komchornrit (2017); Karaşan and Kahraman (2019); Roso, Brnjac, and Abramovic (2015); Rožić, Ogrizović, and Galić (2016); Li, Shi, and Hu (2011)
Land purchase costs	Costs of purchasing land for the inland terminal	Nguyen and Notteboom (2016); Regmi and Hanaoka (2013); Yıldırım and Önder (2014); Özceylan et al. (2016)
Construction costs	Costs of building the inland terminal	Nguyen and Notteboom (2016); Regmi and Hanaoka (2013); Karaşan and Kahraman (2019)
Other investment costs	Other costs with regards to setting up the inland terminal (e.g. for equipment)	Nguyen and Notteboom (2016); Ka (2011)
Land use near location[a]	Land-use at sites near the inland terminal location	Nguyen and Notteboom (2016); Kayikci (2010); Komchornrit (2017)
Expansion possibilities	Available land that could potentially be used to physically expand the inland terminal	Nguyen and Notteboom (2016); Karaşan and Kahraman (2019); Yıldırım and Önder (2014); Özceylan et al. (2016); Roso, Brnjac, and Abramovic (2015)

[a]Although often called *Spatial development* in the literature, we use *Land use near the location* in the criteria selection survey we sent to transport chain experts to more clearly indicate the factor representation.

2015; Nguyen and Notteboom 2016; Özceylan et al. 2016; Karaşan and Kahraman 2019). The entities at these locations make up the total market volume potential in a given area, as previously described in Section 2.2.1. As such, the *market proximity* is the only locational factor included in this study.

3. A consensus-building model for BWM group decision-making

Because of the multiple actors and multiple criteria involved in the decision-making process regarding the selection of an inland terminal location, we developed a group BWM that consists of 6 phases.

3.1. Phase 1: Define the location selection problem and determine the stakeholders

The first phase of the research methodology involves defining the inland terminal location selection problem of the particular case study by determining the scope of the study and the potential alternatives within that scope, and then selecting the experts from the stakeholders identified by the shipping line. The total number of experts is indicated as K.

3.2. Phase 2: Determination of criteria

The basis of the criteria selection procedure is formed by the criteria we identified in the literature review or proposed by experts. Through a *criteria selection survey*, a list containing the observed criteria is sent to and assessed by the experts, in accordance with Phase 1. They are then asked to indicate which criteria they consider to be important and relevant to the selection problem. Based on these indications, a list of relevant decision-making criteria is assembled for each stakeholder. It is worth mentioning that, unlike conventional methods, each expert could provide a different list of criteria according to their own backgrounds.

3.3. Phase 3: Criteria operationalisation and data gathering

Next, we need to determine the measurement of each criterion and gather the corresponding data. Determining the measuring units makes it possible to know the types of data that have to be gathered to sufficiently represent the criteria, to define the criteria in comparable metrics and to determine whether the criteria are of the benefit or cost type. The evaluations are collected in a decision-making matrix $R = \{r_{ij}\}_{m\times n}$, where r_{ij} represents the evaluation on the ith alternative with respect to the jth criterion, with m alternatives and n criteria.

3.4. Phase 4: Determination of criteria weights using BWM

The reason we use the BWM to calculate the criteria weights is that (i) it is a structural pairwise comparison method that requires fewer pairwise comparisons than the AHP (Analytic Hierarchy Process) method, (ii) by considering two opposite references (best and worst), it helps mitigate an anchoring bias, and (iii) it can generate more consistent and reliable results (Rezaei 2015, 2020). The BWM has been widely used in different areas, including location selection problems (Pamučar et al. 2017; Stević et al. 2018; Kheybari, Kazemi, and Rezaei 2019). For more information, see a recent review of BWM (Mi et al. 2019).

To calculate the weight w_j^k of criterion j for expert k ($k = 1, 2, \cdots, K$), we first need to ask the experts to indicate which is the most influential or important (best) and the least influential or important (worst) criterion.

Then, the experts are asked to determine their preferences for their most important criteria over all the other criteria, using a number from $\{1, 2, \ldots, 9\}$, where, for example, 1 represents 'equally important', while 9 represents 'extremely important than'. The obtained Best-to-Others vector for expert k is $A_{Bj}^k = (a_{B1}^k, a_{B2}^k, \cdots, a_{Bn}^k)$, where a_{Bj}^k represents the preference of the best criterion B over criterion j given by expert k. Suppose expert k has determined n criteria.

Next, the experts are asked to determine their preferences for all their selected criteria over their worst criterion using a number from $\{1, 2, \ldots, 9\}$. The obtained Others-to-Worst vector for expert k is $A_{OW}^k = (a_{1W}^k, a_{2W}^k, \cdots, a_{nW}^k)$, where a_{jW}^k represents the preference of criterion j over the worst criterion W given by expert k. Note that the best and worst criteria may be different for each expert.

The next phase involves calculating the optimal weights w_j^{k*}. The optimal weights for the criteria are determined by setting the conditions where, for each pair of w_B^k/w_j^k and w_j^k/w_W^k, $w_B^k/w_j^k = a_{Bj}^k$ and $w_j^k/w_W^k = a_{jW}^k$. To find a good approximation for all j, a solution in which the maximum absolute differences $|w_B^k/w_j^k - a_{Bj}^k|$ and $|w_j^k/w_W^k - a_{jW}^k|$ for all j are minimised is formulated in the following model:

$$\min \max_j \left\{ \left| \frac{w_B^k}{w_j^k} - a_{Bj}^k \right|, \left| \frac{w_j^k}{w_W^k} - a_{jW}^k \right| \right\} \tag{1}$$

$$s.t.$$

$$\sum_{j=1}^{n} w_j^k = 1$$

$$w_j > 0, \ \forall j$$

.

This model can generate multiple optimal solutions. By using the two models proposed by Rezaei (2016), we can include these solutions in the form of interval weights $\bar{w}_j^k = [w_j^{k,\min}, w_j^{k,\max}]$, where $w_j^{k,\min}$ and $w_j^{k,\max}$ represent the minimum and maximum weights for criterion j for expert k.

To assess the reliability of the comparisons provided by expert k, we consider the consistency ratio (CR^k) proposed by Liang, Brunelli, and Rezaei (2020):

$$CR^k = \max_j \frac{|a_{Bj}^k \times a_{jW}^k - a_{BW}^k|}{a_{BW}^k \times a_{BW}^k - a_{BW}^k}, \tag{2}$$

When $a_{BW}^k = 1$, $CR^k = 0$.

After we obtain the consistency ratios, we need to check whether the judgements are consistent enough and acceptable according to these *CRs*, which means that thresholds are needed. We use the consistency thresholds (Table 5) from the study by Liang, Brunelli, and Rezaei (2020). This threshold table consists of combinations of scales (a_{BW}^k) from 3 to 9 and number of criteria (n) from 3 to 9. The *CRs* obtained in the manner indicated above are compared to the thresholds: if the *CRs* are smaller than the thresholds, the judgements are acceptable, and vice versa.

3.5. Phase 5: Alternatives' value determination using the proposed consensus model

To compare these alternatives, we use an additive value function (Keeney and Raiffa 1976) to determine the overall value V_i^k of each alternative i for expert k based on the weights of criteria w_j^k and the normalised evaluations p_{ij}:

$$V_i^k = \sum_{j=1}^{n} w_j^k p_{ij}. \tag{3}$$

where

$$p_{ij} = \begin{cases} \dfrac{r_{ij} - r_j^{\min}}{r_j^{\max} - r_j^{\min}}, & \text{for benefit criteria} \\ \dfrac{r_j^{\max} - r_{ij}}{r_j^{\max} - r_j^{\min}}, & \text{for cost criteria} \end{cases}. \tag{4}$$

It is, of course, possible to use other normalisation formulas instead of (4). The weights obtained from the BWM may be intervals, which means we have to consider the interval calculation of the values of alternatives ($\bar{V}_i^k$). Because we assumed that the value function has an additive form, it makes sense to proceed in parallel with the approach commonly used in Multi-Attribute Value Theory (MAVT) and take the weighted average of the contributions of each criterion, just by using interval arithmetic and the following formula:

$$\bar{V}_i^k = \sum_{j=1}^{n} \bar{w}_j^k p_{ij} = \left[\sum_{j=1}^{n} p_{ij} w_j^{k,\min}, \ \sum_{j=1}^{n} p_{ij} w_j^{k,\max} \right]. \tag{5}$$

However, it is well known that the obtained interval would be unrealistically wide. In fact, if we require the weight vector to be nonnegative and include components summing up to one, it is easy to show that the lower and upper bounds of Equation (5) cannot be reached. For instance, if all the weights were at their lowest level, $w_j^{k,\min}$, they would not add up to 1 (in which case there is no full consistency), which means that, together, they would not represent a weight vector. To solve this problem, we need to use constrained interval arithmetic (Lodwick 2007) and use the

Table 5. Thresholds for different combinations.[a]

	Criteria number						
Scales	3	4	5	6	7	8	9
3	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
4	0.1121	0.1529	0.1898	0.2206	0.2527	0.2577	0.2683
5	0.1354	0.1994	0.2306	0.2546	0.2716	0.2844	0.2960
6	0.1330	0.1990	0.2643	0.3044	0.3144	0.3221	0.3262
7	0.1294	0.2457	0.2819	0.3029	0.3144	0.3251	0.3403
8	0.1309	0.2521	0.2958	0.3154	0.3408	0.3620	0.3657
9	0.1359	0.2681	0.3062	0.3337	0.3517	0.3620	0.3662

[a]The thresholds for the combinations with 2-scale should be 0.

following approach:

$$\bar{V}_i^k = [V_i^{k,\min}, V_i^{k,\max}], \tag{6}$$

where

$$V_i^{k,\min} = \min\left\{\sum\nolimits^{j=1} np_{ij}w_j | w_j \in [w_j^{k,\min}, w_j^{k,\max}]\ j = 1, \ldots, n,\ \sum\nolimits^{j=1} nw_j = 1\right\},$$

$$V_i^{k,\max} = \max\left\{\sum\nolimits^{j=1} np_{ij}w_j | w_j \in [w_j^{k,\min}, w_j^{k,\max}]\ j = 1, \ldots, n,\ \sum\nolimits^{j=1} nw_j = 1\right\}.$$

This generates stakeholder-specific *values*, where the lower and upper bounds result from stakeholder k's criteria evaluations: $[V_i^{k,\min}, V_i^{k,\max}]$. With the value of each stakeholder k for each alternative i, each alternative's set of values is used to determine the overall value score for the alternative.

After obtaining the value for each expert, we then need to calculate the aggregated value for all the experts. A traditional technique for aggregating intervals in the literature is to take the average of the interval centres (Yaniv 1997). However, that approach does not take the ranges of the intervals into account (Lyon, Wintle, and Burgman 2015) and overlooks the overlapping areas of the intervals.

Thus, in this section a group consensus model is proposed to solve this problem, the rationale of which is to eliminate outliers and place the aggregated value in the overlapping areas to the greatest extent possible because they represent the consensual opinions of the experts. To that end, we need to calculate the minimum of the sum of the differences between the aggregated values (which we first need to determine), as well as each stakeholder's extremes of the interval $\bar{V}_i^k \in [V_i^{k,\min}, V_i^{k,\max}]$, for which we use the following approach:

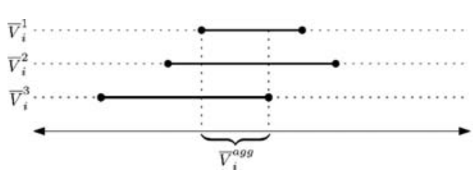
$$\bar{V}_i^{\mathrm{agg}} = \left\{x^* | x^* = \arg\min_x \sum_{k=1}^{K} |x - V_i^{k,\max}| + |x - V_i^{k,\min}|\right\}, \tag{7}$$

where $\bar{V}_i^{\mathrm{agg}}$ itself could possibly be an interval. It can be observed that if we rank from the smallest to the greatest all the $V_i^{k,\min}$ and the $V_i^{k,\max}$ values for all the experts and we rename them in a unique ordered set $\{y_1, \ldots, y_{2K}\}$, we then obtain $V_i^{\mathrm{agg}} = [y_K, y_{K+1}]$. Figure 3 clarifies the approach with two simple examples with three experts each.

Our decision to use this formulation is based on the fact that it allows us to eliminate outliers, similar to what the median does for a set or real numbers.[5]

3.6. Phase 6: Location selection

The resulting values can now be ranked[6] to select the most desirable alternative.



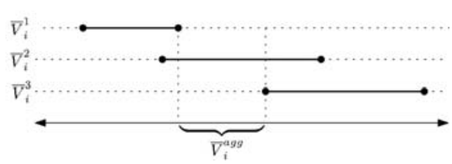


Figure 3. Two examples of computing $\bar{V}_i^{\mathrm{agg}}$.

4. Application to the location selection problem

The method described above is applied to the inland terminal location selection case study of the Maersk shipping line. The results of the case study are discussed in this section. The framework of the group BWM methodology proposed in Section 3 applied to this study is presented in Figure 4.

4.1. Results of phase 1: location selection problem definition

The inland terminal location selection problem examined in this study involves a specific geographical region (for reasons of confidentiality, Maersk requested not to reveal the name of the locations), which, broadly speaking, encompasses the urban and catchment areas of the cities we shall refer to as C, D and E. In total, six alternative locations were submitted for evaluation (two

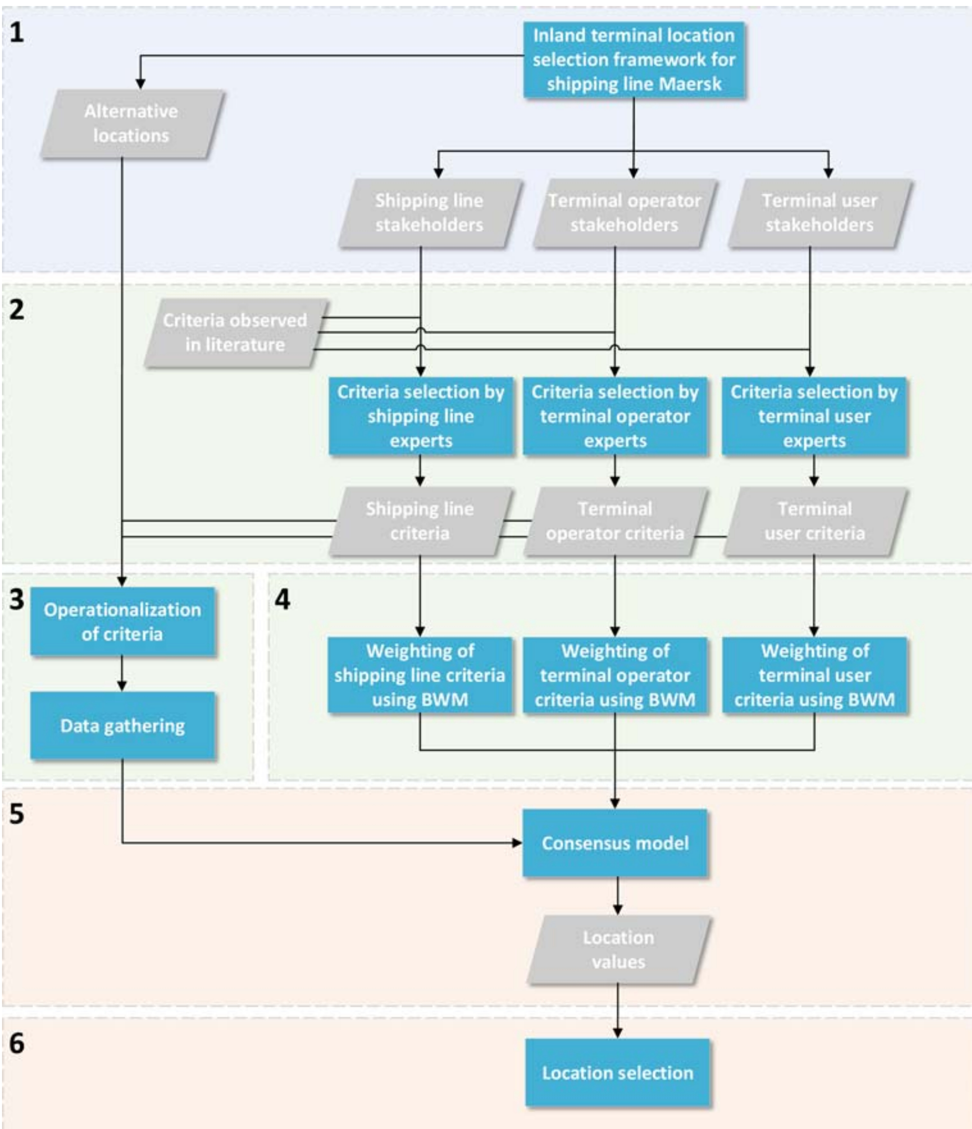


Figure 4. The framework of multi-stakeholder BWM inland terminal location selection.

per city), referred to generically as C1, C2, D1, D2, E1 and E2. All alternatives meet the conditions of being at least 50 hectares in size and being located next to road and rail infrastructure, as indicated in advance by Maersk.

Next, relevant stakeholders are included by the Maersk shipping line. In addition to including the shipping line and terminal operator as decision-making stakeholders, two types of terminal user stakeholders were also included for the evaluations: truck transport operators, as representatives of pre-/end-haulage transport operators, and rail transport operators, as representatives of intermodal transport operators. Only rail operators were approached due to the geographical scope of this study, since the region in question does not have an extensive inland waterway network and/or a correspondingly extensive (focus on the) barge transport market in connection to intermodal hinterland transport.[7] A selection of relevant experts of Maersk and the relevant vendors[8] of the company is also included to represent the stakeholder expert groups. These experts were nominated by the managers of Maersk as representatives of the different areas. In total, 12 shipping line experts, eight terminal operator experts, three rail transport operator experts and two truck transport operator experts were contacted.

Despite the fact that the resulting stakeholder configuration consists of the actual decision-making stakeholders (i.e. the shipping line and terminal operator stakeholders) and the evaluating stakeholders (i.e. terminal users), as discussed in Section 2, it was decided to equally include all the stakeholders and their preferences in the initial consensus model setup.[9] As such, no specific weights were assigned to specific stakeholders in order to reflect their assumed importance within the actual decision-making process.

4.2. Results of phase 2: decision criteria

The stakeholder-specific decision-making criteria are based on the way the experts assessed the criteria we identified in the literature review. Through a survey, the criteria resulting from the literature review were presented to the stakeholders, who were asked to indicate the ones they found most important with regard to evaluating the location of an inland terminal. The criteria included for each stakeholder were based on the number of times they were mentioned by the experts. Because the shipping line provided more experts than the other stakeholders, a criterion had to be mentioned at least twice by experts from the shipping line to be included, as opposed to at least once for the other stakeholders. In addition, the experts were asked to suggest additional important criteria they felt were missing from the list we provided. The resulting criteria for each stakeholder are listed in Table 6.

4.3. Results of phase 3: Operationalised criteria and data

Phase 3 involves the operationalisation of the criteria into measurable and comparable metrics, which leads to particular data-gathering methods and, ultimately, to a collection of quantitative data corresponding to each criterion for each alternative. The resulting data are listed in Table 7.

4.4. Results of phase 4: criteria weights

In this phase, the criteria discussed above are further evaluated to assign weight factors to each stakeholder via the BWM. To that end, a preference statement survey was sent to the expert group, in which they indicate the Best and Worst criterion, the relative preferences of the remaining criteria compared to the Best criterion and the relative preferences of the Worst criterion compared to the remaining criteria. Based on the survey, which was ultimately completed by nine respondents (three experts from the shipping line, three from the terminal operator, two from the rail transport operator and one from the truck transport operator), the criteria weight intervals for each expert were

Table 6. Criteria to be considered in a study based on the criteria selection survey results.

Criterion	Stakeholder: Shipping line	Terminal operator	Rail transport operator	Truck transport operator
Anchor customer proximity[a]		✓		
Enabling modality shift[a]		✓		
Expansion possibilities	✓		✓	✓
Government policy	✓			
Inland terminal CAPEX	✓	✓	✓	
Intermodal market profitability[a]	✓			✓
Land use near location				✓
Local depot capacity[a]	✓			
Market proximity	✓		✓	✓
Market volume potential	✓	✓	✓	✓
Regional economic development		✓		
Regional transport/logistics competition	✓	✓		✓
Terminal market profitability[a]				✓
Total inland transport costs	✓	✓		✓
Transport infrastructure network in area	✓	✓	✓	✓

[a]Criteria additionally added based on the experts' inputs.

Anchor customer proximity: the anchor customer volume (in FEU) within an area. *Enabling modality shift*: the potential volume to be shifted from the modality in an area. *Intermodal market profitability*: the margins gained from providing/practising intermodal transport services in a certain area. *Local depot capacity*: the total container volume that could possibly be stored in the broader area in which an alternative location is situated. *Terminal market profitability*: the margins gained from providing inland terminal operations in a certain area.

calculated by means of solving the nonlinear BWM model with the respective preference statement inputs, as shown in Tables 8–11.

In addition to calculating the weight intervals, the comparison consistencies are checked using the consistency threshold values. Using Equation (2) we can calculate the consistency ratios and then compare them to Table 5. We found that, except for Rail transport operator 1 (whose CR is 0.2857, against a consistency threshold of 0.2844),[10] all the CRs of the other experts are below the corresponding thresholds.

4.5. Results of phase 5: values of the alternatives

First, the original evaluation data in Table 7 need to be normalised using Equation (4), which results in Table 12, where we use '+' to present the benefit criteria and '-' to present the cost criteria.

The normalised data, in combination with the criteria weight intervals as determined in Phase 4, are used to calculate the value assigned to the alternatives. The separate values based on each stakeholder's preferences and the corresponding data are added to generate a set of values for each alternative using Equation (5). The resulting values for the various individual experts are shown in Figure 5. The error bars represent the interval values of the alternatives, while the columns represent the middle values of the intervals.

The individual values are then aggregated using the group consensus model (7). The aggregate values for each alternative are shown in Figure 6, where the average values are presented numerically.

4.6. Results of phase 6: location selection

The final values of C1 and C2 (see Figure 6) are very close to one another. In fact, C1 and C2 are two sites in one district.

Table 7. Evaluation of alternatives based on the criteria.

Criteria	Alternatives C1	C2	D1	D2	E1	E2
Anchor customer proximity (FEU)[a]	17431	15931	1337	1337	0	0
Enabling modality shift (FEU)	23215.21	21950.21	1337	1337	2277.56	2946.06
Expansion possibilities (m^2)	831919	0	1039121	174705	102817	0
Government policy (index)[b]	1	1	1	1	0	0
Inland terminal CAPEX (€)	58517500	57767500	56767500	57517500	56517500	56267500
Intermodal market profitability (€/TEU)	87.78	93.10	127.01	151.97	147.07	144.85
Land use near location (index)[c]	1	1	1	0	0	0
Local depot capacity (TEU)	5650	5650	2950	2950	1000	1000
Market proximity (FEU/km)	3357.62	3670.63	875.27	887.38	740.62	744.45
Market volume potential (FEU)	31509.73	29993.73	4751.15	4870.10	5947.68	7427.05
Regional economic development (€)	31600	31600	30300	30300	28300	28300
Regional transport/logistics competition (number)[d]	108	108	130	130	134	134
Terminal market profitability (€)[e]	−24.06	−24.06	−27.67	−27.67	−15	−15
Total inland transport costs (€/TEU)	432.22	426.90	555.49	530.53	495.43	497.65
Transport infrastructure network in area (km/100 km^2)	78.18	61.86	33.94	42.55	112.45	111.15

[a]Forty-foot Equivalent Unit (FEU).
[b]A government policy index is proposed to indicate whether the local government within the region is willing to support inland terminal development, where −1 is negative, 0 is neutral, and 1 is positive.
[c]We use 1 and 0 to represent whether the land-use near the location has a positive or negative effect on the (operations of) the potential inland terminal.
[d]The regional number of companies offering transport and logistics services on one hand implies a certain level of competition, while on the other hand also indicates the potential for cooperation. Since the line between these two is not directly clear, the *competition* factor is simplified to the *number of companies offering transport, logistics and terminal services in the area.*
[e]Terminal market profitability involves the margins gained from providing inland terminal operations in a certain area. These margins thus depend on the local market, which is quantitatively assessed through the rates applied by the locally existing and operating terminal service providing companies. As the rates applied by the shipping line are not yet known (because it currently does not operate any terminal it owns, no rates have been developed), only the *costs* for terminal handlings are used as in indication for the possible margins gained per area (the higher the costs, the lower the margins).

4.7. Sensitivity analysis

A sensitivity analysis was conducted to test how the input affects the final results, which can be assessed by adapting the corresponding model parameters and comparing the results to those of the model in Phase 5.

Because the container volume is considered to be relatively important by most stakeholders, it accounts for a substantial share of the value for the alternatives, especially for the locations in area C, where the potential container volume is significantly higher than those in the other

Table 8. Criteria weights for shipping lines.

	Expert					
	Shipping line 1		Shipping line 2		Shipping line 3	
Criterion	Lower	Upper	Lower	Upper	Lower	Upper
Expansion possibilities	0.0046	0.0051	0.0039	0.0039	0.0751	0.0751
Government policy	0.0252	0.0288	0.0161	0.0188	0.0623	0.0623
Inland terminal CAPEX	0.0263	0.0263	0.1727	0.1727	0.0615	0.0615
Intermodal market profitability	0.1811	0.1811	0.4002	0.4002	0.1930	0.1930
Local depot capacity	0.0190	0.0207	0.0195	0.0195	0.0343	0.0343
Market proximity	0.2368	0.2705	0.0255	0.0298	0.2713	0.2713
Market volume potential	0.1902	0.2368	0.1677	0.1963	0.1648	0.1648
Regional transport/logistics competition	0.0657	0.0750	0.0675	0.1033	0.1025	0.1025
Total inland transport costs	0.1613	0.1613	0.0521	0.0521	0.0196	0.0196
Transport infrastructure network in area	0.0410	0.0429	0.0391	0.0391	0.0156	0.0156

Table 9. Criteria weights for terminal operators.

	Expert					
	Terminal operator 1		Terminal operator 2		Terminal operator 3	
Criterion	Lower	Upper	Lower	Upper	Lower	Upper
Anchor customer proximity	0.0874	0.1741	0.1356	0.1621	0.2710	0.2836
Enabling modality shift	0.0817	0.1047	0.0345	0.0377	0.0312	0.0541
Inland terminal CAPEX	0.0286	0.0367	0.0985	0.1075	0.0785	0.0900
Market volume potential	0.1181	0.2079	0.2812	0.3067	0.1277	0.1336
Regional economic development	0.2332	0.2987	0.1356	0.1621	0.0249	0.0261
Regional transport/logistics competition	0.0546	0.1010	0.1356	0.1621	0.1277	0.1336
Total inland transport costs	0.0855	0.1525	0.0401	0.0619	0.2710	0.2836
Transport infrastructure network in area	0.1121	0.1580	0.0646	0.0788	0.0252	0.0393

Table 10. Criteria weights for rail transport operators.

	Expert			
	Rail transport operator 1		Rail transport operator 2	
Criterion	Lower	Upper	Lower	Upper
Expansion possibilities	0.0391	0.0443	0.1138	0.1138
Inland terminal CAPEX	0.1670	0.1896	0.1138	0.1138
Market proximity	0.0914	0.1278	0.0526	0.0526
Market volume potential	0.3799	0.4313	0.3599	0.3599
Transport infrastructure network in area	0.2269	0.3063	0.3599	0.3599

Table 11. Criteria weights for truck transport operators.

	Truck transport operator expert	
Criterion	Lower	Upper
Expansion possibilities	0.0254	0.0474
Intermodal market profitability	0.1288	0.2179
Land use near location	0.0227	0.0282
Market proximity	0.1544	0.2498
Market volume potential	0.2432	0.3023
Regional transport/logistics competition	0.0519	0.0703
Terminal market profitability	0.0743	0.0923
Total inland transport costs	0.0979	0.1313
Transport infrastructure network in area	0.0294	0.0561

areas, which increases the relative value of C compared to the others. However, due to particular economic events, container volumes generated in/attracted to a certain area may have more fluctuations in shorter time periods, for example, when a (new) shipper/consignee opens a facility in a particular region (e.g. a factory or distribution centre), which is sufficiently large to cause a relatively high influx of annual container volumes. As such, *the market volume potential* also turns out to be a critical factor in the MCDM study.

We use several hypothetical (albeit fairly realistic) scenarios to assess a sudden growth in container volume areas D and E, which are selected because they currently have the lowest container volumes. This allows us to measure the effect of such an increase in volume on their performance as potential locations compared to option C, which already has higher volumes. As the hypothetical market volume potential influx is unlikely to occur at both locations at the same time, we decided to assess them individually by increasing their *market volume potential* incrementally.[11]

The incremental development of the aggregate values[12] for the alternatives as a result of an increase in container volume areas D and E are shown in Figures 7 and 8, respectively.

As can be seen, their values as alternative locations increase along with the container volume, and when the market volume potential of area D surpasses 20000 FEU p.a. (per annum), the value of area D exceeds that of area E (see Figure 7). However, the growth in the market volume in areas D and E does not change the fact that area C is the best alternative, which means that,

Table 12. Normalised data scores for all criteria sets.

	Alternatives					
Criteria	C1	C2	D1	D2	E1	E2
Anchor customer proximity (+)	1	0.9139	0.0767	0.0767	0	0
Enabling modality shift (+)	1	0.9422	0	0	0.0430	0.0735
Expansion possibilities (+)	0.8006	0	1	0.1681	0.0989	0
Government policy (+)	1	1	1	1	0	0
Inland terminal CAPEX (–)	0	0.3333	0.7778	0.4444	0.8889	1
Intermodal market profitability (+)	0	0.0829	0.6111	1	0.9237	0.8890
Land use near location (+)	1	1	1	0	0	0
Local depot capacity (–)[a]	0	0	0.5806	0.5806	1	1
Market proximity (+)	0.8932	1	0.0460	0.0501	0	0.0013
Market volume potential (+)	1	0.9433	0	0.0044	0.0447	0.1
Regional economic development (+)	1	1	0.6061	0.6061	0	0
Regional transport/logistics competition (–)	1	1	0.1538	0.1538	0	0
Terminal market profitability (+)	0.2850	0.2850	0	0	1	1
Total inland transport costs (–)	0.9586	1	0	0.1941	0.4671	0.4498
Transport infrastructure network in area (+)	0.5634	0.3556	0	0.1097	1	0.9834

[a]Local depot capacity is a cost criterion because it measures the amount of depot capacity already present in the area. In this sense, the greater the capacity already present, the more competition there is in the area and the lower the demand for a new depot capacity.

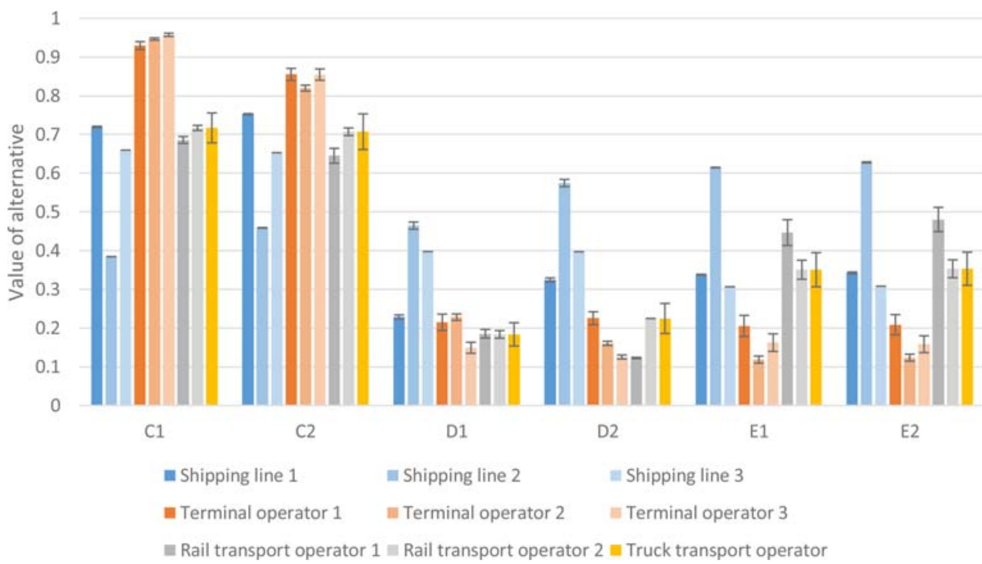


Figure 5. Values for each alternative of each expert.

between 10,000 and 30,000, an increase in the potential market volume in an alternative location has no impact on the final selection.

This conclusion can be supported by noting that the weight of the criterion Potential market volume is, at the most, 0.4313, as specified by Rail transport operator 1, which is less than the value difference between the two best alternatives and the remaining four, which means that, even if we increase the Potential market volume to the maximum level for alternatives D1, D2, E1 and E2, that does not make them preferable to C1 and C2.

5. Conclusions and discussion

Summary: The aim of this study was to identify a desirable location for a shipping line to set up an inland terminal that can be incorporated into the inland transport services the company provides to

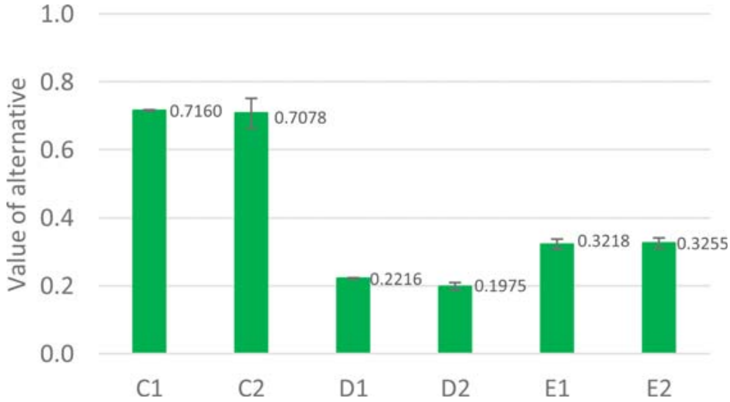


Figure 6. The aggregated value of each alternative.

its customers, which meant we had to take the interests of a number of different stakeholders into account, including the shipping line, terminal operator, and terminal user. To that end, a group BWM consensus model was proposed to determine the criteria weights for each stakeholder and aggregate the interval values of the relevant alternatives.

Results and discussions: In addition to the existing criteria, several new criteria (anchor customer proximity, enabling modality shift intermodal market profitability, local depot capacity, and terminal market profitability) were added to this specific project to shed light on the criteria set. Based on these criteria, different stakeholders apply different subsets of criteria to assess their particular areas. While the shipping line assigns the greatest value to *intermodal market profitability* and *market proximity*, terminal operators and users indicate that they place greater value on container volume-related (e.g. *market volume potential*) factors. Overall, these container-related characteristics are rated highly by all the stakeholders involved, including the shipping line. As a result, the two locations in city C were the best alternatives, in large part thanks to the potential container volume in area C. Sensitivity analyses indicated that the influence of a growth in the market volume at the other locations has a limited impact on the final selection.

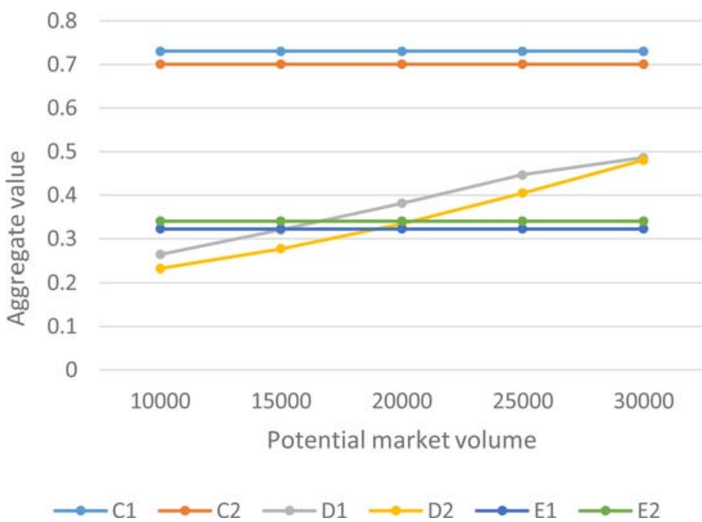


Figure 7. Aggregate values of alternatives with respect to a varying container volume influx in area D.

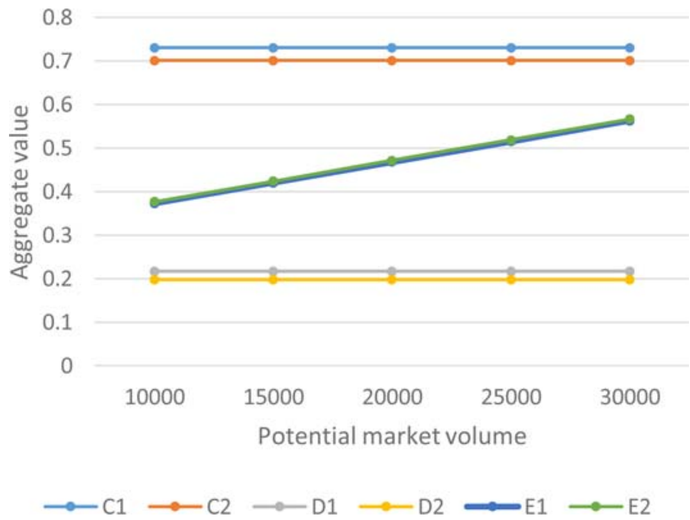


Figure 8. Aggregate values of alternatives with respect to a varying container volume influx in area E.

Furthermore, it can be concluded that most of the weights the different stakeholders placed on specifically relevant criteria ultimately lead to comparable results in terms of preferability, which shows that although the business models and objectives of the different stakeholders may vary, an increasingly (cost) efficient inland transport chain ultimately benefits everyone involved. Based on the insights from the relevant stakeholders and combined with the data used as input for the MCDM model, location C1 emerged as the optimal choice, especially in terms of local market conditions and expansion possibilities.

Limitation and future study: First, in a real-life situation there may be more stakeholders involved in selecting inland terminals than those included in this study, including the government and local shippers. These stakeholders were not included in this study because of the nonexecutive role they play in the container transport domain. However, since the government (can) also take(s) part in the development of terminal infrastructure in areas under its jurisdiction, it would be interesting to include its preferences with regard to the relevant criteria. Second, as far as shippers are concerned, the decision to not include them in the research stems from the Maersk's objective to first choose a location near some potential partner shippers and conduct more in-depth research including other shippers at a later date. Third, further research should look at the inland terminals themselves and on the terminals within the container port hinterland in general, rather than focusing exclusively on the specific framework applied in this manuscript.

In addition, it may be worthwhile to take a closer look at the shipping line's vertical integration into the container port hinterland in a broader sense, which is an increasingly interesting development. In the past, before shipping lines began providing door-to-door services, the inland transport services were managed entirely by third parties such as freight forwarders, making them *customers* of the shipping lines. However, because of the developments described in this research, shipping lines are increasingly becoming *competitors* of former customers, thus it would be interesting to explore the changing dynamics between shipping lines and their customer competitors, especially since the implications of these changing dynamics could also affect the suitability of inland terminals located in certain inland transport chains.

Notes

1. In the original four-layer framework, the focus is on the seaport as a node between ocean and hinterland transport. In the adapted framework, this focal point has shifted from the seaport node (which is less relevant in this

study) towards the inland terminal, as a node between the main haulage transport and the pre-/end-haulage transport.
2. https://www.scopus.com/.
3. https://scholar.google.com/.
4. As existing literature is often unclear on whether the environmental effects are local or global, this criterion is subdivided into Local environmental effects and Global environmental effects in the criteria selection survey that was sent to the transport chain experts.
5. It can actually be shown that when the intervals collapse into real numbers our approach identifies the median of these real numbers. Following the conventions of probability theory, we interpret the median of an even number of observations as the interval that has the two middlemost values as extremes.
6. For the ranking method of intervals, we refer readers to Rezaei (2016).
7. This means that barge operators are excluded from the surveys and inland waterway networks and features are excluded from the analyses.
8. The vendors are the suppliers of the shipping line, i.e., the terminal and transport operators performing the inland services offered by Maersk.
9. The decision-maker at Maersk agreed to this arrangement.
10. Because the CR of Rail transport operator 1 lies slightly above the threshold, and because the relevant comparisons are ordinally consistent (for the checking method, refer to Liang, Brunelli, and Rezaei 2020), we consider this situation to be acceptable and the expert was not asked to revise the preferences.
11. An incremental market volume potential influx is considered; the minimal increase begins with 10,000 FEU extra potential p.a. (which is approximately the size of the largest shippers/consignees in the current study region in eastern Germany), up to a maximum increase of 30,000 FEU extra potential p.a. (which is approximately the size of the largest shippers/consignees in all of Germany), with intermediate steps of 5000 FEU p.a.
12. For a clear presentation, we only use the average values instead of using intervals, but this has no impact on the final implications.

Acknowledgment

The authors especially appreciate the help from Matej Vybiral from Maersk, Bart Wiegmans from Delft University of Technology, and all the other experts from Maersk, APM Terminals and Maersk's vendors. Additionally, the authors gratefully acknowledge the financial support for PhD study from the China Scholarship Council (No. 201708440305).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Additionally, the authors gratefully acknowledge the financial support for PhD study from the China Scholarship Council (No. 201708440305).

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