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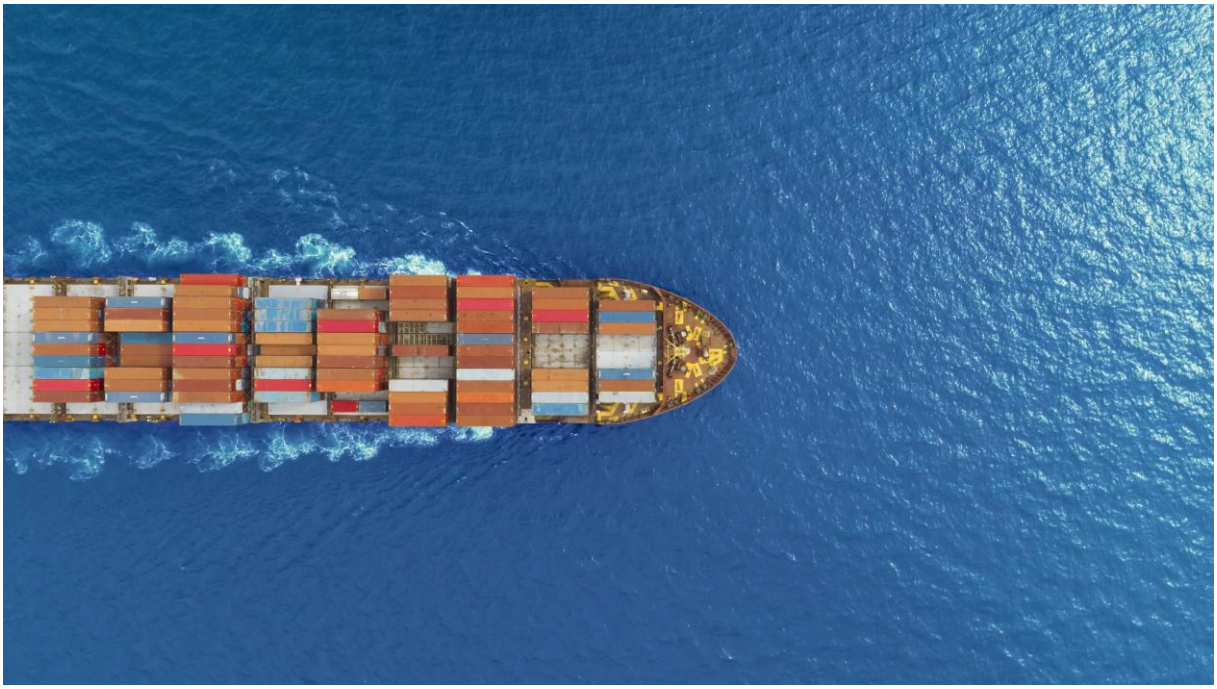

A Case Study of Container Import Flows to Sweden:

Understanding Bottlenecks, System Structure, and Cascading Effects

Master's thesis in Maritime Management

Rasmus Eriksson

CHALMERS SCHOOL OF MARITIME STUDIES
DIVISION OF TECHNICAL AND MARITIME MANAGEMENT

CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden 2026

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ABSTRACT

This thesis examines containerized import flows to Sweden by adopting an end-to-end perspective of the Container Shipping Supply Chain (CSSC).

The study aims to analyze how import flows are structured in practice, where bottlenecks and delays occur, and how these are shaped by interactions between different logistics segments, including maritime transport, ports and terminals, transshipment hubs, and hinterland transport systems.

The research is based on a deductive approach, combining a Systematic Literature Review (SLR) with a qualitative case study in Sweden. The empirical data were collected through semi-structured interviews with multiple actors across the supply chain, including freight forwarders, port representatives, inland transport operators, and other logistics stakeholders.

The analysis is conducted using a thematic framework derived from the literature, focusing on supply chain structure, reliability, bottlenecks, port performance, and hinterland connectivity. The findings show that container import flows to Sweden are highly dependent on hub-and-spoke network structures, where transshipment at major European hub ports plays a central role. Bottlenecks and delays occur across multiple segments of the supply chain, particularly at transshipment hubs, port terminals, and in hinterland connections. These disruptions are not isolated but propagate through the system, creating cascading effects that impact overall reliability and lead times. The results further indicate that efficiency-driven practices, such as minimizing storage and keeping containers in continuous flow, contribute to increased system vulnerability. While these practices improve efficiency under normal conditions, they reduce the system's ability to absorb disruptions, thereby amplifying delay propagation.

The study contributes to existing research by providing a geographically specific analysis of containerized import flows to Sweden. It highlights the importance of understanding container flow performance as a system-level outcome shaped by interdependencies between maritime, port, and hinterland segments. The findings also provide practical insights for transport planning and freight transport modelling by improving the understanding of how container flows are structured, where bottlenecks emerge, and how disruptions propagate across the system.

Keywords: Container Shipping Supply Chain (CSSC), Import flows, Sweden, Congestion, Bottlenecks, Container, Dwell time, Waiting Time, Reliability, Hub-and-spoke, Hinterland transport, Port performance, Transshipment

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Finally, I wish to thank my friends and family for their encouragement and support throughout this journey. I am deeply grateful to my fiancée Elin, whose unwavering belief in me has meant a great deal. A special thanks also goes to my four-legged friend, Haddock, who has reminded me to take regular breaks and spread happiness in tough moments.

Rasmus Eriksson,

Göteborg, 2026.

ABBREVIATIONS

CSSC = Container Shipping Supply Chain

ETA = Estimated Time (of) Arrival

TEU = Twenty-foot Equivalent Unit

FCL = Full Container Load

SLR = Systematic Literature Review

AIS = Automatic Identification System

Incoterms = International Commercial Terms

COO = Country of Origin

COD = Country of Consignment

MTY = EMPTY

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1. Introduction

1.1 Background

Maritime transport accounts for approximately 80-90 percent of global trade and plays a central role in international trade (UNCTAD, 2025). Containerized shipping accounts for a substantial proportion of that seaborne trade. Furthermore, Sweden is highly dependent on containerized maritime transport for its imports and exports (Vierth, 2026), with approximately 600,000 loaded TEUs discharged annually in Swedish ports (Trafikanalys, 2026). This highlights the importance of well-functioning containerized import flows and efficient port-related logistics systems. European transport policy aims to shift long-distance road freight towards alternative transport modes, such as sea transport, thereby increasing the demand on container logistics systems (Schøyen et al., 2018; European Commission, 2011).

Containerization continues to grow globally, which is partly driven by increasing trade volumes (UNCTAD, 2025) but also by the growing use of containers for a wider range of cargoes (Feng et al., 2023). Cargo that was previously transported as breakbulk (i.e., sawn timber) is increasingly being containerized due to the efficiency, flexibility, and cargo protection offered.

Containerized import flows are part of an interconnected Container Shipping Supply Chain (CSSC), comprising logistics segments such as maritime transport, storage, transshipment operations, ports and terminals, and hinterland connectivity (Song, 2021). Multiple actors, such as shipping lines, logistics providers, public and private actors, are involved across these segments (Wendler-Bosco & Nicholson, 2019), and the performance of one part of the system may influence conditions in other logistics segments and, thereby, affect overall supply chain efficiency (Fransoo & Lee, 2013; Song, 2021). In the context of import flows to Sweden, this includes interactions among deep-sea and feeder services, transshipment ports, Swedish port terminals, and inland transport networks.

Container shipping networks in Europe are commonly organised in a hub-and-spoke structure, in which large ports such as Rotterdam and Hamburg connect intercontinental flows to smaller ports and regions via feeder networks (Ducruet & Notteboom, 2012). Conditions at destination ports and further into the hinterland are often shaped by events and decisions occurring earlier in the CSSC (Yue & Mangan, 2023; Song, 2021). Except for Gothenburg, Swedish ports generally cannot accommodate the largest container vessels (Vierth, 2024). Consequently, import flows to Sweden usually involve at least one transshipment at an intermediate hub port. In the network, congestion at upstream transhipment ports and delays during modal transfers may propagate downstream (Fransoo & Lee, 2013; Song, 2021). Thus, estimating import flows requires an understanding of total flow time along the logistics chain, including potential congestion, dwell times, and delays at connecting ports, which motivates an end-to-end analysis of containerized import flows (Fransoo & Lee, 2013; Song, 2021; Yue & Mangan, 2023).

Congestion and dwell time are growing global problems, with waiting times and handling delays in developed countries increasing substantially in recent years (UNCTAD, 2025). Such

delays may reduce the reliability of container flows and, in some cases, lead to missed connections, thereby extending logistics chains (Yue & Mangan, 2023; Song, 2021). These characteristics highlight the complexity of containerized import flows, in which delays and disruptions may arise across multiple interconnected logistics segments (Karmelić et al., 2025).

The structure of CSSC networks, including the specific characteristics of nodes within them and the connections between logistics segments, varies across geographical contexts (Notteboom & Rodrigue, 2008; Calatayud et al., 2017). There are, however, differences in the origination of container flows, and port performance and operational bottlenecks are strongly shaped by geographical and network-specific conditions, limiting the transferability of findings across regions. This highlights the need for geographically specific empirical studies of containerized logistics systems (Calatayud et al., 2017).

From a transport planning perspective, investments in port infrastructure rely on assumptions about freight volumes, reliability, flow structures, and operational conditions (De Jong et al., 2014; Forsgren & Westin, 2014). Inadequate representation of these assumptions may introduce significant uncertainty into infrastructure appraisal and capacity planning (De Jong et al., 2014). For an export/import-dependent country such as Sweden (SCB, 2025), improved empirical understanding of containerized import flows is important for supporting long-term physical infrastructure planning (Trafikverket, personal communication, January 2026). In practice, appraisal tools such as Sjökalk (Asplund & Swahn, 2026) rely today on simplified representations of transport flows to/from Sweden. More detailed empirical knowledge of container flows can thus support and improve such appraisal tools by better reflecting how flows and operational conditions occur. (De Jong et al., 2014).

Despite increased research on container shipping, much of the existing literature focuses on individual nodes and segments within the CSSC, especially on port performance or hinterland connectivity. In addition, there is a lack of studies that adopt an end-to-end or system-level approach to capture interactions across multiple segments in the CSSC (Song, 2021; Yue & Mangan, 2023). Yue & Mangan (2023) argue that both studies focusing on a specific segment and those with an end-to-end perspective are important. However, both Yue & Mangan (2023) and Song (2021) emphasize the need for more research that captures interactions across the full CSSC.

In Sweden, this phenomenon is under-researched. Studies in this area have primarily focused on isolated components of the CSSC (e.g., Gonzalez-Aregall & Bergqvist, 2019; Lind, 2024), rather than on end-to-end container flows from origin to destination. Consequently, there is limited empirical knowledge of where and how delays and bottlenecks arise in container imports to Sweden, especially how they are shaped by interactions among different logistics segments and the actors involved. This study addresses this gap by analyzing containerized import flows to Sweden from origin to destination.

1.2 Purpose

The purpose of this thesis is to analyze containerized import flows to Sweden, via Swedish ports, by following the flows from origin to destination. The study aims to identify system structures and bottlenecks, examine their impact on storage and waiting times, and understand how upstream network disruptions create cascading effects on Swedish port operations and hinterland logistics.

1.3 Research Questions

Based on the stated main and second purpose, the following four RQs have been used:

1. How are import flows of standard containers to Sweden structured in practice, including intermodal interfaces, when following container flows from origin to final destination through Swedish ports?
2. Where along import flows of standard containers to Sweden do waiting times and bottlenecks occur in relation to vessel size and the capacity, layout, and storage characteristics of Swedish ports?
3. Which operational and terminal-related factors influence the performance, waiting times, and bottlenecks of import flows of standard containers to Sweden through Swedish ports?
4. How can observed import flows of standard containers to Sweden, through Swedish ports, from origin to final destination, be simplified into representative flow structures?

1.4 Limitations

First, this study focuses exclusively on containerized cargo, while other cargo types, such as bulk, breakbulk, trailers, and Ro-Ro, are only considered as contextual references. Furthermore, the study focuses the analysis on import container flows to Sweden, to maintain analytical consistency. Export flows are excluded as a primary object of analysis but are occasionally referred to for comparative purposes. Additionally, the study primarily focuses on full container load (FCL) and standard container (20-ft & 40-ft dry) flows. As a result, other container types (e.g., reefer containers) and logistics setups such as less-than-container load (LCL) are not the primary focus of this study.

Third, the geographical scope is limited to container flows destined for Sweden via Swedish ports. Although the study covers the national container port system, it groups ports into broader categories (e.g., major ports, smaller ports, and Gothenburg as the primary gateway). As a result, variations in operational conditions and configurations at individual ports may not be fully captured. In addition, because the findings are context-specific to Sweden, the results may be difficult to generalize to other national settings.

Additionally, the study focuses on current operational conditions. As a result, the findings reflect recent system dynamics and may not capture future developments, structural changes, or long-term trends in container shipping.

2. Methodology

In this chapter, the research approach used in this thesis will be explained, including how the literature review was conducted, followed by the design and analysis of the interviews. The chapter also explains the approach to ethics, validity, and reliability.

2.1 Research approach

The deductive research approach was used in this study, in which existing theory and academic literature on the subject guided the empirical investigation (Cresswell, 2014). The study begins with a Systematic Literature Review (SLR) of published academic literature to establish a theoretical foundation for the thesis and identify challenges in the existing literature on container logistics chains. (Cresswell, 2014)

The deductive research approach ensures a consistent linkage between existing theory, the identification of themes in the literature review, the design of interview guides, and the analysis of the empirical data (Cresswell, 2014; Bell et al., 2019).

The SLR was conducted in accordance with guidelines for snowball sampling (Wohlin, 2014). With the aim of identifying key concepts and central themes relevant to the research purpose (Cresswell, 2014; Bell et al., 2019). Since a deductive research approach was selected, the identified themes will subsequently serve as the theoretical foundation for empirical data collection. Interview guides were developed directly from the theoretical foundation identified in the literature review.

Thereafter, the empirical data were collected through a qualitative case study of Swedish import container flows, using semi-structured interviews with actors across the container shipping supply chain. (Yin, 2009)

2.2 Structure of literature review

The literature review in this study was conducted as a SLR following guidelines on a snowball sampling approach (Wohlin, 2014). The steps conducted are presented in Figure 1. The purpose of applying a systematic snowballing-based literature review is to identify and structure key themes relevant to CSSC, which subsequently form the analytical framework for the empirical study.

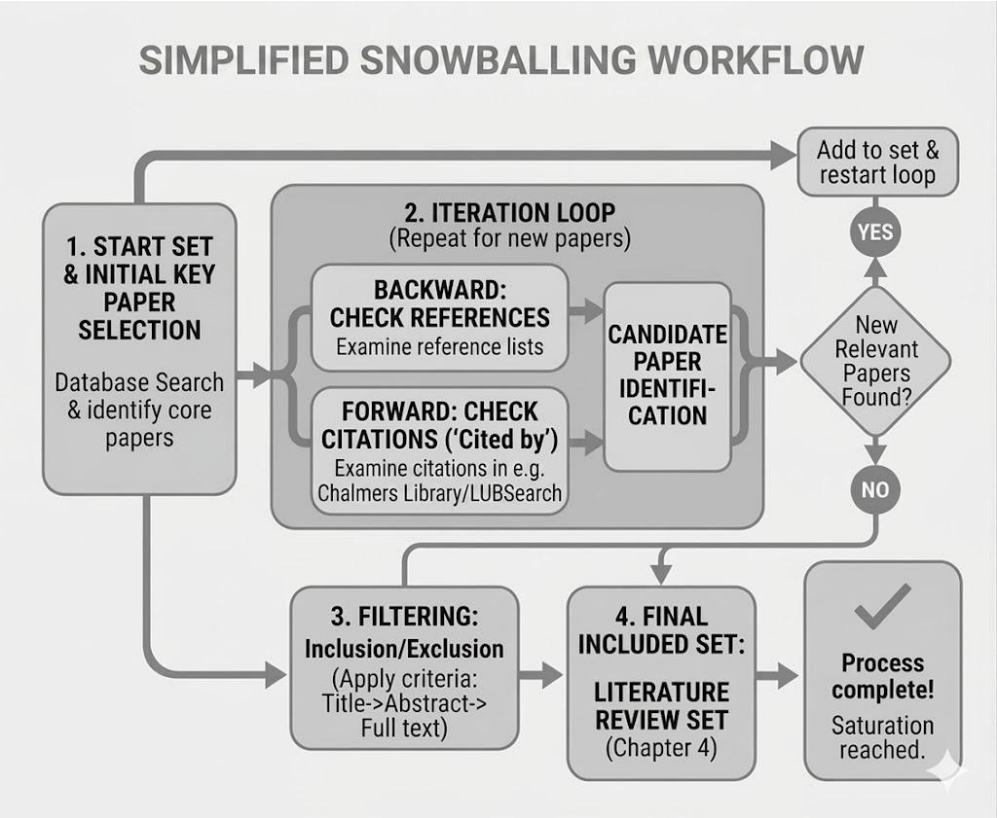

Figure 1: Systematic snowballing step-by-step guide adopted and modified from Wohlin (2014, p. 4) [Created with Gemini, (2026)].

The steps presented above and in *Figure 1* will be explained in greater detail in the following sections. The total number of papers found and selected in each step is shown in APPENDIX 1.

2.2.1 Step 1 - Start set and inclusion criteria

Inclusion Criteria

The basic inclusion criteria were, first, that the article had to be peer-reviewed. Secondly, the publication year in the initial set was limited to articles published from 2016 onward, to capture recent developments in container shipping, such as changes in network structures, increasing vessel sizes, and evolving operational practices. This approach aligns with recommendations to ensure that literature reviews reflect current knowledge while maintaining sufficient temporal scope (Wohlin, 2014; Creswell, 2014). Furthermore, older articles through backward snowballing were included if published from 2006 forward, allowing the inclusion of seminal and highly cited studies in the frame of reference. The third inclusion criterion was that only articles written in English or Swedish were included, to minimize the risk of misinterpretation due to translation and to ensure an accurate understanding of the study content. (Wohlin, 2014)

Selection of Database

According to Wohlin (2014), the database used to identify the initial set of articles should provide broad coverage across publishers to avoid systematic bias, i.e., choose a wide-ranging search database that includes multiple publishers. In this thesis, the Chalmers Library (2026)

database was selected because it provides broad coverage across publishers and offers advanced filtering options, such as excluding non–peer-reviewed material, thereby supporting a systematic and transparent literature search.

Key Words and Search Strings

The keywords and search strings were designed to reflect the research that is conducted and the phenomena under investigation (Wohlin, 2014). Synonyms and alternative wording were incorporated into the search strings and keywords to reduce the risk of excluding relevant studies due to different terminology. The search strings were developed based on the different preliminary themes this thesis covers (Tabari et al., 2019). To ensure consistency between the literature search strategy and the analytical framework, all search strings and the corresponding number of results obtained from the Chalmers Library database are presented (see APPENDIX 1).

The search strings and keywords used to identify the initial set of articles for snowballing were based on preliminary themes derived from the purpose of the study and the established literature on container shipping supply chains (Wohlin, 2014; Tabari et al., 2020). Following Wohlin's (2014) guidelines on snowballing, these preliminary themes guided the formulation of search strings and keywords for the database search to identify the initial set of articles.

Thereafter, the thematic structure remained flexible, allowing preliminary themes to be refined, merged, excluded, or supplemented as the literature review progressed (Tabari et al., 2020). Based on recurring concepts in prior research, the five preliminary themes used to formulate the search strings were: (1) Container shipping supply chain structure, (2) Port and terminal performance, (3) Intermodality and hinterland connectivity, (4) Bottlenecks and congestion, and (5) Container dwell time and waiting time.

Selection Start set of papers

The selection of the aims to identify a limited number of relevant and well-established studies, enabling effective forward- and backward snowballing. (Wohlin, 2014)

An initial relevance assessment of the identified articles was conducted based on their titles and abstracts to ensure alignment with the study’s purpose. In addition to this, citation count was used as an inclusion criterion, as articles with enough citations provide a stronger basis for forward snowballing. Articles with 20 citations or fewer were therefore excluded from the starting set. In the final selection of start set papers, the papers were reviewed at greater depth through full-text, content analysis, to confirm their relevance and contribution to the study purpose. That combination, along with relevance screening, citation-based selection, and final decision-making, ensured that only articles with a clear focus on the research aim were included in the starting set. In addition, the initial set was selected to ensure a breadth of perspectives by including studies published in different journals and authored by different research groups, reducing the risk of conceptual or publication bias. (Wohlin, 2014)

2.2.2 Step 2 – Iteration and Snowballing

Iterations

The iteration step included forward and backward snowballing (Figure 1), which was conducted until no new papers or additional information were identified in the reviewed literature. Each paper from the starting set was processed individually. For each paper, backward and forward snowballing were conducted and continued until no additional relevant papers were found. This procedure was then repeated for each of the remaining papers in the starting set. The snowballing process was terminated when thematic saturation was reached, meaning that additional iterations did not contribute new themes or insights relevant to the research aim (see APPENDIX 1). (Wohlin, 2014)

Backward snowballing

Backward snowballing consists of examining references to identify those that could be included in the frame of reference, then examining the references used in the newly identified papers, and so on, until no more relevant information is found (Wohlin et al., 2022).

This included scanning the reference lists of all papers in the initial set. Thereafter, an initial exclusion was applied to articles that did not meet the predefined criteria for publication date, language, and peer-review status. In addition, duplicate references were removed, i.e., studies that had already been evaluated or previously included or excluded in earlier stages of the selection and snowballing process. (Wohlin, 2014)

After the initial steps were made, the remaining papers were candidates for inclusion in the frame of reference. The next step involved screening the titles to assess their relevance to this research focus. For example, titles lacking keywords or a clear connection to the research area were excluded. In contrast, titles containing phrases or terms such as “container,” “dwell time,” “hinterland connection,” or “bottlenecks” were selected for further examination. The publication venue was considered as an additional filtering criterion. Articles published in journals unrelated to logistics or transportation, for example medical journals, were excluded from further examination. (Wohlin, 2014)

Following these inclusions and exclusions, the remaining candidate articles were subjected to a more detailed screening. At this stage, key parts such as the abstract, background, and conclusion of the papers were reviewed to assess whether the articles should be included or excluded, without conducting a full-text read. The remaining papers were then evaluated for inclusion in the final frame of reference during full-text reading. The important point here is to evaluate whether the articles contributed new and relevant insights to the study and did not repeat insights or findings already covered in previously included articles. Once a paper was selected for inclusion through backward snowballing, the same procedure was applied to its reference list. (Wohlin, 2014)

Forward snowballing

The forward snowballing, on the other hand, examines the articles that cite the selected articles. The procedure follows the same general structure as backward snowballing, with the key difference being that citation lists are examined rather than reference lists. Apart from this difference, the same inclusion/exclusion steps as in backward snowballing were applied before an article was included in the final frame of reference. This ensured consistency in the evaluation process across both backward and forward snowballing. (Wohlin, 2014)

2.3 Case study

A case study (Yin, 2009) of the import of CSSC to Sweden via Swedish ports was conducted, drawing on perspectives from multiple actors within the container transport value chain.

2.3.1 Case Description

The empirical data in the case study were collected through qualitative interviews (Kvale & Brinkmann, 2015; Yin, 2009) with companies, stakeholders, and actors across the CSSC (i.e., from origin to destination) for imported containers to Sweden (see APPENDIX 3). The scope of the case study is presented in Figure 2.

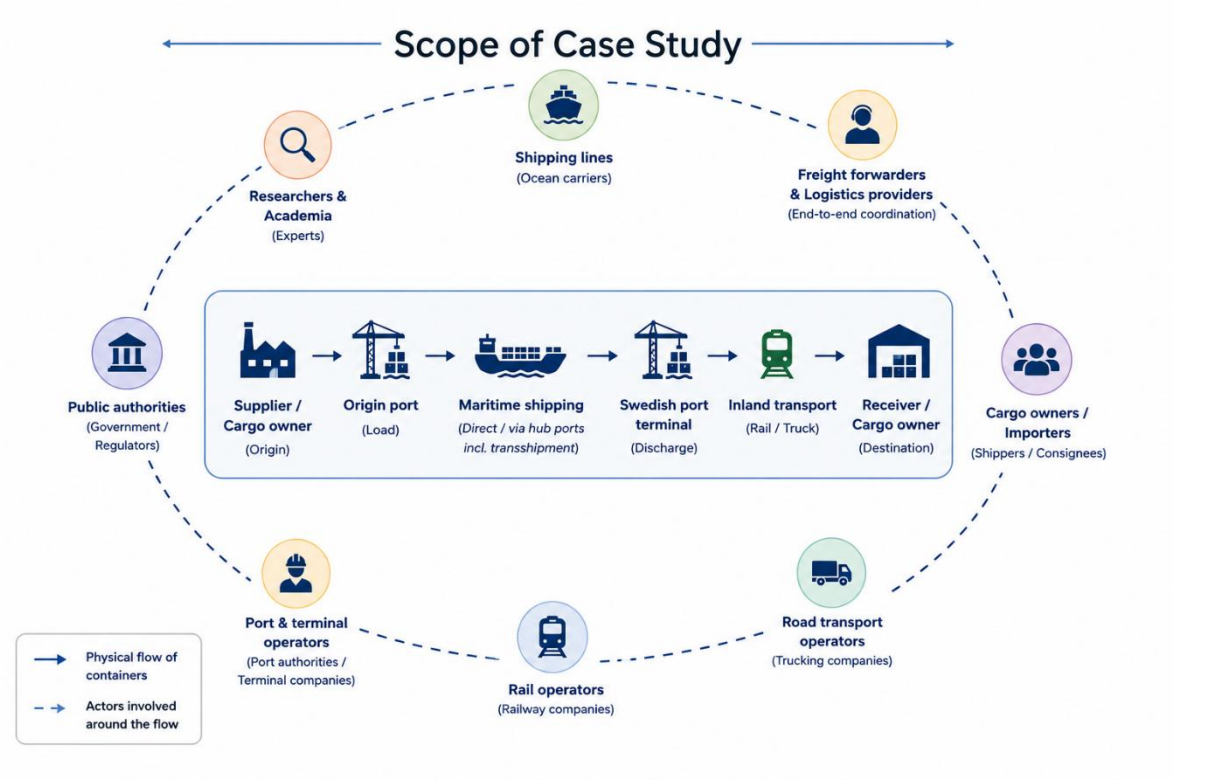

Figure 2, Case study scope (Song, 2021; Ducruet & Notteboom, 2012; Wendler-Bosco & Nicholson, 2019) [Created with PowerPoint and modified with Gemini (2026)].

The empirical data in this study were drawn from three main sources: (1) semi-structured interviews, (2) documents and statistics, and (3) scholarly publications. The interviews were the primary data source and were conducted in a Swedish import context, focusing on containerized cargo flows through Swedish ports. The documents, statistics, infrastructure

planning frameworks, policy instruments, and scholarly publications served as secondary data to describe and contextualize the case study's empirical setting.

2.3.2 Respondents

Interview respondents comprised actors along the container supply chain. The initial interviews focused primarily on actors with broad visibility across the supply chain, particularly freight forwarders, who coordinate activities between producers and buyers/importers in Sweden. This approach enabled the study to establish an overarching perspective on the container supply chain from origin to destination. Additionally, interviews were conducted with other actors and stakeholders along the supply chain, such as inland transport companies (truck/train) in Sweden, ports and shipping companies, cargo owners, receivers, and logistics experts and researchers. Although all interviews were conducted from an end-to-end perspective, each interview naturally emphasized the respondent's specific area of expertise within the supply chain.

The full list of all respondents in this thesis is presented below and found in APPENDIX 3.

Interview ID	Date of interview	Experience	Actor type	Role in CSSC
I.1	2026-02-09	5 Years	Logistics provider (Sea/Inland)	Coordinate: End-to-end → Sweden (customer delivery)
I.2	2026-02-17	10 Years	Logistics provider (Sea/Inland)	Coordinate: End-to-end → Sweden (customer delivery)
I.3	2026-02-12	40+ Years	Logistics provider + Shipping line (deep-sea/feeder)	End-to-end transport & logistics solutions → Sweden
I.4	2026-02-19	30+ Years	Academic	Professor in logistics & shipping, end-to-end perspective.
I.5	2026-02-25	30+ Years	Shipping line (deep-sea/feeder/short sea)	Global end-to-end services → Sweden (sometimes inland as well)
I.6	2026-03-06	25+ Years	Shipping line (feeder/ short sea)	Maritime transport, European ports → Swedish ports
I.7	2026-03-06	30+ Years	Rail operator (Inland)	Port → inland distribution (Sweden)

I.8	2026-03-09	5 Years	Shipping line (feeder/ shortsea)	Maritime transport, European ports → Swedish ports
I.9	2026-03-11	20+ Years	Swedish Port/Terminal	Terminal operations, Discharge → hinterland connectivity
I.10	2026-03-18	35+ Years	Industry Expert	Cross-segment expertise across the entire CSSC
I.11	2026-03-19	40+ Years	Swedish Port/Terminal	Terminal operations, Discharge → hinterland connectivity
I.12	2026-03-19	5 Years	Importer/Goods owner	Demand-side actor (inbound logistics, Service procurement & coordination)
I.13	2026-03-19	15+ Years	Swedish Port/Terminal	Terminal operations, Discharge → hinterland connectivity
I.14	2026-03-23	20+ Years	Importer/Goods owner	Demand-side actor (inbound logistics, service procurement & coordination)
I.15	2026-03-24	20+ Years	Importer/Goods owner	Demand-side actor (inbound logistics, service procurement & coordination)

Table 1: Respondent list from interviews in the case study.

2.3.3 Interviews

According to Barriball et al. (1994), respondents from different actor groups possess varying knowledge, insights, and perspectives, which requires adaptation of the interview approach. As noted by Song (2021), actors in the CSSC have distinct responsibilities and knowledge across different areas. Due to that, separate semi-structured interview (Kvale & Brinkmann, 2015) guides were used for different actors in the CSSC. For segments of the supply chain involving interactions between multiple actor groups, equivalent questions were used to enable comparison across perspectives. For example, interviews with port actors focused on the flow from vessel arrival to vessel departure. In contrast, interviews with cargo owners, logistics companies, and freight forwarders focused on the end-to-end supply chain. Interviews with inland transport companies focused on the flow from the point at which containers leave the port.

The semi-structured guides included questions organized into specific themes based on the SLR to ensure a strong connection between research and empirical investigation (Kvale & Brinkmann, 2015). The questions were formulated to allow respondents a high degree of

freedom in how to reply. The questions were open-ended, clearly worded, and participant-oriented (Kallio et al., 2016). The interviews were held either face-to-face or over webcam. The semi-structured interview guides followed a two-level question structure within each theme: (1) main questions, i.e., the main content that the research needs to cover, and (2) follow-up questions (Kallio et al., 2016). Follow-up questions comprised both pre-designed questions and additional questions introduced by the interviewer to clarify or expand on respondents' answers (Kvale & Brinkmann, 2015; Bell et al., 2019). Questions could also be skipped if they were indirectly answered in other questions. In general, all main questions were asked of all respondents, with a similar tone and wording across interviews. To encourage descripted responses, questions were formulated using introductory words such as "What", "Who", "Where", "When", and "How", or similar (Kallio et al., 2016).

All interviews followed a structure that began with a brief introduction, some small talk, and a welcome to establish a connection with the respondent (Bell et al., 2019). Thereafter, permission to record the interview was requested, and respondents were informed about anonymity, data storage, and their right to leave the interview at any time. The interview then started with background questions regarding the respondent's role in the company, position, experience, years in the industry, etc. The main themes were then addressed, with flexibility to move between themes or omit questions if the respondent's answers covered multiple areas (Kallio et al., 2016). The interview ended with some open-ended questions, allowing respondents to add information that may not have been covered and to suggest additional potential interviewees (Bell et al., 2019).

In addition, an internal pre-testing of the interview guides was conducted with two individuals to obtain feedback and critique on the formulations and to assess whether the questions were indeed open-ended (Kallio et al., 2016). For a complete interview guide, see APPENDIX 2.

2.4 Data analysis of empirical data

2.4.1 Analytical approach

The empirical material is analyzed using a qualitative and deductive thematic approach (Miles et al., 2014). Where the analysis is guided by a predefined analytical framework, derived from the literature review (Braun & Clarke, 2006). The purpose of the analysis is to investigate how themes identified in existing research (Chapter 4) are reflected in the empirical material within the Swedish context of containerized imports. (Miles et al., 2014). In doing so, the study applies a form of methodological triangulation in the analytical process (Fusch et al, 2018). This involves analyzing empirical insights from interviews in relation to published academic literature (Chapter 4) and grey literature and statistical data (Chapter 3). By combining these different data sources, the analysis allows for cross-validation of findings and provides a more nuanced understanding of containerized import flows in the Swedish context.

The analysis follows a structured process in which transcripts from the recorded interviews are systematically analyzed and coded according to the theoretical framework. These themes

provide a common analytical structure across all interviews, enabling comparison between respondents and across different parts of the container shipping supply chain. (Miles et al., 2014)

The analytical process involves moving between the coded empirical data and the theoretical framework. This is to identify patterns, similarities, and differences. A Qualitative Data Analysis (QDA) software was used to support the organization, analysis, and visualization of the data. The interpretation of the data remains the responsibility of the researcher, in line with established quality research principles. (Miles et al., 2014)

2.4.2 Thematic analysis of literature

Scholarly papers selected in the SLR were analyzed using thematic analysis (Braun & Clarke, 2006) based on three parameters.

1. Themes were retained based on their analytical relevance to the research questions rather than solely on frequency or occurrence in the literature (Braun & Clarke, 2006; Tabari et al., 2020).
2. Themes were included if they were discussed and emphasized across multiple studies in the literature, indicating recurring patterns or shared concerns across the studies (Braun & Clarke, 2006).
3. Certain themes were included to ensure theoretical coverage of key segments of the whole container supply chain, even if they did not recur in multiple studies (Braun & Clarke, 2006; Bell et al., 2019). The final set of themes is further presented and discussed in greater depth in the literature review.

Based on the systematic literature review (SLR), a final set of main themes was identified and subsequently used to develop interview guides and as a foundation for the empirical analysis (Wohlin, 2014). The analytical approach used in this study was deductive coding, in which these themes formed a predefined analytical framework that guided the coding process (Miles et al., 2014).

The thematic analysis of the SLR identified key analytical dimensions for understanding CSSCs. These themes were used to guide both the interview design and the subsequent empirical analysis of interviews.

- **Structure and organization of CSSC**, including hub-and-spoke systems, transshipment structures, feeder dependence, port structure and hinterland integration/structure, etc (e.g., Song, 2021; Wendler-Bosco & Nicholson, 2019; Ducruet & Notteboom, 2012).
- **Bottlenecks and operational disruptions in CSSCs**, including congestion, schedule variability, transfer delays, and reliability challenges at critical nodes (e.g., Rodrigue, 2024; Calatayud et al., 2017; Song, 2021; Yue & Mangan, 2023).

- **Operational performance and infrastructure conditions**, including port, terminal, and inland transport operations, capacity constraints, handling efficiency, and hinterland connectivity (e.g., Roy et al., 2020; Van Der Horst & De Langen, 2008; Ceulemans et al., 2024).
- **Demand and capacity dynamics,** including demand variability, flow imbalances, and capacity-pressure relationships affecting transport performance and congestion patterns (e.g., Calatayud et al., 2017; Karamelic et al., 2025; Yue & Mangan, 2023).
- **Interdependencies and cascading (domino) effects** within interconnected CSSCs, where disruptions propagate across transport legs and nodes, affecting system-wide performance, reliability, and flow efficiency (e.g., Fransoo & Lee, 2013; Calatayud et al., 2017; Arpin et al., 2024).

Together, these themes informed the study's analytical framework and guided the organization of the empirical findings.

2.4.3 Analysis of interviews

To prepare the data for analysis, all interviews were transcribed into separate text files. The transcriptions were conducted digitally using the software Klang AI (Klang AI, 2016) and "cleaned" manually afterward by the researcher. By 'cleaned', this refers to the removal of non-substantive audio, such as small talk or filler sounds, such as recorded small talk that was not part of the interview or sounds from either the respondent or the interviewer, like "eehmm". Otherwise, all other wordings were kept, minimizing transcription-related bias. (Bell et al., 2019).

The transcripts from all interviews were imported into Qualitative Data Analysis (QDA) software Taguette (Taguette, 2026) and prepared for analysis. Through this, Taguette was used to support the systematic organization, coding, and retrieval of qualitative data, while the analytical interpretation remained the researcher's responsibility (Miles et al., 2014). This use of Taguette included data condensation, deductive coding, and thematic organization, where relevant segments of the interview material were assigned to analytically meaningful categories (Miles et al., 2014).

The identified themes from the SLR (2.4.2) functioned as an analytical framework for organizing the empirical material (Miles et al., 2014). During the coding process, some sub-themes were introduced to capture patterns, variations, and the behaviour within each main theme. All of this is in line with the iterative qualitative analysis process and allows for the refinement of sub-themes within the predefined thematic framework. The thematic coding of interviews is shown in APPENDIX 4.

Thus, Taguette was used to organize and retrieve coded data, enabling comparisons across interviews, supporting the identification of recurring patterns, and visualizing the empirical data. It is important to note that Taguette does not analyze data on its own; it should be seen as a support tool for interpreting and reasoning about the collected data. (Miles et al., 2014)

2.5 Research quality

2.5.1 Validity

Validity in research concerns the extent to which a study accurately captures and investigates the phenomena under study (Creswell, 2014; Denzin & Lincoln, 2018). In this study, validity was strengthened through a clear alignment between the research aim, the theoretical framework, and the interview questions. Critical examination and reflection were conducted during the process to ensure this alignment (Noble & Smith, 2024). Furthermore, the interview questions were based on established literature (Bell et al., 2019).

The validity was further supported using triangulation, where the use of multiple data sources, including interviews, academic literature, grey literature, and statistical data, complemented each other (Fusch et al., 2018). This enabled a broader empirical grounding of the findings, where patterns could be identified and interpreted across different types of material.

Internal validity refers, for example, to how internal processes are conducted and documented (Bell et al., 2019; Creswell, 2014). This study furthermore seeks to be transparent in all processes; all study-related activities are documented (Noble & Smith, 2024). All records relevant to the study will either be mentioned in the text or listed in the APPENDIX.

External validity refers to the degree to which the findings can be generalized in other contexts and settings (Bell et al., 2019; Creswell, 2014). As this study focuses on imported containers through Swedish ports, the scope is deliberately narrow. The aim is to generalize it to the Swedish context for imported containers. Generalization beyond this specific context should therefore be approached with caution. A critical reflection on the collected data will be conducted; if the data are insufficient to draw any conclusions, this will be clearly described and reported in the conclusions (Noble & Smith, 2024).

A key challenge related to validity, reliability, and replicability in qualitative research concerns subjective bias, both from respondents and from the researcher (Bell et al., 2019; Denzin & Lincoln, 2018). For example, when using the snowball method, some article inclusions/exclusions are made based on the authors' judgment, while interview responses may vary depending on how questions are formulated. Noble & Smith (2024) therefore argue for the importance of critical reflection in qualitative studies of what is being found.

2.5.2 Reliability

Reliability refers to the trustworthiness of the research process and the extent to which the research approach is consistent and systematic (Creswell, 2014; Noble & Smith, 2024). In this study, reliability was strengthened by documenting the research process. (Bell et al., 2019). To further enhance reliability, triangulation has been applied to the analysis of results (Fusch et al., 2018).

The literature process is clearly documented and described, including the database used, the search phrases used, and how the snowballing procedure was conducted (see APPENDIX 1).

Furthermore, the procedure for identifying themes is transparently described; these themes lay the foundation for their development. (Bell et al., 2019; Braun & Clarke, 2006)

All interviews were audio-recorded and transcribed, and the analytical process conducted using Taguette was systematically described and documented. By ensuring transparency and consistency throughout the data collection and analysis phases, the study aims to enhance the reliability of its findings. (Creswell, 2014)

2.5.3 Replicability

This study aims to enhance replicability by establishing a clear and transparent structure (Denzin & Lincoln, 2018). The study is designed to be replicated by other researchers. This means that the methods and procedures are clearly defined, structured, and documented. By providing a detailed description of the process, another researcher could follow the same structure and conduct a similar study, potentially yielding similar results (Bell et al., 2019).

Furthermore, achieving full replication is more challenging in a qualitative study than in a quantitative one. In qualitative research, the data collection process is influenced by contextual factors and respondents' subjective interpretations (Denzin & Lincoln, 2018). Moreover, the use of semi-structured interviews introduces flexibility in questioning, which may lead to variations in responses and interactions between interviews (Kvale & Brinkmann, 2015). As a result, exact replication of the study is difficult, even if the same research design is applied. This research study is a fairly specific case, both in location and in the type of business, and everything outside that scope cannot be replicated or expected to yield the same results (Bell et al., 2019).

2.6 Ethics

There is no conflict of interest in this thesis. The thesis was written independently by the author.

2.6.1 Ethics using literature

All references used are cited correctly and presented in the author's own words, which is an important ethical aspect of academic research (Bell et al., 2019; Creswell, 2014). The study follows a clear and transparent approach to referencing, ensuring that all sources are correctly handled and that plagiarism is avoided. The references were furthermore used in the correct context. Some of the methodological sources used do not specifically address logistics or shipping; the methods described in those articles are suitable for qualitative research across different academic disciplines.

The references used also need to be ethical (Denzin & Lincoln, 2018). All references in the literature review are peer-reviewed, and only studies that adhere to ethical research practices and have no hidden agenda were included.

2.6.2 Ethics in qualitative research

According to Bell et al. (2019), participation in research should be voluntary. All respondents in this research voluntarily participated in the thesis, and no financial or other incentives were

offered. Furthermore, all respondents were informed of their right to withdraw from the interview at any time, which was clearly explained prior to the interviews. All respondents were also informed of the study's purpose before the interview (Kvale & Brinkmann, 2015).

Another important ethical aspect concerns responsibility for the handling of empirical data collected (Creswell, 2013). All interviews were audio-recorded with the respondent's permission. All files and transcripts were safely stored, with access restricted to the researcher. All respondents were anonymized, and no identifying information, such as names or ages, was disclosed (Denzin & Lincoln, 2018). The data were furthermore only used for this study, and after the study was finished, all transcripts and sound files were deleted permanently.

Furthermore, the interviews were conducted in Swedish, so all findings were translated into English by the researcher. To minimize the risk of misinterpretation, the translations aimed to preserve the original meaning and context of the respondents' statements as accurately as possible. However, minor linguistic adjustments were made to ensure grammatical correctness, readability, and a natural academic flow in English. (Kvale & Brinkmann, 2015)

2.6.3 Use of AI and other help tools

In this thesis, AI served as a helpful tool for spelling, grammar, and alternative phrasing. The help tools that were used in this thesis were Grammarly (2026), Gemini (2026), and ChatGPT (OpenAI, 2026). Furthermore, AI assisted in creating figures and images in this thesis. All of this is in line with Chalmers' directives on how AI may be used (Chalmers, 2026). With the help of these tools, the author created a good flow and grammatical structure in the thesis. AI tools were not used to generate new text or find sources. All writing was conducted by the author, and the source scanning was conducted by the author. AI was only a tool to help correct grammar errors, structure the text, and suggest alternative wordings for the author's already written text.

3. The Case Study's Empirical Context

This chapter presents the empirical context of the Swedish container port system, including import flow patterns and hinterland transport structures. It also outlines relevant regulations, infrastructure planning frameworks, and policy instruments such as "Sjökalk". These elements provide the contextual basis for the case study.

3.1 Seaborne Containerized Trade import patterns to Swedish ports

Sweden is highly dependent on maritime transport for both imports and exports (SCB, 2025; Vierth, 2024). According to Trafikanalys (2026), approximately 600,000 loaded TEUs are discharged in Swedish ports each year, corresponding to around 5.5 million tonnes of containerized imports. This pinpoints the importance of well-functioning logistics chains in which ports play a central role.

Figure 3 and Figure 4 present the development of loaded TEUs and discharged containerized cargo in tonnage between 2016 and 2024 (Trafikanalys, 2026), illustrating the scale of containerized import flows handled by Swedish ports during the period.

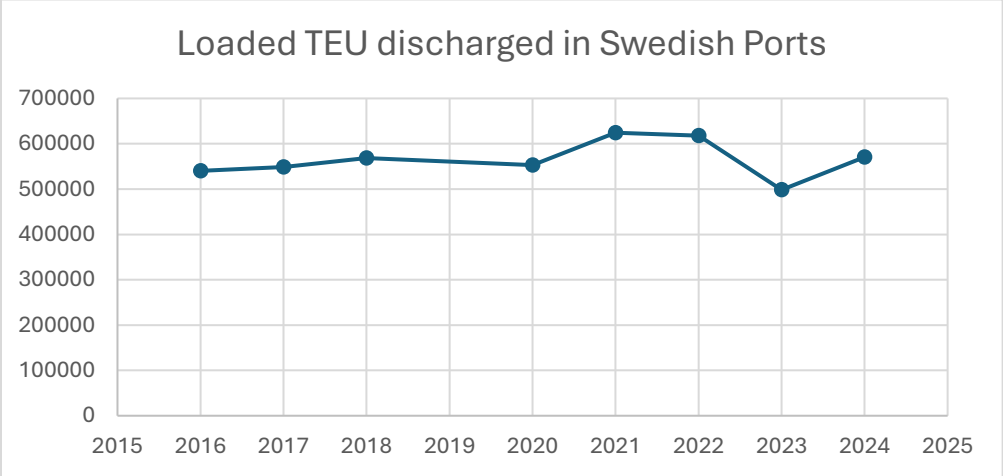

Figure 3: Number of loaded TEU discharged in Swedish ports 2016-2024 (Trafikanalys, 2026).

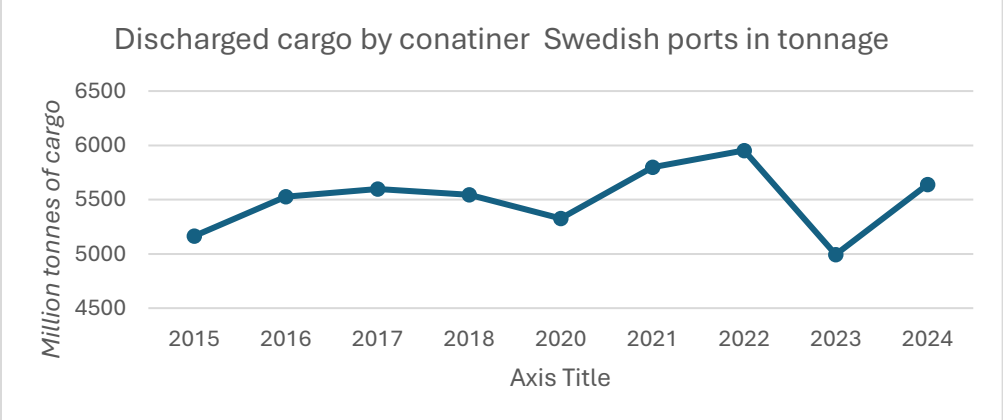

Figure 4: Discharged cargo by container – Swedish ports in tonnage (Trafikanalys, 2026).

Figure 5 illustrates the importance of imports and exports to the Swedish economy (SCB, 2026). However, this study focuses specifically on containerized import flows.

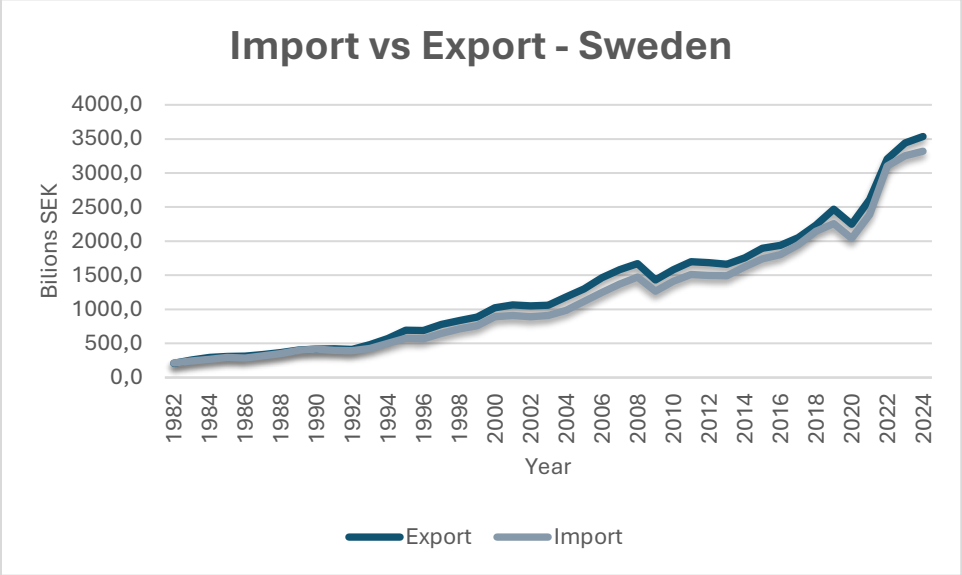

Figure 5, Import vs Export to and from Sweden (SCB, 2026).

3.1.1 Trading Partners and Import Structure

Sweden imports goods from many countries. The primary countries of import include the Nordic countries (Norway and Finland), Germany, the Netherlands, and China (Kommerskollegium, 2024).

When distinguishing between Country of Origin (COO) and Country of Consignment (COD), different patterns emerge (Kommerskollegium, 2024). In terms of Country of Origin, China represents the largest source country outside the Nordic region. However, in terms of Country of Consignment, Germany represents the largest source country.

According to Eurostat (2025), the distinction between COO and COD is important in the context of containerized trade. While COO refers to the country where the goods were originally produced, COD refers to the country from which the goods were dispatched to Sweden. This reflects the role of intermediary countries and logistics hubs within European distribution networks (Sharma, 2011). As a result, Swedish import flows are shaped not only by production geography but also by transshipment patterns and regional distribution systems.

3.1.2 Transshipment structure and Hub connections

As indicated by the discrepancy between COO and COD, Swedish container imports rely heavily on a hub-and-spoke network centred around major North European logistics hubs (Brunander et al., 2025). Key gateway ports such as Rotterdam, Antwerp, and Hamburg serve as primary transshipment points, connecting global container networks to destinations in Sweden.

Many Swedish ports currently lack the depth and infrastructure to accommodate the largest classes of container vessels, except for Gothenburg (Sjöfartsverket, 2026; Vierth, 2024). Gothenburg is the only Swedish port with direct deep-sea services from Asia and North America, with particularly high volumes on Asia–Europe routes (Sjöfartsverket, 2024; Brunander et al., 2025; Sjöfartstidningen, 2025).

Nevertheless, the term "direct line" should not be interpreted as a non-stop connection between Asia and Gothenburg. Rather, it refers to a liner service configuration where vessels call at several ports during the same rotation (Brunander et al., 2025). For example, Gemini's (Maersk & Hapag-Lloyd) Asia–Europe rotation includes the following port sequence:

> ***Shanghai - Yantian - Tanjung Pelepas – London Gateway – Aarhus – Gothenburg – Rotterdam – Southampton – Singapore*** (Maersk, 2026).

In addition to deep-sea services, Gothenburg and other Swedish container ports are integrated into European feeder networks that connect to major hub ports (Brunander et al., 2025).

Thus, import flows of containers to Sweden frequently involve transshipment at intermediate European hubs. The final leg of maritime transport to Swedish ports is typically served by feeder vessels (Brunander et al., 2025; Unifeeder, 2026; MSC, 2026).

3.1.3 Illustrative Routing Structures

To illustrate how import flows may be routed, Table 2 presents examples of routing patterns for containerized shipments from Asia to the Port of Gävle and to the Port of Gothenburg (Hapag-Lloyd, 2026; Maersk).

Port-port	Route	Vessel Type
Tokyo-Gavle	1. Tokyo- Shanghai 2. Shanghai-Wilhelmshaven/Hamburg 3. Wilhelmshaven/Hamburg-Gavle	1. Feeder 2. Ocean carrier 3. Feeder
Shanghai–Gavle	1. Shanghai-Wilhelmshaven/Hamburg 2. Wilhelmshaven/Hamburg-Gavle	1. Ocean carrier 2. Feeder
Tokyo–Gothenburg (Direct call 2nd leg)	1. Tokyo-Shanghai 2. Shanghai- Gothenburg	1. Feeder 2. Ocean Carrier
Tokyo-Gothenburg	1. Tokyo – Shanghai 2. Shanghai -Wilhelmshaven 3. Wilhelmshaven – Gothenburg	1. Feeder 2. Ocean carrier 3. Feeder
Shanghai -Gothenburg (Direct call)	1. Shanghai-Gothenburg	1. Ocean carrier
Shanghai-Gothenburg	1. Shanghai- Wilhelmshaven 2. Wilhelmshaven-Gothenburg	1. Ocean carrier 2. Feeder

Table 2. Examples of routing structures to Sweden from Asia (Hapag Lloyd, 2026; Maersk, 2026).

Similar routing patterns can be observed for other carriers to Swedish ports, often involving at least one transshipment at a major North European hub (except for some calls that are direct to the port of Gothenburg from Asia) (MSC, 2026; Hapag-Lloyd, 2026; Maersk, 2026). This is not exclusive to the Asia trade line; even shipments within Europe or from America often involve at least one transshipment.

Within Europe, Swedish ports are commonly connected to ports in Germany, Belgium, and the Netherlands, particularly Rotterdam, Antwerp, Hamburg, Wilhelmshaven, and Bremerhaven (Brunander et al., 2025; Eurostat, 2026).

3.2 The Swedish Container Port System

Sweden has approximately 15 ports that regularly handle container vessels and containerized cargo (Johansson, 2024). According to Eurostat (2026), approximately 1,600 container vessels arrived annually at Swedish ports in 2025.

When considering the number of port calls, the two largest container ports are Gothenburg and Helsingborg (Johansson, 2024). However, the number of vessel calls alone does not fully reflect a port's importance, as it does not account for the volume of cargo handled or the size of the vessels calling at the port. A more accurate indicator is therefore the number of containers handled, or the tonnage of cargo discharged (Trafikanalys, 2026).

Table 3 presents the number of container ship calls at Swedish ports based on AIS data (Johansson, 2024). Differences between Johansson (2024) and Eurostat (2026) may partly reflect differences in measurement methods and vessel classifications, but could also indicate increasing concentration effects, where larger vessels carry higher cargo volumes per port call.

Port	2017	2018	2019
Åhus	81	96	59
Göteborg	645	599	501
Gävle	173	168	182
Halmstad	99	102	171
Helsingborg	472	470	549
Karlshamn	31	34	1
Malmö	64	50	49
Norrköping	213	205	235
Oxelösund	12	41	34
Piteå	54	51	50
Sundsvall	85	96	101
Södertälje	57	49	52
Stockholm	159	156	131
Umeå	52	52	55
Varberg	92	51	52

Table 3: Number of port calls by container ships to Swedish ports (Johansson, 2024, p.6).

3.2.1 Container Volumes and Port Concentration

Gothenburg is Sweden's largest container port by both container volumes and tonnage (Trafikanalys, 2026). Other major container ports include Gävle, Helsingborg, the ports of Stockholm and Norrköping (Vierth, 2024).

In 2024, the Port of Gothenburg handled approximately 55% of all containerised cargo imported to Sweden, measured in unloaded TEUs (Trafikanalys, 2026). This illustrates the strong concentration of container flows to a limited number of ports (Vierth, 2024). Table 4 presents the number of unloaded containers across Swedish port regions in 2024 (Trafikanalys, 2026).

Geographical areas 2024	*Unloaded with cargo No/TEU*		*Unloaded empty No/TEU*
Haparanda–Skellefteå	4 311		1 580
Umeå–Sundsvall	424		3 877
Gävle	28 620		80 108
Stockholm Harbors	12 445		1 169
Uppsala–Eskilstuna	9 127		419
South Eastcoast	53 886		10 767
Karlskrona–Trelleborg	171		4 371
Helsingborg-Malmö	125 848		14 631
Halmstad–Varberg	19 487		3 376
Göteborg	315 121		133 297
Stenungsund–Strömstad	1 134		815

Table 4. Number of TEU unloaded in 2024 (Trafikanalys, 2026)

The figures in Table 4 show that containerised cargo in Sweden is concentrated in a relatively small number of ports, with Gothenburg handling the largest share. Other ports, such as Helsingborg, Norrköping, and Gävle, also handle significant volumes, but on a considerably smaller scale. (Trafikanalys, 2026)

Many Swedish ports are integrated into the European Trans-European Transport Network (TEN-T), which aims to strengthen connectivity between maritime transport, railways, and inland transport infrastructure across Europe (European Commission, 2026). The TEN-T framework identifies key transport nodes and corridors that are considered strategically important for the functioning of the European freight transport system (European Commission, 2024). Within this framework, ports such as the Port of Gothenburg are classified as core network ports, reflecting their role as gateways that connect Scandinavian freight flows to continental European logistics networks. The TEN-T policy also emphasizes the importance of integrating ports with inland transport networks, particularly rail and road infrastructure, to

support efficient multimodal freight transport across the European Union (European Parliament, 2024).

Recent reports (e.g., Vierth, 2024) suggest that this concentration trend may continue to increase. According to Vierth & Johansson (2025), larger vessel sizes and fewer port calls may lead to further concentration of container traffic at a smaller number of larger ports.

3.2.2 Hinterland structure of Cargo in Sweden

Lind (2024) analyzed the inland distribution patterns of containers handled at Swedish ports, including both major and smaller container terminals, across 24 ports. The study maps the geographic distribution of containerized goods from different ports into the Swedish hinterland.

The study shows the distribution patterns are influenced by several factors, including the port's geographical location, available inland infrastructure, and transport costs associated with different routes (Lind, 2024).

In Sweden, imported containers are primarily transported into the hinterland by rail or road (CEIC, 2024). A combination of rail and truck transport, therefore, dominates the Swedish hinterland network. However, in geographically limited cases, inland waterways may also be used, although this mode plays a minor role in Swedish container distribution (Sveriges Hamnar, 2011).

For example, at the Port of Gothenburg, approximately 50% of inland container transport is carried by rail, while the remainder is transported by road (Brunnander et al., 2025; Bergqvist, 2015). However, exact modal shares differ between ports, and detailed statistics are not available for all Swedish container ports. At the national level, around 30% of hinterland freight transport related to container flows is estimated to be carried by rail, while the majority is transported by road, with only limited use of inland waterways (CEIC, 2024; Trafikanalys, 2025).

Rail connections linking Swedish ports with inland regions are part of the broader European rail infrastructure network (European Commission, 2026). The European Union has established rail freight corridors to improve the coordination and capacity of international rail freight transport across Europe (European Parliament, 2024). Sweden is connected to the Scandinavian–Mediterranean corridor, which links the Nordic region with logistics markets in continental Europe (European Commission, 2026). For Swedish ports, these rail connections form part of the hinterland transport system that enables containerized cargo to be distributed inland by rail after arriving by sea.

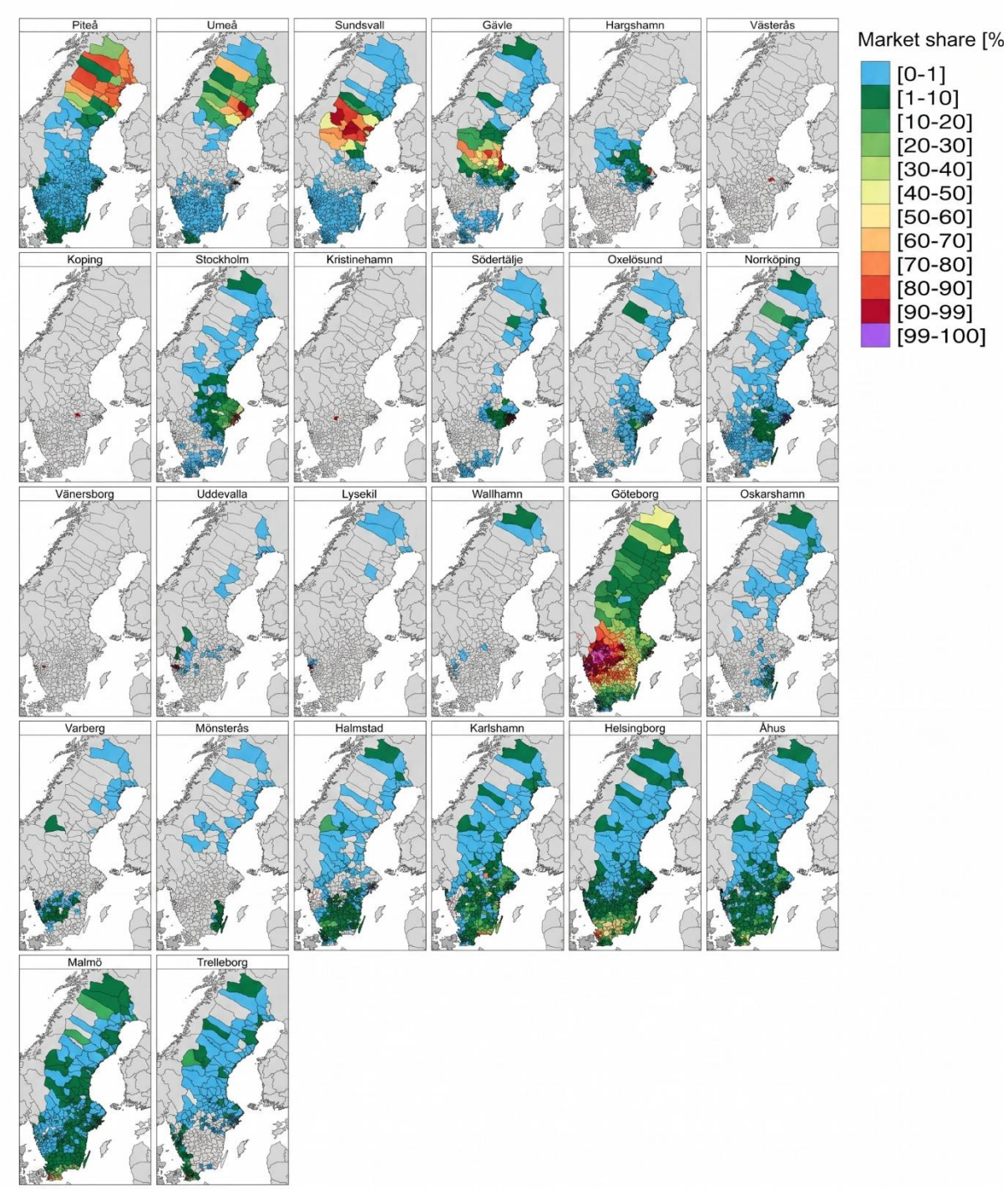

Figure 6 Hinterland distribution from different container terminals in Sweden (Lind, 2024, p.13).

Figure 6 shows the hinterland reach of different Swedish container ports and shows how container flows are distributed across regions. The mapping demonstrates that distribution patterns vary between ports. For example, containers discharged in Gothenburg are distributed across a large share of Swedish regions, making Gothenburg a dominant import gateway in terms of national hinterland reach (Lind, 2024).

Transporting goods over longer inland distances by rail or truck generally incurs higher costs than maritime transport over equivalent distances (Rodrigue, 2024; Trafikanalys, 2025). As a

result, the geographical location of ports and their hinterland connections influences the structure of inland distribution within Sweden (Lind, 2024).

3.3 Infrastructure appraisal tools

In Sweden, infrastructure investments in the transport sector are typically evaluated using socio-economic appraisal methods, primarily based on Benefit–Cost Analysis (BCA) (Trafikverket, 2024). These analyses aim to assess whether the societal benefits of a proposed investment exceed its costs, thereby supporting decision-making in physical infrastructure planning. The principles and valuation methods used in Swedish transport appraisal are defined in the ASEK framework, which provides standardized methods and economic values for socio-economic analyses within the transport sector (Trafikverket, 2024).

According to the European Commission (2024), improving port accessibility, including fairway depth, navigational conditions, and connections to inland transport networks, is an important element of European transport policy and the development of the TEN-T network. Efficient maritime access to ports is considered necessary to support the performance of freight transport systems and to facilitate the integration of maritime transport with inland logistics networks. In Sweden, similar priorities are reflected in national transport planning, where maritime accessibility and fairway capacity are important considerations in physical infrastructure planning and investment decisions (Trafikverket, 2023; Regeringskansliet, 2022).

For maritime infrastructure specifically, the Swedish Transport Administration (Trafikverket) uses the appraisal tool “Sjökalk”, which is designed to evaluate investments related to fairways and maritime accessibility (Asplund & Swahn, 2026; Trafikverket, 2026). The tool applies the same BCA principles as other transport appraisal models used by Trafikverket and is based on the methods recommended in the ASEK guidelines (Trafikverket, 2024; Trafikverket, 2026). In addition, Trafikverket uses the national freight model Samgods to analyze and forecast freight flows across road, rail, air, and maritime transport at the national level (Trafikverket, 2026).

BCA models rely on assumptions about transport demand, vessel movements, and cargo flows to estimate the impacts of infrastructure investments (Asplund et al., 2026; Trafikverket, 2026). In the context of maritime transport, improved insight into vessel traffic and freight flows can contribute to more accurate analyses and better decision support for infrastructure planning (De Jong et al., 2014). Recent reports on BCA analyses of maritime transport have highlighted the importance of detailed data sources, such as AIS vessel data and port traffic statistics, for improving the quality of these evaluations (Vierth et al., 2025).

Together, these characteristics of the Swedish port system, hinterland transport structure, and infrastructure planning framework provide the empirical context for analyzing containerized import flows and identifying potential bottlenecks.

4. Literature review

This chapter presents the theoretical foundation based on literature on container shipping supply chains, with particular emphasis on reliability, transit time, and port-related performance. The review adopts a system-level perspective, examining how maritime transport, port operations, and hinterland logistics interact to shape overall supply chain outcomes. By synthesizing prior research, the chapter establishes the theoretical foundation for the subsequent empirical analysis and identifies key gaps in the current literature.

4.1 Container Shipping Supply Chains as Integrated Systems

The container shipping supply chain (CSSC) can be conceptualized as an integrated logistics system in which maritime transports, ports, and inland distribution are structurally interconnected (Song, 2021; Notteboom & Rodrigue, 2008). Rather than representing a sequence of independent operations, the CSSC consists of multiple interrelated logistics segments. The five main logistics segments in the CSSC can be identified as:

1. Shipment/freight logistics.
2. Container logistics.
3. Seaborne transport & Logistics.
4. Port and terminal logistics.
5. Inland transport logistics & depot logistics. (Song, 2021; Lee & Song, 2016).

Each of the logistics segments performs distinct functions, yet coordination requirements and operational constraints across the chain shape their performance. (Song, 2021; Lee & Song, 2016; Notteboom & Rodrigue, 2008; Fransoo & Lee, 2013).

The logistics segments are functionally and temporally interdependent, meaning that decisions, delays, or capacity constraints in one part of the system may influence overall transit times, reliability, and flow performance (Karmelić et al., 2025; Song, 2021). Thus, containerized flows cannot be fully understood through isolated analysis of ports, vessels, or hinterland transport, as system-level outcomes emerge from interactions between multiple logistics segments within the supply chain (Schøyen et al., 2018; Fransoo & Lee, 2013).

Complementing the supply-chain-oriented perspective, Caschili & Medda (2012) conceptualize container shipping as a complex adaptive system characterized by non-linear interactions between multiple actors and operational components. In such systems, performance patterns and disruptions may emerge from the interplay between interconnected units rather than from single, identifiable causes. Thus, reliability and performance in container shipping are system-level phenomena shaped by structural interdependencies and coordination across logistics segments. (Song, 2021; Caschili & Medda, 2012; Schoyen et al., 2018; Fransoo & Lee, 2013).

While the CSSC perspective emphasizes structural interdependence, a deeper understanding of containerized flow performance requires examination of specific coordination mechanisms, operational interfaces, and disruption dynamics within the chain (Song, 2021). The following

sections, therefore, review existing research on key performance dimensions of container shipping systems, i.e., reliability and transit time, congestion and bottlenecks, port and terminal operations, and hinterland connectivity. Together, these themes provide the conceptual foundation of the literature for analyzing how delays and disruptions emerge across different segments of containerized import flows.

4.1.1 Key actors and stakeholders in CSSC

The transportation of a container from origin to the final destination involves a complex constellation of interdependent actors operating across maritime and inland segments (Song, 2021; Caschili & Medda, 2012). Understanding their respective roles and responsibilities is important for analyzing how congestion, delays, and capacity imbalances emerge and propagate within the container shipping supply chain. Based on a review of maritime supply chain literature, Wendler-Bosco and Nicholson (2019) identify six key actor groups involved in container transport:

-*Terminal Operators:* Terminal operators manage cargo handling operations, berth allocation, and yard management within the port.

-*Shipping lines*: Shipping lines design liner service networks, determine port rotations, and allocate vessel capacity. Their scheduling decisions influence the timing and structure of container flows across the network.

-*Cargo owners:* Cargo owners generate demand for transport services and make decisions regarding routing, inventory strategies and service selection.

-*Logistics providers:* Freight forwarders, trucking companies, rail operators, and other intermediaries coordinate transport, documentation, and cargo handling between different logistics segments.

-*Government/Public authorities:* Public authorities regulate customs procedures, safety standards, environmental compliance, and regulatory coordination in port and infrastructure planning, thereby influencing operational conditions within the supply chain.

-*Community and Researchers:* Local stakeholders and research institutions influence port development through environmental, social, and planning considerations.

In the maritime supply chain literature, these six actors are often grouped into internal and external stakeholders, depending on their degree of operational involvement and their relationship to port and logistics operations (Becker & Caldwell, 2015; Wendler-Bosco & Nicholson, 2019).

4.2 Reliability and Transit Time in the CSSC

Reliability is widely recognized as a critical performance dimension in container shipping, influencing both carrier competitiveness and overall supply chain efficiency (Yuen & Mangan, 2023; Sun et al., 2018). In liner shipping, reliability is commonly associated with schedule

reliability and the predictability of transit times, reflecting the extent to which vessels arrive and depart according to planned timetables (Sun et al., 2018). Persistent schedule disruptions caused by operational uncertainties at sea and in port operations have therefore long been identified as a key challenge in liner shipping operations (Zhang et al., 2022). However, from a supply chain perspective, reliability extends beyond vessel punctuality to encompass the coordinated functioning of interconnected logistics segments that jointly determine the door-to-door performance of container transport systems (Yue & Mangan, 2023).

Within CSSCs, integration refers to the degree of coordination and information exchange among interconnected actors and logistics segments (Tseng & Tao, 2015). Previous research suggests that stronger integration between supply chain actors, such as shipping lines, terminals, and shippers, can improve operational efficiency and facilitate smoother cargo flows (Wu, 2009; Tseng & Tao, 2015). Improved coordination and information sharing may therefore enhance reliability by aligning schedules, capacity utilization, and operational planning across different segments of the supply chain (Yuen et al., 2019).

4.2.1 Reliability as a System-Level Outcome

Yue & Mangan (2023) emphasize that reliability in container shipping should be understood from a system-level perspective, rather than through isolated assessments or individual nodes. Their conceptual framework illustrates how overall reliability in container shipping networks emerges from the interaction between infrastructure reliability, network configuration, and connectivity (Figure 7).

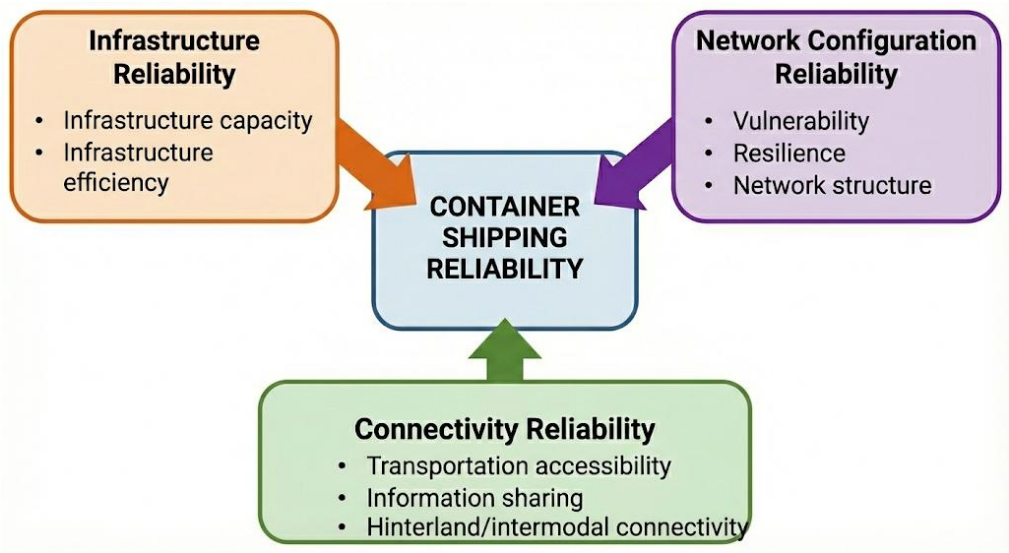

Figure 7: A framework for reliability in the context of container shipping network, adapted and modified from Yue & Mangan (2023, p. 530).

Infrastructure reliability refers to the capacity and operational performance of the physical infrastructure supporting container transport systems (Yuen & Mangan, 2023). This includes the infrastructure of ports, terminals, hinterland transport networks, and intermodal connections that enable the movement and storage of containers within the supply chain (Dekker et al., 2011;

Yau et al., 2020). Additionally, infrastructure reliability is determined not only by the transport infrastructure itself but also by how, and within what range, it can handle and recover from potential disruptive events (Yuen & Mangan, 2023; Mutombo & Ölcer, 2017).

Network configuration reliability refers to how the network is affected by disruptions and the supply chain's ability to maintain performance even when disruptions occur (Yue & Mangan, 2023). In this context, three closely related concepts are commonly discussed in the literature: vulnerability, resilience, and network structure.

Vulnerability refers to the extent to which a supply chain is affected by disruptive events (Yuen et al., 2019; Calatayud et al., 2016). Resilience reflects the system's ability to recover and return to normal operations after disruptions (Yue & Mangan, 2023; Asadabadi & Miller-Hooks, 2020). Thirdly, the structure of the network itself also plays a critical role, as the configuration and connectivity of nodes determine how disruptions propagate across the container shipping system (Yue & Mangan, 2023).

Connectivity reliability refers to the extent to which nodes within the container shipping network are effectively connected through transport infrastructure and logistics services (Notteboom, 2006; Calatayud et al., 2016; Yuen & Mangan, 2023). This includes physical connectivity between transport modes, such as sea–rail or sea–road interfaces, which enable the movement of containers between maritime and inland transport systems (Burghouwt & Redondi, 2013). In addition to physical connectivity, connectivity also refers to how various actors in the supply chain coordinate with each other, and how information and services interconnect with each other, which is important to maintain reliable cargo flows through different logistics segments (Notteboom, 2006; Calatayud et al., 2016; Yue & Mangan, 2023).

Similarly, Karmelić et al. (2025) demonstrate that disruptions within the CSSC may propagate across different logistics segments. For example, schedule disturbances in maritime transport can affect port performance and inland transport services. These findings reinforce the view that reliability and performance outcomes are shaped by interdependencies across the supply chain rather than by single operational events. Understanding how disruptions interact and propagate across logistics segments is, therefore, central to improving reliability in door-to-door container transport systems (Yue & Mangan, 2023; Karmelić et al., 2025).

4.2.2 Transit Time and Lead Time Decomposition

A key determinant in analysing lead time in CSSCs is that transit time constitutes (Fransoo & Lee, 2013; Zhang et al., 2022; Yue & Mangan, 2023). In container shipping, transit time should not be understood as a single variable, but rather as a composite outcome emerging from several interdependent logistics segments. Consistent with prior research (Notteboom, 2006; Fransoo & Lee, 2013), total transit time can be decomposed into three primary components: maritime sailing time, terminal dwell time, and hinterland transport time.

Maritime sailing time refers to the duration of transport between ports, and is largely influenced by network configuration, service design, vessel speed, and route structure (Song, 2021; Yue & Mangan et al., 2019; Notteboom, 2006). Although sailing time may appear relatively predictable under stable operating conditions, its reliability depends on both schedule reliability (i.e., adherence to planned timetables) and transit reliability (i.e., the consistency of actual voyage duration) (Notteboom, 2006; Chung & Chiang, 2011). Variations in sailing time may arise from weather conditions, congestion at upstream ports, slow-steaming strategies, customs procedures, or disruptions in global shipping networks (Zhang & Lee Lam, 2014). Variations in sailing time reliability also affect other logistics activities such as port planning and inland transport planning, as these segments depend on predictable vessel arrival times (Hye & Habib, 2025).

Port-related transit time includes both vessel turnaround time and container dwell time (Hye & Habib, 2025). Turnaround time captures the duration required for unloading and loading operations (Kuznetsov et al., 2021), while dwell time reflects the period containers remain within the terminal before onward transport (Molini et al., 2011). These components are highly sensitive to terminal capacity, crane productivity, yard utilisation, and operational coordination (Kourounioti et al., 2016). As such, port-related processes often introduce significant variability into total transit time and may therefore affect overall supply chain reliability (Kourounioti et al., 2016; Hye & Habib, 2025).

Hinterland transport time refers to the inland movement of containers between ports and final distribution points (Notteboom, 2006; Gonzalez-Aregall & Bergqvist, 2019). This segment is influenced by transport mode (e.g., rail or truck), distance, infrastructure capacity, and coordination between logistics actors (Fransoo & Lee, 2013; Kourounioti et al., 2016). In geographically extensive countries, hinterland transport time may constitute a substantial share of total transit time and can represent a critical source of variability within the logistics chain (Fransoo & Lee, 2013).

Hence, the three types of time illustrate that transit time is a system-level performance outcome shaped by interactions between maritime operations, terminal processes, and inland logistics. Consequently, variability in lead time frequently emerges not from a single segment but from the cumulative and interdependent effects of disruptions, congestion, and coordination challenges across the container shipping supply chain. (Fransoo & Lee 2013; Notteboom, 2006)

4.3 Key Elements in Analysing CSSCs

4.3.1 Key Concepts

To establish conceptual clarity for the subsequent analysis, the relationships between bottlenecks, capacity mismatch, and congestion, and how these phenomena manifest as waiting

time and dwell time within CSSCs is presented (Notteboom, 2006; Song, 2021; Kourounioti et al., 2016).

Congestion and bottlenecks are central mechanisms through which reliability is reduced and transit times become extended in container shipping supply chains (Song, 2021; Rodrigue, 2024). Capacity constraints at ports, transhipment hubs, and hinterland interfaces may limit throughput and disrupt flow continuity across interconnected logistics segments.

To understand how delays emerge and accumulate along import flows, it is necessary to distinguish between structural capacity limitations within the transport system and the operational manifestations of congestion, which may appear as waiting times, extended dwell times, or other disruptions across interconnected logistics segments.

Bottlenecks,
refers to a specific point in a logistics system where capacity is lower than the surrounding segments, thereby limiting the overall flow of goods. (Rodrigue, 2024; Notteboom, 2006). In container shipping supply chains, bottlenecks may occur at ports, terminals, transshipment hubs, rail corridors, or road interfaces (Song, 2021; Calatayud et al., 2017). When the flow of containers exceeds processing capacity, delays accumulate, and throughput becomes constrained (Karmelić et al., 2025). Unlike congestion, which describes the observable condition of delay or queuing, a bottleneck refers to the underlying structural constraint causing such congestion.

Capacity mismatch,
refers to situations in which an imbalance exists between arrival rates and available handling capacity within a logistics system (Kourounioti et al., 2016). This may arise from concentrated vessel arrivals, limited berth availability, insufficient yard space, or differing handling times between transhipment and incoming goods, for example, transhipment to hinterland connections (Hye & Habib, 2025). Over time, recurring capacity mismatches may generate persistent congestion and reduce overall supply chain reliability. (Yue & Mangan, 2023)

Congestion,
in CSSCs refers to situations in which demand for infrastructure or services exceeds available capacity, resulting in delays, queuing, and reduced operational performance and reliability (Song, 2021; Notteboom & Rodrigue, 2012; Rodrigue, 2024). In CSSCs, congestion occurs when the arrival rate of vessels, containers, trucks, or trains exceeds the system's ability to process them within a given time period.

Waiting time,
refers to the delay experienced before receiving service (Xinyan et al., 2022; Rodrigue, 2024). In a container supply chain context, this may include vessel waiting time prior to berth allocation, waiting time before passing a canal, trucks waiting at terminal gates, or trains

waiting for available slots (Xinyan et al., 2022). Waiting time is therefore primarily associated with the queuing processes that arise when demand temporarily exceeds service capacity.

Dwell time,
refers to the period during which a container remains stored in a terminal after discharge and before leaving the port for onward transport (Ottjes et al., 2007; Kourounioti et al., 2016). In contrast to waiting time, which represents delays before service, dwell time reflects the storage duration of containers within the terminal system. Kourounioti et al. (2016) identify several factors influencing container dwell times, including the day and month of discharge, the port of origin, container characteristics such as size and type, and the nature of the cargo being transported.

Thus, the definition of the concepts illustrates how structural capacity constraints within container shipping supply chains may translate into observable operational delays. Bottlenecks and capacity mismatches represent structural limitations within the system, while congestion reflects the operational outcome of these constraints. Waiting time and dwell time, in turn, represent measurable manifestations of such congestion within different stages of containerized logistics flows.

4.3.2 Network structure, Transshipments, and Network Vulnerability

The network structure of container supply chains is often highly centralized, with traffic flows concentrated around a limited number of nodes (i.e., ports) that maintain the majority of network connections (Ducruet & Notteboom, 2012; Hu & Zhu, 2009). For example, major east–west trade corridors connect Asia, Europe, and North America, while regional and peripheral ports are linked to these main routes through feeder services and relay operations (Ducruet & Notteboom, 2012).

Since the CSSC is highly centralised, the CSSC network becomes hierarchical, with a relatively small number of hub and gateway ports functioning as pivotal connection points, while smaller ports depend on these nodes for access to intercontinental trade (Bai et al., 2023; Ducruet & Notteboom, 2012; Liu et al., 2017), i.e., hub-and spoke (Figure 8). However, the exact configuration of the network nodes differs from company to company, even when they have similar end-to-end flows (Calatayud et al., 2017).

For example, in Europe key nodes such as Rotterdam, Antwerp, and Hamburg serve as primary gateways and transshipment hubs, linking global mainline services with extensive feeder and hinterland networks (Ducruet & Notteboom, 2012).

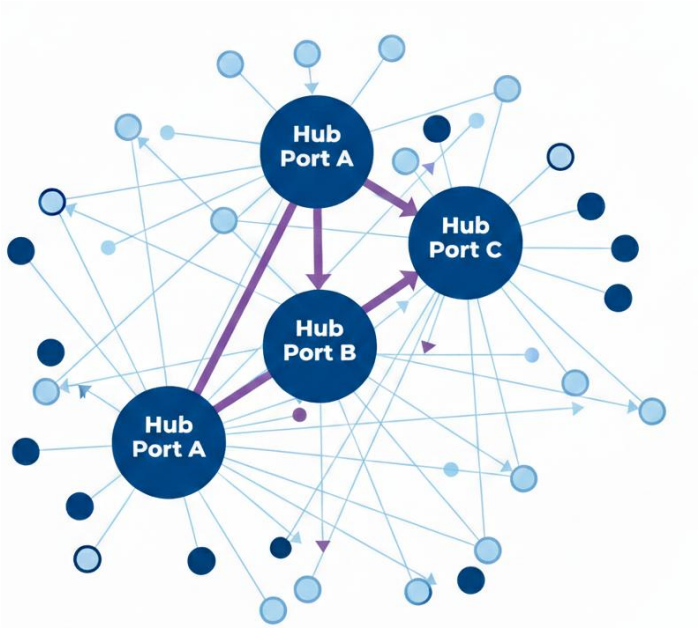

Figure 8: The hub-and-spoke structure (Calatayud et al., 2017; Arpin et al., 2024; Ducruet & Notteboom, 2012; Liu et al., 2017).

Organising container shipping networks in a hub-and-spoke configuration, implies that traffic flows concentrate through a limited number of strategically positioned nodes, including major hub ports and critical maritime chokepoints such as canals (Calatayud et al., 2017; Bai et al., 2023; Arpin et al., 2024).

The structural concentration enhances efficiency under normal operating conditions, it simultaneously increases systemic vulnerability if one or several of these nodes are disrupted (Bai et al., 2017; Tsantis et al., 2023). When disruptions or congestion occur at a central node or link, their effects may extend beyond the immediate location and influence connected parts of the network.

Hence, the operational performance of these intermediate nodes may therefore significantly influence not only the continuity of container flows but also the performance conditions at downstream destination ports (Calatayud et al., 2017). Disruptions affecting central nodes, even when occurring outside the destination country, may therefore contribute to congestion, accumulated delays, and operational pressure across other parts of the network.

This increasing centralisation of container shipping networks further reinforces this vulnerability, as the total number of nodes in the system has expanded both at sea and in the hinterland (Ducruet & Notteboom, 2012). This development implies that many smaller ports and inland nodes depend on a limited number of major hubs within the global container transport network (Bai et al., 2023; Ducruet & Notteboom, 2012).

4.3.3 Trade imbalance and empty container repositioning

A structural characteristic in the CSSCs, is the imbalance between import and export flows across regions (Braekers, 2011; Song, 2021). When trade flows are uneven, empty containers must be repositioned between ports, hubs, and inland depots to meet export demand, a process

often referred to as empty container repositioning (MTY repositioning) (Breakers, 2011; Notteboom & Rodrigue, 2012; Song, 2021). These repositioning flows account for a significant share of container movements and may influence network efficiency, terminal storage requirements, and inland transport demand (Song, 2021).

4.3.4 Drivers of Disruptions in Container Shipping

To understand operational indicators such as waiting time, dwell time, inefficiency, and congestion, it is important to distinguish these from the underlying drivers of disruptions or bottlenecks within the system (Rodrigue, 2024). In this context, two main categories of drivers can be identified: structural and episodic drivers.

Structural drivers are persistent and predictable capacity constraints embedded in the supply chain system, such as limited port capacity, recurring waiting times at canals or port entrances, or at hinterland connections (Rodrigue, 2024). These bottlenecks are not temporary disturbances; they rather reflect a long-term mismatch between transport demand and available system capacity within the container supply system (Yuen & Mangan, 2023). These structural weaknesses in the system often require long-term investments and planning to resolve. In other words, the demand exceeds what the system can handle over the long term.

Episodic drivers refer to something that is temporary, caused by a temporary increase in demand, or due to an unpredictable event. (Cao et al., 2024; Rodrigue, 2024). Episodic congestion can further be harder to predict and analyse; one example was the onset of the war in the Red Sea (Chen et al., 2025). Furthermore, some episodic drivers are more predictable, for example, episodic congestion that occurs in ports during peak-season events, such as the Chinese New Year or before Christmas (Tang, 2015).

Even if the primary cause of congestion is an episodic driver, the duration and severity of the impact are heavily dictated by the system's underlying structural characteristics (Calatayud et al., 2017; Cao et al., 2024). The time required for a supply chain to recover from a temporary shock depends on its inherent reliability and robustness (Cai et al., 2024). In a system characterized by high structural vulnerability, such as a centralized hub-and-spoke network, as mentioned earlier, with limited buffer capacity, even a short-lived episodic event can lead to prolonged recovery periods (Liu et al., 2017; Ducruet & Notteboom, 2012). This interplay suggests that while episodic events act as triggers, the long-term performance and the system's ability to resume normal operations are ultimately determined by the structural resilience of the network (Calatayud et al., 2017; Cao et al., 2024; Liu et al., 2023).

4.3.5 Propagation and Cascading Effects in the CSSC

Disruptions in container shipping supply chains do not necessarily remain confined to the location where they originate (Karmelić et al, 2025). Due to the interconnected nature of maritime transport, port operations, and hinterland logistics, disturbances in one segment of the system may propagate across multiple nodes and transport stages (Karmelić et al., 2025; Song, 2021). For example, delays at subsequent ports, transhipment terminals, or during modal

transfers may influence the operational performance of the last port and subsequent inland transportation.

The propagation effect is particularly relevant in container shipping networks characterised by hub-and-spoke structures, where cargo flows frequently pass through intermediate transshipment ports before reaching their final destination (Ducruet & Notteboom, 2012; Calatayud et al., 2017). When disruptions occur at these central nodes, delays may affect feeder connections, vessel schedules, and the timing of cargo arrivals at downstream ports and further to the hinterland transportation (Fransoo & Lee, 2013). In addition to the network's structural characteristics, propagation effects may also be triggered by external events affecting major maritime routes or strategic chokepoints (Karmelić et al., 2025). Geopolitical conflicts, disruptions in critical canals, or extreme weather events may force carriers to reroute vessels or adjust liner schedules. Thereby generating cascading delays across multiple ports and logistics segments (Calatayud et al., 2017; Cao et al., 2024).

Consequently, congestion and waiting times observed at a specific port do not necessarily originate from local operational constraints alone but may instead reflect disruptions occurring earlier in the container shipping network (Fransoo & Lee, 2013; Song, 2021). Delays generated upstream in maritime transport, transshipment ports, or inland logistics may therefore materialize as congestion or extended dwell times at downstream ports (Schøyen et al., 2018). Analysing bottlenecks and other disruptions in containerized import flows may therefore require a broader system perspective that considers how delays behave across interconnected logistics segments within the container shipping supply chain (Fransoo & Lee, 2013; Song, 2021; Schøyen et al., 2018; Calatayud et al., 2017; Karmelić et al., 2025).

4.4 Ports and port-terminals in CSSCs

Ports and terminals are critical nodes not only as gateways between different transport modes and places where cargo is stored, but also as key nodes for the efficiency of the overall value chain (Pettit & Beresford, 2009; Han et al., 2018). Container terminals are thus fundamental nodes in global freight distribution (Notteboom & Rodrigue, 2012). The performance of ports is influenced by both internal operational processes within the terminal and external interactions with maritime services and hinterland transport systems (Roy et al., 2020; Schoyen et al., 2017). As a result, port performance may significantly influence the efficiency, reliability, and continuity of container flows across the wider supply chain (Pettit & Beresford, 2009).

In estimation of port performance, it is important to distinguish between internal port performance, which refers to operational processes within the terminal (Roy et al., 2020), and external port performance, which refers to interactions between ports and the surrounding logistics system (Jeevan et al., 2019; Kourounioti et al., 2016).

4.4.1 Internal port performance

Internal port performance refers to the efficiency of operational processes within the terminal that support cargo handling and vessel operations (Roy et al., 2020). Internal performance is

closely linked to the physical layout and interactions between different functional areas within a container terminal. A container terminal is commonly divided into two main operational zones: the quayside and the landside (Günther & Kim, 2006; Roy et al., 2020; Carlo et al., 2015). These zones typically consist of several functional areas, including the berth, quay cranes, internal transport systems, storage yards and terminal gates (Carlo et al., 2015). The berth and quay constitute the quayside, while the storage yard and terminal gate form part of the landside, with internal transport systems linking the two areas (Günther & Kim, 2006; Carlo et al., 2015). Terminal layout is an important factor influencing overall terminal performance and the interaction among different functional and operational areas within the terminal (Günther & Kim, 2006). Terminals must thus have sufficient storage capacity and internal transport systems to handle different container types efficiently. Roy et al. (2020) further highlight that coordination between quayside operations, yard management, and internal transport is central to port performance.

In addition to this, internal factors such as handling equipment, information systems, and the complexity of managing large container volumes may significantly influence operational performance in container terminals (Roy et al., 2020).

A key performance metric in container terminals is vessel turnaround time, referring to the time required for a vessel to complete loading and unloading operations at the port (Carlo et al., 2015; Hendriks et al., 2012). In addition to vessel turnaround time, container dwell time is a critical indicator of internal terminal performance, as prolonged storage increases yard occupancy and reduces effective handling capacity (Kourounioti et al., 2016). High yard occupancy levels may therefore reduce operational flexibility and increase the risk of congestion within the terminal. One factor influencing both turnaround time and dwell time is crane capacity and crane availability at the port, including yard and quay cranes used for loading and unloading vessels. This is often referred to as berth productivity, which is the average number of container moves performed per crane per hour while a vessel is at berth (Hye & Habib, 2025). Increased berth productivity improves overall container flows through the port and represents a key indicator when analysing internal port performance. It is therefore important for both terminal efficiency and overall supply chain performance (Beskovnik et al., 2019; Lu & Wang, 2017).

Internal port performance is also affected by a range of operational planning decisions at the seaside, including berth allocation, quay crane assignment, and crane scheduling (Carlo et al., 2015; Roy et al., 2020). These interrelated decision problems, often studied in the operations research literature, directly influence vessel waiting times, quay productivity, and overall terminal capacity utilisation (Li et al., 2023; Carlo et al., 2015). Efficient internal terminal operations are therefore essential for maintaining smooth container flows and avoiding congestion within the port system.

4.4.2 External Port Performance

External port performance refers to the extent to which port operations are synchronised with upstream maritime services and downstream hinterland transport systems (Jeevan et al., 2019; Kourounioti et al., 2016). Schøyen et al. (2018) argue that port performance cannot be analysed independently of the logistics chain to which the port belongs, as performance may be influenced by the extent to which associated logistics services are included in the analysis. Container terminals are a key element in logistics chains, acting as links between maritime transport and hinterland connections, or between maritime services in transshipment networks (Kourounioti et al., 2016; Lyons et al., 2016). Ports and port terminals are considered key regulators of efficiency and reliability in the container supply chain, as they may absorb delays and bottlenecks created in other parts of the logistics network (Kourounioti et al., 2016; Rodrigue et al., 2008). The position of a port within a shipping network also influences delay propagation, as delays occurring at one port may affect subsequent ports within the port rotation (Vernimmen et al., 2007; Fransoo & Lee, 2013). Similarly, hinterland connectivity is highly important for overall port performance and value creation in port systems (Bergqvist, 2012).

However, extended dwell times may reflect mismatches between maritime arrivals, terminal handling capacity, and inland transport synchronization, thereby signalling bottlenecks that extend beyond the terminal itself (Kourounioti et al., 2016). Thus, container dwell time in terminals should not be understood merely as an indicator of operational inefficiency, but rather as a manifestation of system imbalance within the broader container supply chain.

External coordination between actors involved in port operations is essential for maintaining smooth flows through the port node (Jeevan et al., 2019; Van der Horst & De Langen, 2008; Hintjens, 2018). From a bottleneck perspective, external port performance reflects how constraints may arise not only from internal terminal operations, but from mismatches across the wider supply chain (Jeevan et al., 2019). Ports may therefore act as bottlenecks due to variability in vessel arrivals, limited hinterland absorption, or coordination failures between actors (Yue & Mangan, 2023). Distinguishing between such dynamic imbalances and structural capacity constraints is essential for understanding the underlying causes of congestion and extended dwell times.

Customer integration in ports may positively influence both service quality and cargo flow through the port (Han, 2018). Nevertheless, the efficiency of port operations also depends on the capacity and synchronization of hinterland transport systems, where limited inland capacity may create bottlenecks manifested in congested container yards and extended waiting times (Jeevan et al., 2019; Rozic et al., 2025). External port performance, therefore, reflects how effectively ports interact with the wider logistics system, influencing congestion levels, dwell times, and the reliability of container flows.

4.4.3 Port congestion

Port-related congestion is widely recognized, in the literature, as one of the major contributors to schedule unreliability, operational disruptions and cumulative delays within container shipping supply chains (Notteboom & Rodrigue, 2012; Song, 2021; Karmelić et al., 2023). Due to the central position of ports as interfaces between maritime transport and hinterland logistics, congestion at ports may have disproportionate system-wide effects (Karmelić et al., 2025). In addition, port congestion may materialize at several operational interfaces (Karmelić et al., 2023; Notteboom & Rodrigue, 2012; Song, 2021; Notteboom, 2006). According to published literature, there are three primary operational interfaces where port congestion may occur.

1. At the seaside, congestion may occur when vessels experience waiting time prior to berth allocation, typically shown as anchorage queues outside the port area (Tang et al., 2015; Karmelić et al, 2023). Such berth-related congestion arises either when vessel arrival rates exceed available quay capacity or when operational productivity at the berth is insufficient to clear arriving traffic. As container shipping typically operates on fixed schedules, delays in one port may propagate to subsequent ports in the rotation and further affect connecting transport modes across the supply chain (Song, 2021; Calatayud et al., 2017; Notteboom, 2006).
2. Within the terminal, congestion may emerge in the storage yard (Karmelić et al., 2023). Yard congestion typically refers to a lack of available storage space for containers, which may force terminals to limit the number of containers they handle per vessel. This reduces the number of possible moves and may increase overall transit times within the supply chain (Wang & Meng, 2012; Karmelić et al., 2023).
3. At the landside interface to the hinterland through the port, including gate systems and connecting road or rail infrastructure (Hintjens, 2018; Rozic et al., 2025). Well-functioning interfaces with connecting transport modes may reduce disruptions within the port and improve operational efficiency. Efficient interfaces between ports and hinterland connections may also reduce congestion at both the seaside and within the terminal yard (Roso & Lumsden, 2010; Rožić et al., 2025).

The literature further emphasizes that port congestion has intensified in recent years due to larger vessel sizes, increased service concentration, and persistent schedule unreliability (Song, 2021). Larger vessels discharge higher container volumes within shorter time windows, placing simultaneous pressure on berth productivity, yard capacity, and hinterland absorption capability (Karmelić et al., 2023). When combined with fragmentation and limited coordination across supply chain actors, congestion risks are amplified. Furthermore, port-related congestion may occur at the port itself but is often the result of disruptions, delays, or poor information sharing in other parts of the container supply chain (Han, 2018).

Several studies, therefore, argue that port congestion should be analyzed from a system-level perspective rather than solely focusing on internal port operations (Schøyen et al., 2018; Song, 2021; Caschili & Medda, 2012).

4.5 Hinterland Connectivity and Inland Logistics

4.5.1 Hinterland transport and modal choice

The concept hinterland refers to the inland area served by a seaport, encompassing the transport networks, distribution centers, and economic regions that depend on the port for the movement of goods (Rodrigue, 2024; Wendler-Bosco & Nicholson, 2019). The hinterland network thus refers to the logistics network that connects seaports with inland distribution areas, terminals, and final customers via transport modes such as rail, inland waterways, and road (Gonzalez-Aregall & Bergqvist, 2019; Song, 2021). Thus, inland distribution from the port to the hinterland is typically organized by inland logistics actors who transport or temporarily store containers after discharge (Wendler-Bosco & Nicholson, 2019). Traditionally, these activities were often handled by specialized inland transport agents. However, increasing vertical integration in logistics has led to shipping lines and logistics providers managing larger portions of the inland transport segment themselves (Hintjens, 2018; Wendler-Bosco & Nicholson, 2019). Hence, hinterland transport creates a key link between port operations and inland distribution systems (Song, 2021; Notteboom, 2006; Fransoo & Lee, 2013; Gonzalez-Aregall & Bergqvist, 2019).

The efficiency of hinterland connections largely depends on the accessibility of inland transport systems to the port (Wendler-Bosco & Nicholson, 2019). Well-connected hinterland transport networks may reduce congestion in port yards and improve overall supply chain competitiveness (Rožić et al., 2025; Jeevan et al., 2019). Consequently, hinterland access is increasingly perceived as a key success factor for port competitiveness (Van der Horst & De Langen, 2008).

Hinterland transport between ports and inland destinations can be organized through different transport modes and logistics arrangements, often referred to as intermodal/multimodal transport (Ceulemans et al., 2025). Intermodal/multimodal transport refers to the movement of goods from an origin to a destination using a sequence of two or more transport modes, for example, vessel, rail, and truck (Wendler-Bosco & Nicholson, 2019). The choice of transport mode for inland transport is determined by factors such as the accessibility of available transport modes between ports and inland destinations, costs, customer requirements, transit time, and transport distance (Rozic et al., 2025; Gonzalez-Aregall & Bergqvist, 2019).

In container shipping, vessel sizes have increased, allowing more containers to be loaded and discharged at ports (Woxenius & Bergqvist, 2010). As container volumes handled at ports increase, the efficiency of hinterland transport systems becomes increasingly important (Fransoo et al., 2013; Schøyen et al., 2013).

Rail transport is often used for longer hinterland distances and for transporting larger volumes of standardized containers (20ft and 40ft) (Fransoo & Lee, 2013; Gonzalez-Aregall & Bergqvist, 2019). Due to the standardized design of ISO containers, they can be easily transferred between vessels, trucks and rail wagons, facilitating efficient intermodal transport

(Rodrigue, 2024). This is particularly common for Full Container Load (FCL) shipments, where containers can be transported directly between port terminals and inland destinations without additional cargo handling (Song, 2021).

4.5.2 Inland terminals and Dry ports

Inland terminals or dry ports function as extended gateways of seaports, facilitating the transfer of containers between maritime and inland transport networks (Rozic et al., 2025; Roso & Lumsden, 2009). By relocating certain logistics functions inland, such as customs clearance, storage, or consolidation, dry ports may reduce congestion at seaport terminals and improve overall supply chain efficiency (Wilmsmeier & Monios, 2020; Woxenius & Bergqvist, 2010). Inland terminals may also perform additional logistics functions such as storage, customs clearance, mode shifting and cargo processing (Wilmsmeier & Monios, 2020).

Inland terminals facilitate intermodal transport by enabling the transfer of containers between different transport modes such as rail, road and inland waterways (Rodrigue, 2024; Roso & Lumsden, 2009). Through these functions, they support the consolidation and distribution of container flows between seaports and inland markets, thereby strengthening port–hinterland connectivity (Wilmsmeier & Monios, 2020).

4.5.3 Coordination in Hinterland Transport Systems

Coordination between actors in the hinterland logistics chain is often complex (Hintjens, 2018; Van Der Horst & Langen, 2008). The coordination of hinterland transport typically involves several actors, including freight forwarders, terminal operators, barge and rail operators, road haulers, shippers and consignees, who jointly organize the movement of containers between ports and inland destinations (Van Der Horst & De Langen, 2008). Efficient coordination among actors and modes in the hinterland logistics network could reduce costs and time and increase efficiency (Ceulemans et al., 2024). One of the obstacles to this coordination is that different stakeholders aim to guard their interests, and information sharing between actors is often limited. Another obstacle is the unequal distribution of the costs and benefits of coordination, in which some actors may need to invest in improvements while others capture most of the benefits (Van Der Horst & Langen, 2008). In addition, strategic considerations and strong competition between firms may reduce the willingness of actors to cooperate, even when coordination would improve the efficiency of the overall transport chain (Van der Horst & De Langen, 2008; Ceulemans et al., 2024).

According to Van Der Horst & Langen (2008), most bottlenecks in door-to-door transport within container supply chains occur in the hinterland. Hinterland logistics plays a key role in consolidating container flows from multiple origins and distributing them to different inland destinations (Yin et al., 2023). As goods from various actors and locations are collected and redistributed through inland transport networks, the coordination and efficiency of hinterland transport systems become critical for maintaining reliable container flows. Consequently, depending on the level of coordination, hinterland logistics may either mitigate disruptions that

occur earlier in the supply chain or become a decisive bottleneck affecting overall supply chain performance (Gonzalez-Aregall & Bergqvist, 2019; Van Der Horst & Langen, 2008; Yin et al., 2023).

4.6 Synthesis and Geographical Context

Some studies have examined CSSCs from a systematic, end-to-end perspective; however, this area of research remains limited, and several papers highlight the need for further studies adopting such an approach (Song, 2021; Fransoo & Lee, 2013; Yue & Mangan, 2023). Ducruet & Notteboom (2012) suggest, in their study of container flows at sea level, that further studies should include hinterland connectivity to deepen the understanding. A lot of the published literature about container shipping focuses on isolated segments in the container supply chain, such as port performance, hinterland connectivity, or on just the maritime side (i.e., Carlo et al., 2015; Wendler-Bosco & Nicholson, 2019; Bartosiewicz et al., 2024; Roy et al., 2020; Kuznetsov et al., 2022; Schøyen et al., 2017; Liu et al., 2018; Molini et al., 2012; Ducruet & Notteboom, 2012; Gonzalez- Aregall & Bergqvist, 2019; Han, 2018).

Multiple studies of the container shipping supply chain, whether adopting an end-to-end perspective or focusing on specific segments, suggest that ports, nodes, hinterland systems, and overall performance should be analyzed within a regional context, as characteristics differ across regions (Calatayud et al., 2017; Arpin et al., 2024; Karmelić et al., 2025; Cao et al., 2024). For example, disruptions in liner services and inland transport may have region-specific causes related to infrastructure, network structure, or logistics arrangements.

Research adopting the CCSC perspective in a Swedish context remains limited; no such studies were identified in the literature review, nor were any that examine export flows. Several studies and reports address specific parts of the container supply chain within a Swedish context, such as hinterland connections and port performance (Roso et al., 2009; Lind, 2024; Gonzalez-Aregall & Bergqvist, 2019; Roso & Lumsden, 2010; Woxenius & Bergqvist, 2012; Vierth, 2024).

5. Results & Analysis

This chapter presents a triangulated analysis of insights from the interviews conducted (see APPENDIX 3), supported by academic literature, secondary sources, and statistical data. The analysis is based on a thematic approach (see APPENDIX 4) and structured around the study's purpose and research questions. It examines how import flows of standard containers to Sweden are organized in practice, where waiting times and bottlenecks occur along these flows, and how these patterns can be simplified into representative flow structures for modelling. The findings are presented thematically rather than by individual interview to highlight recurring patterns, differences in perspective, and broader system-level mechanisms across the studied import CSSCs to Sweden.

5.1 Structure of import container flows to Sweden

This section describes how container import flows to Sweden are structured and organized. Based on empirical material from interviews (APPENDIX 3), supported by statistics and grey literature (Chapter 3), this section outlines the physical configuration of the transport system, key flow characteristics, and the roles and control of different actors within the chain.

5.1.1 Physical structure of the transport system

Physical structure of the maritime flows

Three recurring types of maritime import flows to Sweden can be identified (Figure 9), based primarily on interview data (Appendix 3) and supported by grey literature and statistics. The first, and most dominant, structure of flows consists of container flows originating outside Europe, arriving at a major hub port in Northern Europe (i.e., Rotterdam, Hamburg, or Antwerp), and subsequently being transhipped onto a feeder vessel for onward transport to Sweden. This structure, commonly referred to as a hub-and-spoke system, was consistently described by respondents as the dominant configuration for container imports to Swedish ports (e.g., I3, I5, 10). As one respondent noted, *"It is usually said that at least one transshipment occurs for ninety-five percent of the volumes"* (I5).

The second type consists of direct deep-sea calls from ports outside Europe to Sweden. According to the respondents, such a flow is limited and only associated with the Port of Gothenburg in a Swedish context (e.g., I1, I2, I3, I5, I6, I10, I11, I12). One respondent mentioned, *"There are actually four ocean carriers that can offer products that come directly from Asia and directly to Gothenburg*" (I10). Direct deep-sea services to other Swedish ports were described as non-existent; those ports are instead connected through feeder-based solutions or flows within Europe (e.g., I6, I8, I9, I13).

The third type comprises intra-European (short sea) flows. These flows may either move directly from a European port to a Swedish port or follow a structure involving one or more transshipment ports before reaching Sweden. Some respondents described these flows as differing in both scale and organization compared to intercontinental container imports (e.g.,

I5, I6, I8, I11, I12). Furthermore, respondents described flows between Swedish ports as non-existent or very small in scale (e.g., I3, I5).

Additionally, the analyzed interviews indicate that hub-and-spoke structures are not limited to Europe; they may also occur in the region of origin. Cargo originating from smaller ports, for example, in Asia, is often consolidated at regional hubs before being transported by deep-sea services to Europe. As some respondents noted, the largest vessels operate between major hubs, while smaller feeder vessels distribute cargo between ports (e.g., I3, I5, I10, I15).

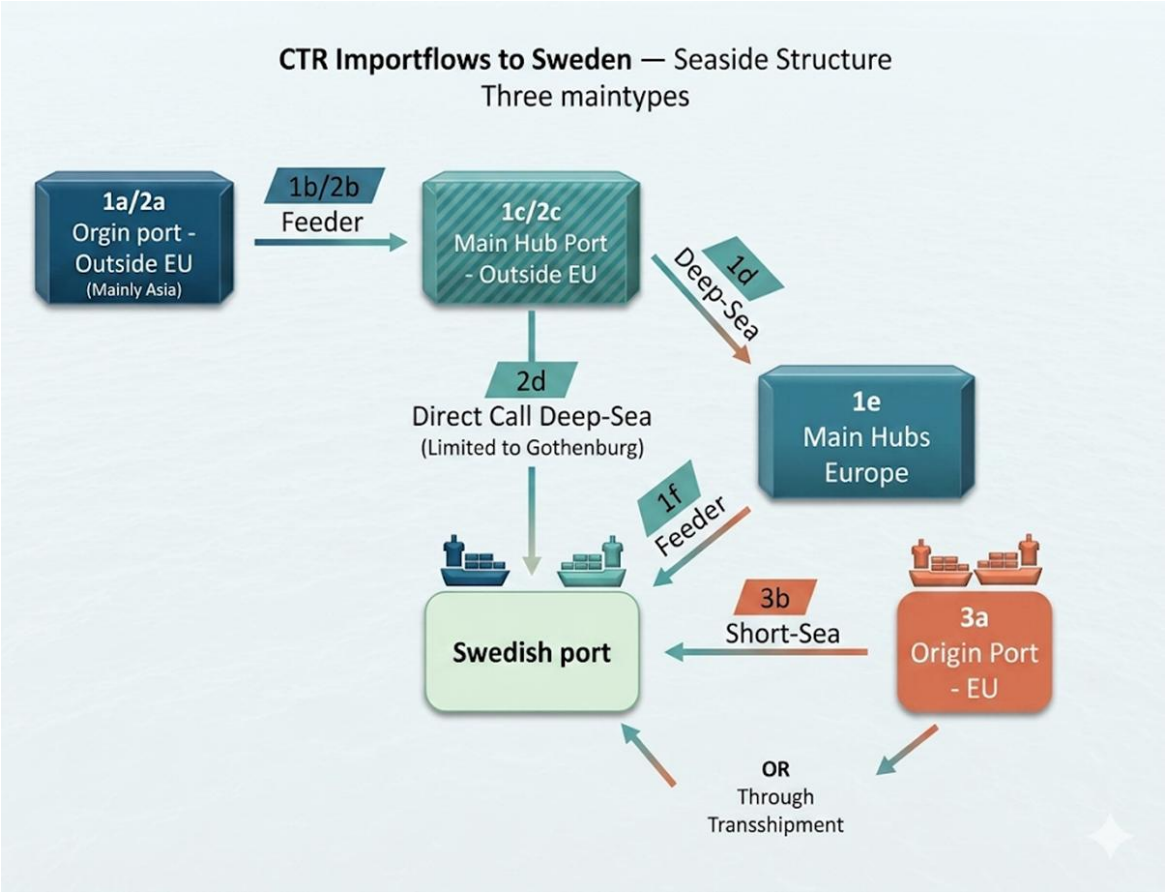

Figure 9. Seaside structure of container import flows to Sweden. [Created with PowerPoint and modified by Gemini, (2026)].

In addition to the configuration mentioned above, the exact configuration may differ across shipping lines and origins within the CSSC. As one respondent said, *"There are different variants depending on the shipping company and also depending on which origin you ship from"* (I2).

The interviews indicate that Swedish ports primarily function as end nodes within the maritime transport system (e.g., I2, I5, I8, I11). Containers discharged in Sweden are rarely transhipped onwards by sea, as one respondent described such operations as *"very, very, very unusual"* (I5).

Although Gothenburg is the only Swedish port with direct deep-sea calls, it remains integrated into wider feeder-based and transshipment-dependent structures, depending on routing, carrier setup, and destination (e.g., I11, I3, I5, I6). Even though Gothenburg has direct calls, feeder-

based solutions still account for a majority of all containers discharged in port, as one respondent estimated, *"sixty, forty maybe. Sixty percent with a feeder. Very rough"* (I11).

Furthermore, interviews, supported by analyses of reports and statistics, show that container flows are distributed across multiple Swedish ports, while volumes remain concentrated in a limited number of nodes. Gothenburg was consistently identified as the dominant port, handling a significant share of total import volumes (e.g., I5, I8, I11).

Structure of hinterland connectivity and inland logistics

The transport chain does not end at the port; it continues through inland and intermodal transport systems. After arrival in Sweden, containers are typically transported further by truck, rail, or a combination of both, depending on the distance to the destination and the service setup (e.g., I4, I12).

In most cases, last-mile transport is by truck, even when containers are initially transported over longer distances by rail (e.g., I1, I7). As one respondent noted, *"It is often that you take the train for a bit and then you have a truck the last bit out to the customer"* (I2). For many Swedish ports, a large share of imported containers is distributed within nearby regions (Figure 6), making truck transport the dominant mode of transport. In contrast, the Port of Gothenburg was described as having a wider national reach, where a significant share of containers is transported further inland by rail (e.g., I1, I7, I11). Additionally, some respondents noted that Gothenburg is sometimes selected as the port of entry even when the container's final destination is in the Stockholm region, as rail connections from Gothenburg can offer a more cost-efficient inland transport solution compared with direct routing through ports closer to the final destination (e.g., I2, I3, I5, I12).

This inland distribution system relies on a network of connected terminals and intermodal solutions, enabling the movement of larger volumes across longer distances, where "*large batches can be handled simultaneously"* (I11).

5.1.2 Flow characteristics and movement of goods

Origin of containerized import flows

The interview material indicates that most container imports to Sweden originate from outside Europe, with Asia as the dominant source region. Several respondents described Asia as particularly important for these flows, with one referring to it as "*impossible to replace*" (I10). This is further illustrated by one respondent, who estimated that approximately "*seventy to eighty percent*" of container imports to Sweden originate from Asia (I11).

In contrast, intra-European (short sea) flows were described as smaller in scale and structurally different (I5, I6). Three respondents noted that transport originating from Europe more frequently involves alternative load units, such as trailers rather than containers (I8, I12, I15). This suggests that containerized imports to Sweden are primarily shaped by long-distance intercontinental trade, whereas regional flows may follow different logistical configurations (e.g., I12, I15).

This indicates that long-distance, intercontinental trade patterns largely shape containerized import flows to Sweden, while regional European flows may follow different transport structures and modal configurations.

Continuous movement and limited storage

A key characteristic of the observed import flows is the emphasis on maintaining continuous movement of containers throughout the transport chain. The empirical material indicates that actors aim to minimize storage time on the ground, as one respondent noted, *You want it to arrive as quickly as possible"* (I1).

This is largely driven by cost considerations, with the fact that it is very expensive to store the containers during the CSSC, as one respondent said: "It *is extremely expensive to store... It is enormous costs for the shipping companies to have it standing against the port operator*" (I3). At the same time, storage is not something terminal operators seek either; they want to maximize throughput and reduce dwell times to maintain operational efficiency (I9, I11, I13).

As a result, the container is intended to move continuously from origin to destination, while storage could be seen as a temporary condition when movement is disrupted or delays arise. This was emphasized by several respondents, for example, "*The only time you make money from a container, it is when it is in motion"* (I3) and "*it makes no money when it is not on the move*" (I10).

Import vs export characteristics

The findings from the interviews also highlight structural differences between import and export container flows, particularly regarding planning and predictability (I9, I11, I12, I13).

Export flows were described as more structured and predictable, as containers must be booked on a specific vessel before entering the terminal. As one port operator explained, "*it is booked before it comes to us. We will know which vessel it will come with"* (I11). In other words, export flows are closely tied to vessel schedules and planned operations.

In contrast, import flows were described as less predictable. Containers may sometimes be discharged without fixed arrangements for onward transport, meaning that the timing and mode of inland transport may not be determined at the time of arrival, as noted by one respondent, *"Because you never know when or how they will be picked up*" (I9). This could create uncertainty about when they will be collected, how they will be transported further into the hinterland, and where they should be positioned within the terminal (I9, I11, I13). Furthermore, export flows, as described by two respondents, are more closely tied to a specific port, whereas import flows are more flexible in terms of port choice (I9, 113).

Together, these indicators suggest that export flows are characterized by higher coordination and predictability, whereas import flows exhibit greater flexibility but also increased operational uncertainty.

5.1.3 Organizational structure and control

The interviews indicate that container import flows to Sweden are organized through a network of multiple actors operating across different stages of the transport chain (e.g., I1, I12). These include, in line with the academic literature, shipping lines, freight forwarders, terminal operators, inland transport providers, authorities, and cargo owners.

These actors fulfil distinct roles within the system. Freight forwarders were, for example, described as coordinators of the flow rather than physical operators, acting as intermediaries between customers and transport providers. As one respondent explained, they "*…handle the entire flow… from the supplier to final delivery… without physically handling the goods themselves"* (I2). In contrast, terminal operators and transport providers are responsible for the physical handling and movement of containers.

The interviews further indicate that the control within the transport chain is unevenly distributed (e.g., I2, I4, I8, I12, I10). Shipping lines were consistently described as key decision-makers, particularly regarding routing, port selection, and transshipment patterns. As one respondent noted, "*Choice of transport route... The shipping company decides. Like that, they decide, this is the path we take. And container, we reload it in these ports"* (I10). While cargo owners determine the final destination of the goods, the specific routing and operational setup are largely controlled by the shipping lines (I3). Operational control over the physical flow is concentrated in a limited number of actors within the system. As a result, other actors often adapt to the network structures and service offerings defined by these carriers (e.g., I14, I15).

This concentration of control and influence within the routing structure is further reinforced by alliances among shipping lines that share capacity and networks, such as the Gemini alliance between Hapag-Lloyd and Maersk (I2). In addition, respondents noted a trend towards increased vertical integration, in which large shipping lines expand their role by offering freight forwarding and end-to-end logistics solutions (I4).

There are differences in the organizational setup across flows. Short sea flows within Europe were described as differing from intercontinental flows in terms of planning horizons and operational characteristics (I10). For short-sea, the time frame for bookings is shorter in advance, as one respondent described it, "*a booking could come in just two to three days in advance of voyage"* (I5), while the planning window for longer distance voyages outside Europe is often planned several months of reaching the final customer in Sweden (I2, I5).

The interviews further indicate that the degree of control over the transport chain varies with contractual arrangements, particularly the chosen INCO-terms (I1, I2, I10, I12). These terms define the distribution of cost, risk, and responsibility between actors, meaning that control over different parts of the flow may shift depending on the setup. As one respondent explained, *"it depends entirely on which terms are chosen"* (I10). In practice, this implies that some actors may control the entire transport chain, while others only influence specific stages, for example, from the maritime leg onwards (I2).

The empirical findings from the interviews show that container import flows are organized through a network of interdependent actors with different roles and levels of control, where operational control is concentrated among a limited number of key players, particularly shipping lines. (e.g., I1, I2, I10, I14)

5.2 Bottlenecks and disruptions in import flows

The interview material reveals several recurring bottlenecks and disruptions across the different stages of container imports into Sweden. These bottlenecks vary in nature, ranging from delays at locations where cargo is physically handled to disruptions related to scheduling, inland transport, and external conditions. While individual situations differ, several common patterns emerge across the interviews. These are summarised in Table 5.

Bottleneck/Disruption Category	Description	Typical manifestations
Network structure and transshipment-related bottlenecks	Disruptions occurring at transfer nodes and due to the structural organization of the CSSC (hub-and-spoke, feeder dependence, node concentration)	Waiting times at hub ports, missed connections, prolonged dwell times, feeder dependency, and concentration on Northern European hubs
Port and terminal operational bottlenecks	Disruptions linked to terminal operations, capacity, and handling performance	Congestion during vessel calls, long turnaround times, yard saturation, storage constraints, gate-out delays, crane and infrastructure limitations
Inland transport	Disruptions in hinterland transport systems connecting ports to final destinations.	Rail capacity shortages, congestion, delays in rail yards, truck queues, and infrastructure constraints
Reliability and schedule disruptions	Variability and uncertainty in transport timing and coordination across the chain	Rolled shipments, changing ETAs, missed time windows, semi-flexible feeder schedules, unreliable connections.
Demand-related and flow imbalance disruptions	Disruptions caused by uneven flow patterns and volume peaks	Seasonal peaks (e.g., Chinese New Year), simultaneous arrivals, volume surges, “everything happens at once”, imbalance between system components
External & route-related disruptions	Disruptions originating outside direct operational control	Weather conditions, ice/snow, canal constraints (e.g., Suez), rerouting, geopolitical events

Table 5: Where bottlenecks occur, adopted from interviews (see APPENDIX 3)

5.2.1 Transshipment and network structure-related bottlenecks and disruptions

The interview material indicates that many bottlenecks and disruptions in Swedish container import flows are closely tied to the structure of the transport network (e.g., I5, I10, I11, I14). In

particular, respondents highlighted transshipment ports and hub-and-spoke dependencies as critical sources of delays, congestion, and variability within the CSSC.

Transshipment Nodes as Critical Bottlenecks

A recurring pattern in the interview material is that transshipment ports represent key locations where delays and disruptions occur within import flows (e.g., I5, I10). Several respondents described how containers may experience waiting times, missed connections, and prolonged dwell times at intermediate ports where cargo is transferred between vessels. As several respondents highlighted, transshipment ports are a major issue. For instance, one respondent noted that, "*the transshipment ports and then there is that, it is a big problem right now. Has been and is, I would say"* (I2), while another emphasized that *"The biggest bottleneck is clearly the transshipment ports. It will be for a long time to come"* (I10). This is consistent with previous research highlighting transshipment ports as critical nodes in container transport systems.

The interview data indicate that transshipment-related delays are not confined to a single region within the CSSC (e.g., I3, I15). For instance, respondents noted that disruptions frequently occur at Asian hub ports, particularly when cargo from smaller ports is consolidated before being shipped on deep-sea vessels. However, these upstream delays, which occur early in the CSSC, are generally perceived as having a less significant impact on the overall flow. As one respondent mentioned regarding delays at Asian hubs: "*it does not affect us as much"* (I14). Instead, the data show that the main hub ports in Europe primarily dictate flow performance and cause the most critical disruptions (e.g., I5, I8, I14).

Specifically, several respondents highlighted European transshipment ports as the primary locations where congestion, waiting times, and delays are more frequent. As one respondent expressed, *"Variation occurs in lead time mostly when they move feeders here in Europe, for example, Hamburg"* (I12). This perception reflects how respondents experience differences in operational performance between European and Asian ports,

> *"That is when the vessels have arrived in Europe...Then the circus begins. Europe's ports are not the same, what can you say? They are not as effective as they are in Asia…The problems usually start when the big ships arrive here in Europe"* (I5).

The interview material further shows that these challenges affect not only flows explicitly organized as hub-and-spoke systems but also direct flows from outside the EU with deep-sea vessels with the destination to Gothenburg (e.g., I2, I3, I14). Even in such cases, cargo often passes through intermediate ports as part of the overall routing. It is therefore exposed to similar transshipment-related delays, as one described it, *"The vessels usually must go into these continental ports. And then, if we do not unload our goods there, it is really one of the big problems that there will be a stop in Europe" (I14)*.

In addition, respondents noted that intra-European (short sea) flows may, in some cases, avoid the largest deep-sea hubs, thereby reducing exposure to such disruptions. (I5, I6, I8, I9). Short-sea operators with intra-European cargo are often less dependent on the major transshipment hubs and may instead call at smaller or less congested ports. This increase routing flexibility and reduces the risk of delays related to congestion for those types of flows.

Structural drivers of network-related disruptions

The interviews indicate that a fundamental cause of many of the identified disruptions lies in the structure of the container transport system (e.g., I5, I10, I15). In particular, the organization of import flows through a hub-and-spoke network creates a high degree of dependence on a limited number of key links and central hubs, primarily large transshipment ports in Northern Europe.

Many of the observed bottlenecks were attributed to the hub-and-spoke structure, in which flows are concentrated through a limited number of central hubs before reaching smaller markets such as Sweden. As one respondent noted, "*We are limited to certain ports, hubs, and certain terminals*" (I3). This concentration increases the system's sensitivity to disturbances, as disruptions in a limited number of nodes may affect large parts of the transport chain.

Several respondents described how this structure is closely linked to infrastructural limitations in Sweden, where only Gothenburg can handle deep-sea vessels (e.g., I2, I5, I11). However, respondents also emphasized that the majority of Swedish container imports, including flows to Gothenburg, still pass through major continental hub ports before reaching Sweden, while the remaining Swedish ports are almost entirely reliant on hub-and-spoke feeder networks. As a result, feeder services connecting continental hub ports to Swedish terminals remain central to the Swedish import system. As one respondent explained:

> *"The large vessels require a certain type of infrastructure… Gothenburg is the only port in Sweden that can handle these vessels. The other ports receive import cargo through feeder networks from the major transshipment ports… Hamburg, Bremerhaven, Antwerp… into Helsingborg, Halmstad, Norrköping, Nynäshamn, and so on"* (I10).

This dependence on hub-and -spoke transport systems creates additional transfer points before cargo reaches Sweden, increasing dependencies between transport legs and the system's overall sensitivity to disruptions.

Another aspect highlighted by multiple respondents was how the configuration of the Swedish port system itself contributes to these dynamics (e.g., I5, I7, I11). In particular, the existence of many relatively small container ports was described as leading to a dispersion of volumes, limiting "*economy of scale*" (I10) and reducing the ability of individual ports to develop sufficient capacity and flexibility. As one respondent noted:

"…we have somewhat too many Swedish ports... If you could concentrate the volumes to fewer ports, they could have had longer port stays and more flexibility...We have to somehow concentrate the volumes on fewer ports" (I5).

Similarly, another respondent also described that there are too many ports, and further, that a more centralized port structure could improve system performance:

"We have a lot of ports in Sweden, which messes up... for Sweden, we think it would be even better to have a fast and efficient hub where everything goes through... Furthermore, I think that two or three (read ports) *would probably be enough to have as a base"* (I11).

This fragmentation of flows was also described by respondents as reinforcing the dependence on larger hub ports, as volumes are insufficient to support more direct vessel services to Sweden (e.g., I5, I11). As a result, the system becomes locked into a structure in which transshipment and feeder solutions are not only common but necessary. An increased number of direct vessel calls would also likely create more reliable import flows, as one said: *"It takes a lot for a direct call to be delayed"* (I2).

These findings, from the interviews, indicate that the hub-and-spoke configuration, combined with the structure of the Swedish port system, represents a key underlying cause of disruptions (e.g., I.10 I.11). By concentrating flows in a limited number of nodes while simultaneously dispersing volumes across multiple smaller destinations, the system becomes both highly interdependent and structurally constrained. This, in turn, places greater pressure on infrastructure and capacity at critical nodes, contributing to many of the identified bottlenecks.

In addition, several respondents pointed to capacity constraints in feeder services, where limited vessel size and available space restrict the volume of cargo that can be transported per sailing (e.g., I3, I5, I8). These limitations reinforce the structural dependency, as not all cargo can be accommodated as planned, increasing the risk of delays when volumes exceed available capacity, as one respondent said,

"*You have the small feeder vessels moving cargo back and forth… but their capacity is limited. The large vessels are prioritized, and if feeders cannot remove cargo from the hubs, the system becomes overloaded… feeder capacity in the hub and spoke system, that is the big problem today*" (I10).

Several respondents also highlighted organizational complexity and the large number of involved actors as factors complicating coordination within the transport structure, as one respondent noted, *"Everything from freight forwarders, shipping companies, to importers and maybe an intermediary, which could complicate things…*" (I13).

5.2.2 Bottlenecks and disruptions in Ports and Terminals Operations

While the previous section focused on network-related disruptions, respondents also identified several operational bottlenecks linked to port and terminal activities.

Several respondents described delays at ports and terminals during vessel calls, particularly due to congestion, waiting times, and the time required to complete loading and unloading operations (e.g., I1, I3, I6, I10). These delays were described as increasing the time vessels

spend in port and contributing to variability in terminal operations. As one respondent described:

> "*A big problem today, and that is probably where the big things are being fought. It is really that there are congestion and other disruptions in the ports"* (I3).

The respondents also highlighted that variability in handling times contributes to uncertainty in port operations, making it difficult to predict turnaround times (e.g., I9). In addition, respondents noted variability in handling times at Swedish ports and earlier ports within the CSSC (e.g., I1, I5, I8, I15).

The interview material indicates that capacity-related challenges are more pronounced at European nodes than at earlier stages of the transport chain (e.g., I5, I12). One respondent argued that ports in Europe have not invested in the infrastructure as they have in Asia: "*it has not invested the money in Europe as it has in Asia"* (I5).

These capacity limitations were further described by the respondents as becoming more critical as vessel sizes and volumes increase (e.g., I3, I8, I10). As one respondent noted, ports and infrastructure systems are not always able to *"handle these large vessels and the volumes that come with them"* (I3), which increases pressure on both terminal operations and hinterland connections.

Yard capacity bottleneck and storage-related delays

The empirical findings showed that yard space and efficiency are a recurring bottleneck in terminal operations, often leading to congestion and increased dwell times. Containers were described as remaining in the yard for extended periods, particularly during high-volume periods. This thereby reduces terminals' ability to handle incoming flows efficiently. This was observed in both large European transshipment ports and Swedish terminals (e.g., I5, I9, I10, I11, I12, I13).

> "*I would probably say that the biggest bottleneck that we are experiencing today is probably our yard, that is, our staging areas, really. That, that we, in periods when there is a lot of traffic, we have a little too high a fill rate*." – I13 about bottlenecks in Swedish ports

This description reflects a broader pattern identified across the interviews, where yard space was repeatedly highlighted as a limiting factor in Swedish ports (e.g., I9, I11). Several respondents described terminals as near saturation, with containers remaining in the yard for extended periods due to limited space and high utilization. As one respondent expressed, terminals are "*so full and congested that changes are required*" (I10). This disruption is consistent with published literature and is a global problem according to UNCTAD (2025).

Release points/Gate out Swedish ports

Some respondents described challenges with the release and gate-out of containers at Swedish ports, particularly during periods of high demand (e.g., I2, I12). These challenges were often

linked to increased congestion and operational pressure when large volumes of containers arrive simultaneously. As one respondent noted, "*there may be a higher risk of queues…especially when large vessels arrive, and many containers are collected at the same time"* (I1).

At the same time, other respondents operating in the same port environment described above did not experience significant issues with container release from the port. As one respondent stated, *"I do not think it is a major problem"* (I5). Suggesting that such challenges may vary depending on operational conditions, timing, and the position of the actor within the transport chain.

Capacity constraints in Swedish ports

In Swedish ports and terminals, several respondents described how limitations in physical infrastructure restrict operational and handling capacity (e.g., I9, I13). These include constraints related to quay space, water depth, terminal area, and handling equipment. As one respondent noted, *"capacity in infrastructure… is what limits us today"* (I2), while another highlighted two things: "*for a little berth and water depth... And the other is terminal yardspace"* which could restrict the ability to handle larger vessels and higher volumes (I9).

Some respondents described these issues, particularly at the smaller Swedish container ports, where limited yard space and lower capacity make terminals more sensitive to volume fluctuations (I3, I8, I12).

Moreover, the interview material suggests that yard-related constraints may pose greater challenges for import flows. As one respondent explained, *"the absolute most difficult thing for a container terminal is import flows, because you never know when they will be picked up"* (I9). In contrast, export flows were described as more predictable, as containers are typically linked to specific vessels and departure times. This uncertainty was described as contributing to challenges in yard utilization and to increased dwell times (I11).

Another physical issue in some Swedish ports is the lack of cranes; several respondents noted limited crane availability, particularly in the smaller Swedish container ports. As one respondent said: "*Smaller ports usually have crane issues, do not have the time to unload a full vessel, due to infrastructure in port, mostly caused by too few cranes, and too few moves per hour*" (I8).

Operational and organizational constraints in port operations

In addition to the physical infrastructure mentioned earlier, respondents highlighted that restricted operating hours and limited workforce availability further constrain terminal capacity.

> *"Swedish ports do not generally work around the clock, but they do in most ports in Europe, and they work either one shift or two shifts. And that means that you have to lie and wait until, if you come in too late in the evening, you have to lie and wait until 07:00 when the next shift starts" (I5).*

To handle increased volumes and larger/more vessels each week, one respondent added, *"We may need to work more nights and weekends…"* (I4). Furthermore, although 24/7 operations

are available in some ports, respondents noted that such services are often associated with significantly higher operational costs. Workforce-related constraints were also observed in other parts of the system. Respondents described shortages of truck drivers from time to time (e.g., I4, I12), and several mentioned the lack of pilots in Swedish ports, which contributes to delays and reduced throughput. One respondent noted, "*The pilot problem is something occurring in many ports (read Swedish). It could be that they must lie still for half a day or more and wait for a pilot"* (I13).

Furthermore, some respondents indicate that IT-related issues may act as an underlying driver of disruptions (e.g., I6, I13). Respondents described how misalignment between systems and varying levels of digital maturity can create delays and inefficiencies, noting that "*systems are not synchronized… some have the maturity, others do not"* (I6).

5.2.3 Disruptions and Bottlenecks in Hinterland Networks

The interview material shows that respondents perceive inland transport in Sweden differently: some describe it as a significant bottleneck, while others experience it as relatively well-functioning. These differences were often linked to factors such as transport distance, mode choice, and proximity to ports. These further highlight how inland transport challenges vary with transport conditions, a pattern supported by previous research.

Several respondents identified inland transport as a major bottleneck in Sweden's container supply chain (e.g., I3, I10, I13). These challenges were described in the context of both rail and road transport, where infrastructure constraints and capacity limitations affect the movement of containers from ports to their final destinations. As one respondent explained:

> "*…the bottleneck is the challenges that the transport from the port to the recipient occurs because of infrastructure challenges…. There are many bottlenecks on the rail network… Trucks that are going out of the ports that are also affected by queues and infrastructure problems…*" (I10).

In contrast, some respondents described inland transport as functioning relatively well, particularly when transport distances are short, and goods are moved primarily by truck. As one respondent noted, *"generally speaking, it works well, I think"* (I14). This suggests that the extent of inland transport challenges may vary depending on the specific transport setup and geographical conditions.

Among those experiencing disruptions, rail transport was frequently highlighted as a source of delays. Respondents described capacity constraints, congestion, and operational limitations within the rail network. For example, one respondent noted that *"there may be capacity shortages on trains… it happens quite often that trains are fully booked"* (I2), while another described congestion, *"If you look at railways, then too, it could also be that there will be congestion sometimes*" (I3).

In addition, some respondents described operational delays related to rail infrastructure, including waiting times on single-track sections, congestion on main routes and delays in rail

yards (e.g., I2, I5, I7, I9). One respondent explained how trains may be required to wait to allow faster services to pass, leading to extended transport times, and noted that bottlenecks occur *"when it gets clogged… there are waiting times to allow faster trains… and when you get into different types of railway yards, it can take time if you are not on time"* (I7).

Some respondents pointed out reliability problems in rail operations, mentioning coordination issues and inconsistent service levels (e.g., I8, I13). Specifically, delays and disruptions were linked to operational and organizational factors within the rail system. One respondent mentioned historical challenges in coordinating with rail operators, with transport services seen as unreliable (I13). These problems were said to cause uncertainty in inland transport flows.

The interview material shows that inland transport disruptions are primarily linked to capacity constraints, infrastructure limitations, and operational variability, although the extent to which these challenges are experienced varies between actors.

5.2.4 Reliability and schedule disruptions

The interview material indicates that disruptions in timing and scheduling represent a key source of variability in import flows. Several respondents described how planned schedules are often not adhered to, resulting in delays, missed connections, and greater uncertainty in lead times (e.g., I1, I4, I5, I6, I12).

One recurring issue described by respondents is the unpredictability of vessel schedules, with departures and arrivals sometimes postponed or adjusted at short notice. As one respondent explained, departures may be "*rolled to a later week"* (I1), meaning that shipments are delayed with limited possibility for intervention. Similarly, another respondent highlighted how estimated times of arrival (ETA) may change significantly in the final stages of transport: "*ETA changes a hell of a lot on the containers last week and last days."* (I12).

In addition, some respondents noted that feeder services do not operate on fixed schedules to the same extent as deep-sea vessels. Instead, feeder operations were described as more flexible and dependent on cargo volumes and demand (e.g., I4, I12). As one respondent explained:

> *"...when the feeder was, it was not as regular as the deep-sea calls that really go on schedule. ...a feeder is semi-flexible… example, next week we only have three containers in X port. Then we do not go in there…"* (I4)

In some cases, limited capacity in feeder services was described as contributing to scheduling disruptions, where cargo may not be accommodated on the intended departure and must instead wait for the next available vessel. As one respondent explained, *"you have to let the cargo remain for another week… and then it is picked up the following week"* (I10).

This flexibility was described as contributing to variability in transport times, as routing decisions and port calls may change in response to operational conditions (e.g., I2, I5, I6, I10, I12). Hence, vessels may not always follow a fixed schedule, further increasing uncertainty about delivery timing and creating a structural bottleneck.

5.2.5 Demand variability & peaks

In addition to structural and operational bottlenecks, respondents described disruptions stemming from fluctuations in demand and uneven cargo volumes over time. The interviews indicate that temporary volume peaks and uneven flow patterns contribute to congestion and operational pressure within the CSSC (e.g., I3, I4, I8).

One example of variability was due to seasonal peaks, which were described as recurring and, to some extent, predictable, yet still difficult to manage in practice. One respondent talked about one seasonal peak, the Chinese New Year, and described it like this: *"You always have certain peaks, for example, everyone wants to ship out before Chinese New Year, and that is one of those, then it becomes very strained*" (I3). This leads to sudden increases in volume throughout the transport chain, creating temporary imbalances between demand and capacity and increasing the likelihood of congestion and delays.

Respondents also described how uneven cargo volumes create mismatches between different parts of the transport system (e.g., I3, I6). These mismatches occur when the timing and capacity of different transport legs are not aligned, for example, between deep-sea vessels, feeder services, and inland transport connections. As a result, cargo may accumulate at certain points in the system, even when capacity exists elsewhere (I7).

Some respondents described this as a structural challenge in which limited flexibility and coordination reduce the system's ability to absorb fluctuations (e.g., I5, I10). For instance, when large volumes arrive at transshipment ports or destination terminals within a short time frame, downstream transport capacity may not be sufficient to distribute the cargo at the same pace. This increases pressure on terminal operations and inland transport systems.

Temporal concentration of flows

These dynamics and volume fluctuations were also described as challenging in the Swedish context, where multiple constraints often occur simultaneously. As one respondent explained, "*it is this classic that everything has to go out and happen at the same time"* (I10). This was linked to factors such as port operating hours, coordination with other actors, and customer delivery requirements, which together create narrow time windows for handling and distribution.

Hence, flows tend to be concentrated rather than evenly distributed over time. One port operator described how "*we could handle more today… if it was more spread out over the day… we have high peaks and deep valleys*" (I13). This suggests that the system's capacity is limited not only in absolute terms but also by how demand is distributed over time. A more even flow of cargo would likely allow the system to handle larger volumes more efficiently and reduce some of the current bottlenecks. This simultaneity places additional pressure on ports and inland transport systems, as large volumes of cargo must be handled, transported, and distributed within limited time windows.

Even relatively small disruptions may have amplified effects, especially if the system already exhibits structural dependencies, and such systems may be particularly sensitive to episodic fluctuations (e.g., I7, I11).

5.2.6 External & route-related disruptions

The interview material shows that several disruptions affecting import flows originate from external factors outside direct operational control (e.g., I4, I6, I10, I12). These include weather conditions, maritime route constraints, and broader external events, all of which contribute to delays and variability in transit times within the CSSC.

Weather-related disruptions

Weather conditions were frequently described by the respondents as a significant source of disruptions in the CSSC. Respondents highlighted how wind, storms, and adverse weather conditions may delay vessel operations, affect port handling activities, and disrupt inland transport operations. As some two respondents noted, *"Weather and wind are also a big factor that causes delayed flows in all transport segments"* (I8) & "*It can be weather and wind that make it impossible to operate cranes or receive ships*" (I6). This is also supported by the published literature, which identifies weather as a key source of disruption in the CSSC.

In Sweden, snow and ice are specific weather-related factors that disrupt container operations. Respondents described these conditions as having a major impact on Swedish container flows. As one respondent stated: "*There is icing and there is snow and some transports are cancelled*" (I3) These conditions affect both maritime and inland transport operations, as one inland operator described: "*We are strongly affected by weather, especially snow and wind*" (I7). In addition, ice conditions were described as a limiting factor for ports in northern regions, where some vessel access could be restricted during winter periods (I8).

Maritime and route-related disruptions

Respondents also highlighted disruptions related to maritime routes and key transport passages, for example, "*Delays at sea due to weather or queues around passage*" (I15). In particular, the Suez Canal and the Red Sea region were described as critical bottlenecks affecting transit times, due to the ongoing rerouting away from the area. One respondent noted:

> *"…we have seen lately that the big bottleneck is Suez. There is nothing else that takes two weeks extra. On the other hand, it is a planned one. We know from the beginning that we plan to drive around, around Africa"* (I4).

This refers to the current rerouting of vessels around southern Africa instead of through the Suez Canal, resulting in substantially longer transit times. Disruptions linked to the routing structure are also mentioned in the published literature as major disruptions.

Respondents also highlighted how changes in routing patterns may themselves create disruptions in the system (e.g., I4, I10). For example, a potential return to the Suez Canal was described as likely to cause extreme congestion in major ports, as a large number of vessels

would arrive over a shorter time frame. As one respondent explained, *"if everyone started using the Suez Canal again, it would create a major congestion in the large ports"* (I9).

In addition to global chokepoints such as the Suez Canal, respondents also referred to constraints on regional maritime routes and passages, such as the Kiel Canal and Skagen, that could limit some vessels (e.g., I3, I5, I6). As one described: *"Can we sail through Kiel or do we have to sail around Skagen? That is an aspect you must take with you"* (I5). These route constraints may limit vessel movements and contribute to delays under certain conditions.

Overall, respondents described both global and regional route constraints as affecting transit times and the predictability of maritime transport. (e.g., I1, I3, I8, I11). This is consistent with previous research, which suggests that certain disruptions, such as specific weather-related issues, may be regional or supply-chain-specific.

Geopolitical disruptions

Several respondents referred to broader external events as sources of disruption in the transport chain (e.g., I4, I8, I10, I15). These include geopolitical conflicts, such as those affecting the Red Sea region, as well as incidents like the grounding of the Evergreen vessel and other blockages in key waterways. As one respondent explained, *"events such as war or similar… can disrupt the system"* (I15). These disruptions were described as difficult to predict and capable of significantly affecting transport flows.

Respondents also described how geopolitical and economic developments may indirectly reshape transport flows and increase system-wide uncertainty. As one noted,

> *"Political decisions such as tariffs and trade restrictions can significantly affect the flow…As a shipper, you may not be able to influence these changes, but you are still affected by them… Such developments can fundamentally change how supply chains are structured, influencing routing, vessel types, and transport patterns… These are indirect impacts that need to be considered when assessing transport risks and planning supply chains."* (I10)

These findings indicate that geopolitical disruptions may affect both the predictability and overall functioning of the import CSSC to Sweden (e.g., I9, I10, I15).

5.3 Domino Effects in Import Flows to Sweden

The interview material indicates that disruptions in container import flows cannot be fully understood as single, isolated events, but rather as interconnected phenomena that propagate as domino effects throughout the import flow to Sweden (e.g., I2, I5, I7, I9). Respondents described how disruptions in one part of the system spread across interconnected nodes and transport legs, affecting multiple stages of the flow. This highlights the strong interdependence within the CSSC, where the performance of individual components is closely linked to the system's overall functioning. This is also shown in the published literature, which indicates that disruptions in one part of the CSSC rarely remain there.

To illustrate how such domino effects may unfold in practice, Figure 10 presents an example based on patterns identified in the interview material (e.g., I2, I3, I5, I6, I8, I12, I15). The figure

illustrates how disruptions may propagate through interconnected transport legs and nodes, ultimately affecting Swedish ports and hinterland transport.

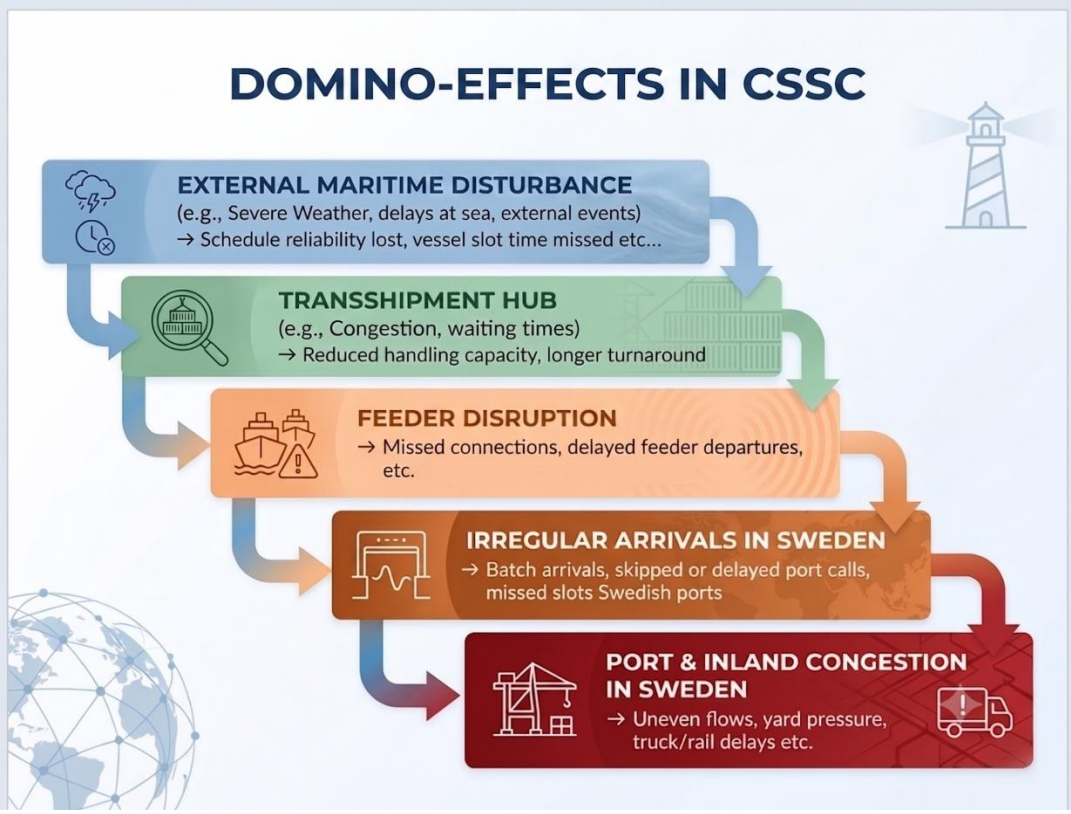

Figure 10: Domino effects in Swedish import flows, derived from interviews. [Created with PowerPoint and modified by Gemini (2026)].

It should be noted that the sequence presented in Figure 10 represents one possible development of the domino effect, rather than a fixed or universal pattern. As highlighted earlier in the chapter, disruptions may originate at various points in the transport chain, including maritime transport, transshipment ports, and inland operations. However, regardless of the point of origin, the empirical data consistently show that a single root cause can trigger disruptions across multiple stages of the container supply chain (e.g., I2, I3, I5, I9, I10, I12, I15). This reflects the high level of interdependence within the system.

Cascading and downstream effects

This mechanism was further described as a "*snowball effect*" (I2), in which initial disruptions, such as weather-related delays or operational disturbances, accumulate over time, increasing system pressure. As vessels are delayed and schedules are disrupted, the system gradually moves out of balance, making it increasingly difficult to recover. One respondent described this as "*that creates heavy congestion at a terminal*" (I5), contributing to prolonged congestion and reduced reliability across the transport chain, with recovery sometimes taking considerable time.

Furthermore, several respondents described how disruptions at individual nodes may trigger chain reactions throughout the transport system (e.g., I1, I2, I3, I4, I5, I8, I10). For example,

port congestion and weather issues were highlighted as key drivers of these cascading effects. As one respondent explained, when terminal operations slow down, "*it takes longer to handle the vessel… then the next vessel has to wait… and that is what creates congestion"* (I5). This also affects subsequent transport operations, as vessels, containers, and terminal capacity remain tied up longer than planned. This illustrates how delays at a single terminal may propagate to subsequent vessel calls and operations. Another respondent further explained how such delays create cascading effects: *"…then you have to let the load stand for another week. So, you will not have to bring it up until next week. So that, it is like this domino effect"* (I10).

The cascading nature of these disruptions becomes particularly visible in the downstream effects on Swedish import flows. Several respondents described how delays at major European hub ports or other issues along the chain directly affected arrival patterns in Sweden (e.g., I3, I5, I10, I15). For example, one respondent explained how missed port calls may lead to cargo being rerouted or temporarily stored in intermediate ports, resulting in uneven arrival patterns: *"the cargo is dropped in a previous port… then the next vessel arrives with a large volume… and suddenly you have congestion in Gothenburg"* (I5). This may create temporary peaks in cargo volumes that exceed terminal handling capacity and contribute to congestion in Swedish ports.

This creates volume fluctuations, with periods of low activity followed by sudden surges when delayed cargo arrives simultaneously. As one respondent explained how Swedish ports are affected by upstream disruptions:

> *"We are part of that chain, so if they have problems, for example Rotterdam or Antwerp, we have problems the week after, and that can both mean that we have a week with very low volumes and then the week after with large ones because the backlog is released"* (I9).

These irregular flows place additional pressure on ports and inland transport systems, as capacity must handle concentrated volumes within short time frames (e.g., I9, I11). One inland operator described, *"The whole chain also affects us, of course... will there be a stop somewhere in the system... Of course, we will have effects on the railways as well"* (I7).

Additionally, another respondent noted, disruptions in one part of the system may *"affect all parts of the flow… ports, trucks, and hinterland connections"* (I15). This highlights how interdependencies between nodes and transport legs enable disruptions to propagate across the entire system, reinforcing the challenges identified in previous sections.

The findings from the interviews can be interpreted through the theoretical perspectives on system interdependencies and cascading effects outlined in the literature review. In such systems, even relatively small initial disturbances may escalate rapidly as delays propagate across interconnected nodes and logistics segments. The analyzed interview material indicates that the relationship between the magnitude of the initial disruption and the resulting operational consequences is non-linear (e.g., I2, I3, I5, I9). Rather than remaining isolated, disruptions tend

to grow disproportionately over time as congestion, rescheduling, and capacity constraints interact dynamically across the CSSC.

To further conceptualize this phenomenon, the consequences of a disruption can be understood as intensifying as they propagate downstream through the hub-and-spoke network structure. While an initial event, such as an external maritime disturbance or a missed slot time, may initially incur a limited operational impact, the data from the interviews show that the disruption accumulates significantly at critical upstream nodes, particularly European transshipment hubs. As described by the respondents, the efficiency-driven practices within the CSSC prioritize continuous movement and minimize storage or buffer capacity, which inherently reduces the system's ability to absorb these variations (e.g., I3, I10). Consequently, by the time irregular arrival flows reach destination ports and hinterland transport systems in Sweden, the operational consequences and associated costs may have developed into a disproportionately amplified pattern. Frequently described by respondents as a “snowball” or “domino” effect, this dynamic highlights how downstream local performance is shaped by the compounding effects of upstream disruptions (e.g., I6, I10). Figure 11 conceptually illustrates this amplification mechanism.

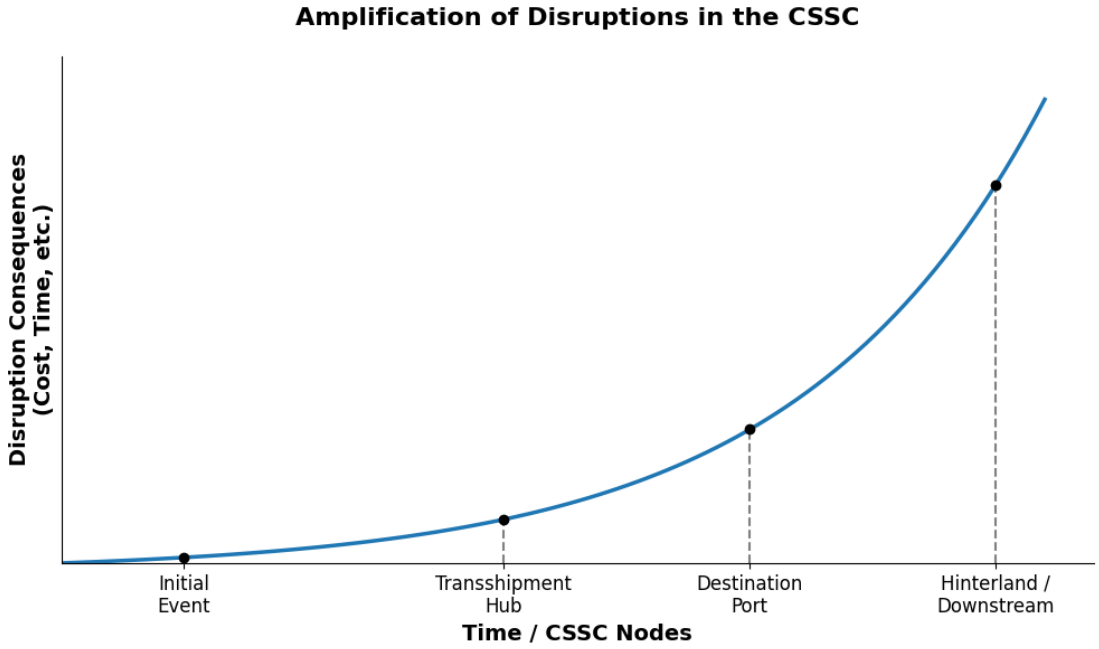

Figure 11: Amplification of Disruptions in the CSSC [Created with Python].

6. Discussion

In the discussion chapter, the previous results and analysis will be discussed alongside the literature review, supported by the empirical context.

6.1 Findings discussion

System-Level Characteristics of the Swedish Import CSSC

The findings indicate that disruptions in container import flows to Sweden are best understood as system-level phenomena rather than isolated operational issues. This aligns with previous research emphasizing that performance in container shipping supply chains arises from interactions among interconnected logistics segments (Song, 2021; Fransoo & Lee, 2013).

What becomes clear in this study is how strongly the Swedish system is shaped by its structural position within the wider CSSC network. Due to the reliance on hub-and-spoke configurations, disruptions at upstream nodes, especially major transshipment hubs, tend to materialize downstream in Swedish ports and inland systems. While this dependency is well established in the literature (Ducruet & Notteboom, 2012; Calatayud et al., 2017), the findings suggest that it may be even clearer in the Swedish context, given the limited number of direct deep-sea connections and Sweden's position as the end-link in container flows.

Instead of viewing congestion and delays as local inefficiencies, the results support an interpretation in which many observed bottlenecks reflect imbalances created elsewhere in the network. This reinforces the argument that analyzing container flows requires an end-to-end perspective, where upstream conditions are considered alongside local performance (Schøyen et al., 2018; Yue & Mangan, 2023).

Structural trade-offs

An interesting implication of the findings concerns the structure of the Swedish port system. Sweden is characterized by a relatively large number of ports, while a significant share of volumes is concentrated in a few major nodes, particularly Gothenburg (Chapter 3). This creates a system that is neither fully centralized nor fully decentralized.

The empirical findings suggest that direct deep-sea services may offer certain advantages in terms of concentration of volumes, fewer transshipments, and improved reliability. At the same time, respondents emphasized that these services remain embedded within wider liner shipping networks and still depend on major European hub ports along the route. As a result, direct calls do not eliminate the structural dependencies within the system, although they may reduce some operational vulnerabilities related to transshipment. Against this background, this hybrid structure highlights a fundamental trade-off. On one hand, further concentration of volumes could strengthen economies of scale and potentially enable more direct deep-sea calls, thereby reducing reliance on transshipment hubs. From this perspective, the current dispersion of volumes contributes to structural dependency on hub ports and feeder networks. On the other hand, both the empirical findings and previous research indicate that highly centralized systems

may become increasingly vulnerable to disruptions (Karmelić et al., 2025; Song, 2021). When large volumes are concentrated to a limited number of nodes, disturbances at these locations may generate system-wide consequences.

The results, therefore, suggest that neither full centralization nor full dispersion is without drawbacks. Instead, the organization of container flows appears to involve a balance between efficiency and resilience, where efforts to optimize one dimension may come at the expense of the other (Calatayud et al., 2017). In this context, some of the respondents described a stronger concentration towards a limited number of Swedish ports to may strengthen economies of scale and reduce the fragmentation of cargo volumes across many small ports.

Cascading effects

An insight from the study is the extent to which disruptions propagate through the system as domino or cascading effects (Figure 10). While this phenomenon has been described in previous research (Song, 2021; Karmelić et al., 2025), the interview findings show that even relatively minor disturbances can trigger broader system-wide impacts. This can be understood in light of the high degree of interconnection among different logistics segments. When transport stages are tightly interconnected, delays in one part of the system directly affect subsequent operations. Additionally, disruptions may spill over not only across individual transport chains but also into later transport assignments, as vessels, containers, and terminal resources remain tied up longer than planned. In combination with high utilization levels and limited buffers, this reduces the system's ability to absorb variability, increasing the likelihood of the propagation of disruptions through the system (Fransoo & Lee, 2013).

An important implication is that congestion in Swedish ports or inland systems should not necessarily be interpreted as a locally generated problem. Instead, they may represent the visible outcome of earlier disruptions within the network. This perspective shifts the focus from isolated bottlenecks to understanding how disturbances evolve and interact across the container flow (Schøyen et al., 2018).

Hinterland in shaping flow performance

While much attention is often placed on maritime transport and ports, the findings indicate that hinterland systems play a more critical role in the CSSC than is sometimes assumed. Inland transport is not merely a downstream activity but an integrated part of the overall system.

In the Swedish context, the efficiency of container flows is closely dependent on the functioning of hinterland transport systems, particularly rail and truck connections between ports and inland destinations. Limitations in rail capacity, scheduling constraints, and competition with passenger traffic may reduce flexibility in the system. This is consistent with previous research highlighting hinterland connectivity as a key determinant of port performance and supply chain efficiency (Notteboom, 2006; Van der Horst & De Langen, 2008). Beyond this, the findings also suggest that the interaction between maritime disruptions and hinterland operations has received more limited attention in previous research, particularly in the Swedish context. The

interviews illustrate how disruptions in maritime flows may propagate into inland transport systems through uneven arrival patterns, congestion, and temporary storage peaks. At the same time, the ability of hinterland systems to absorb such variability appears important for maintaining overall flow performance. The results in this study suggest that mismatches between port operations and the availability of inland transport contribute to uneven flows and temporary congestion. In this sense, hinterland systems should not be treated as separate from port performance, but rather as an extension of it. This further supports the need for a system-level perspective in which coordination across maritime and inland segments is considered jointly (Fransoo & Lee, 2013).

Practical implications

The findings of this study have several practical implications, particularly for transport planning and decision-making in the Swedish context. First, the results suggest that planning approaches based on stable and predictable flows may not fully capture the dynamics of container transport systems. Instead, the observed variability in arrival patterns, combined with the occurrence of domino effects, indicates that transport systems should be analyzed as dynamic and interdependent.

Second, the strong dependency on a limited number of nodes highlights the importance of considering network structure in infrastructure planning. While investments in individual ports or transport links may improve local performance, their overall impact may be limited if system-level dependencies are not addressed, which is also supported by the literature (e.g., Fransoo & Lee, 2013). For example, increasing capacity in Swedish ports may not necessarily reduce delays if bottlenecks remain in upstream transshipment hubs. This implies that infrastructural constraints and shipping network structures may still limit the ability to accommodate larger deep-sea vessels, even if local port capacity is expanded.

Finally, the findings point towards the importance of coordination and information sharing between actors. Given the high degree of interdependence within the system, disruptions in one part of the chain quickly affect others. Improving coordination, synchronization, and system integration may therefore represent an important avenue for reducing the impact of disruptions. However, as mentioned in the interviews, achieving this in practice is hindered by structural and commercial barriers. A major obstacle is the uneven distribution of costs and benefits, where the actor investing in integration may not be the one capturing the benefits, which is also highlighted in the literature (Ceulemans et al., 2024). Furthermore, strong competition limits stakeholders' willingness to share information. These commercial barriers are reinforced by operational challenges, such as mismatched IT systems and an asymmetric distribution of control, where major shipping lines dictate structures. At the same time, other actors are required to adapt to the hierarchical structure of the CSSC. Consequently, incentive and power imbalances explain why systematic coordination remains difficult to implement in practice.

6.2 Methodology discussion

This case study (Yin, 2009) employs a qualitative research approach (Cresswell, 2014), which is well-suited to understanding how bottlenecks and disruptions emerge within a complex container shipping system. As noted in the literature (e.g., Song, 2021) and in empirical findings, such systems are characterized by complex interdependencies and dynamic interactions that may be difficult to capture using quantitative methods. At the same time, the qualitative design introduces certain limitations. The findings are based on respondents' perceptions and experiences rather than objective, hard data, which means the results should be interpreted as indicative rather than definitive (Denzin & Lincoln, 2018).

The use of semi-structured interviews (Kvale & Brinkmann, 2015) enabled a deep exploration of how different actors experience these dynamics and also provided information that would not have been captured with a structured interview format. On the other hand, semi-structured interviews give a degree of flexibility that may influence how data is generated. While this enables rich responses, it also means that interviews are not fully standardized, which may affect comparability between respondents (Kvale & Brinkmann, 2015). However, this flexibility is also a strength, as it allows the researcher to adapt questions and explore emerging themes in greater depth.

A key strength of the approach is the inclusion of multiple actors across different parts of the transport chain. This aligns with case study research principles, in which the aim is to capture a phenomenon from multiple perspectives to understand better system-level behaviour (Barriball et al., 1994; Yin, 2009). By combining insights from a wide perspective of actors, the study was able to capture an end-to-end perspective, which is essential given that disruptions often originate in one part of the system but materialize in another (Calatayud et al., 2017). The use of a deductive thematic approach further strengthened the analysis by ensuring consistency between theory, data collection, and interpretation (Miles et al., 2014).

Another debatable limitation concerns the selection and scope of respondents. The number of respondents was chosen to balance depth and control within the given timeframe (Bell et al., 2019). While this enabled a structured in-depth analysis, it also implies that certain perspectives could be underrepresented. Moreover, capturing inland transport respondents in the origin region proved challenging, resulting in limited empirical material for that part of the chain. As a result, the study mainly reflects processes from the port of origin onwards.

However, the approach is considered a good match for the case study's purpose. By combining an SLR (Wohlin, 2014), empirical context, and qualitative insights from multiple actors, the study effectively employs methodological triangulation (Fusch et al., 2018). This triangulation allows for the cross-validation of empirical findings against both established academic theory and secondary statistical data, which mitigates the risk of subjective bias and provides a more robust, nuanced understanding of Swedish container import flows. Nevertheless, the findings

should therefore be understood as contributing to an improved system-level understanding of container import flows to Sweden, rather than as statistically generalizable results.

7. Conclusion

The purpose of this study was to analyze Swedish import CSSCs through Swedish ports, to understand how these flows are structured and function in practice, where bottlenecks and disruptions occur across maritime and hinterland segments, which factors influence their occurrence, and how the flows can be simplified for transport modelling.

RQ1: How are import flows of standard containers to Sweden structured in practice, including intermodal interfaces, when following container flows from origin to final destination through Swedish ports?

Due to Sweden's geographical position and port infrastructure, container import flows are primarily organized as a hierarchical hub-and-spoke system, in which the majority of goods undergo at least one transshipment. As identified in Section 5.1, three main maritime flow structures can be observed, with the hub-and-spoke configuration being the dominant one. This implies that Swedish ports are integrated into broader international transport networks and are therefore dependent on upstream nodes and processes. Direct deep-sea calls are limited and concentrated mainly in Gothenburg, reinforcing this dependency on transshipment hubs for most Swedish ports. In this context, Swedish ports primarily serve as end nodes in the maritime leg of the transport chain, where containers are discharged and transferred to inland transport systems.

Another key characteristic is the strong emphasis on keeping containers in motion. Storage within the chain is generally avoided due to high costs, resulting in a system optimized for continuous flow rather than buffering.

Finally, inland transport forms an integral extension of the maritime system. Modal choices, port location, and hinterland connectivity influence how flows are distributed within Sweden: Gothenburg serves as a national gateway, while other ports primarily serve regional hinterlands.

RQ2: Where along import flows of standard containers to Sweden do waiting times and bottlenecks occur in relation to vessel size and the capacity, layout, and storage characteristics of Swedish ports?

Waiting times and bottlenecks occur across multiple segments of the container shipping supply chain rather than being concentrated at a single point.

At upstream flows, major transshipment hubs represent critical bottlenecks, especially hubs in Northern Europe. This is due to their central role in the network; congestion at these nodes delays feeder connections and disrupts downstream flows to Sweden.

Within Swedish ports, bottlenecks are mainly related to terminal capacity, operational constraints, and coordination between vessel arrivals and inland transport. Waiting times may arise both before berthing and after discharge, particularly when inland transport is not aligned with port operations. Further downstream, bottlenecks are also present in hinterland transport

systems. Rail capacity constraints, limited flexibility, and competition with passenger traffic contribute to delays, while truck transport may experience local congestion during peak periods. Importantly, bottlenecks are often not locally generated but reflect disruptions occurring earlier in the transport chain, reinforcing the need for an end-to-end perspective.

RQ3: Which operational and terminal-related factors influence the performance, waiting times, and bottlenecks of import flows of standard?

Bottlenecks and disruptions in import flows are driven by a combination of structural, operational, and external factors interacting across the system. A key finding is that many disruptions are rooted in the structure of the transport system itself. The dependency on a limited number of upstream nodes, where disturbances in major transshipment hubs propagate downstream to Swedish ports. At the same time, the structure of the Swedish port system, characterized by multiple ports with relatively dispersed volumes, supports the need for feeder-based transport solutions. Together, these factors contribute to a system in which bottlenecks are not only operational issues but also structurally embedded.

From a capacity perspective, limitations in ports, terminals, and hinterland systems further constrain the ability to handle increasing volumes and vessel sizes. Operational factors, such as uneven arrival patterns, scheduling practices, and limited operating hours, reduce flexibility and increase congestion. Organizational aspects, including labour availability and coordination between actors, also influence system performance, while external conditions such as weather events and demand variability may further amplify disruptions.

RQ4: How can observed import flows of standard containers to Sweden, through Swedish ports, from origin to final destination, be simplified into representative flow structures?

The results identify a limited set of recurring flow structures representing container imports to Sweden. The dominant maritime structure is the hub-and-spoke model, complemented by direct deep-sea calls to Gothenburg and short-sea intra-European flows. These simplified structures capture key system characteristics. At the same time, the findings show that flows vary depending on routing, number of transshipments, and actor configurations, affecting both transit time and reliability. Flow structures are therefore not static but influenced by carrier strategies and external conditions. Additionally, the hinterland structure in Sweden is more difficult to generalize into a number simplified structures, as configurations and hinterland services vary considerably between ports.

To summarize, this study demonstrates that container import flows to Sweden are shaped by a combination of structural dependencies, capacity constraints, and dynamic interactions across the CSSC. A key insight is that efficiency-driven system design, characterized by high utilization and minimal storage, increases vulnerability to disruptions. Combined with the centralized nature of global container shipping networks and Sweden's dependency on feeder connections, this creates a system where upstream conditions have a strong influence on local performance in Swedish ports and throughout the hinterland.

Moreover, the findings pinpoint the importance of adopting a system-level perspective when analyzing container flows, as bottlenecks, delays, and reliability issues emerge from interactions between multiple interconnected segments and actors, rather than from isolated events.

Further studies

Given that this study uses a qualitative research approach, future studies could adopt a quantitative perspective to further investigate import flows into Sweden. As suggested by Cao et al. (2024), the increasing availability of large-scale data sources, such as AIS data and container tracking information, creates opportunities for data-driven analyses. A quantitative study could analyze transport flows from origin to final destination over a defined time period, enabling a more precise assessment of reliability in both maritime transport and hinterland logistics in Sweden.

Another relevant subject for future research would be to conduct a similar study focusing on export flows instead of import flows. In addition, a comparative analysis between import and export flows could provide valuable insights into structural differences and similarities within the CSSC in a Swedish context. This study indicates that, in some cases, import flows may be more difficult to plan for at ports than export flows. However, as this was not the primary focus of the study, this aspect of the comparison was not explored in depth. A comparative study within a Swedish context would therefore be of high interest.

Finally, as this study clearly shows that a significant portion of delays and structural bottlenecks originates in major European transshipment ports, a more in-depth investigation into these specific hubs from a Swedish perspective could be highly valuable. Such research could explore how Swedish stakeholders can better navigate these upstream disruptions and investigate alternative transport routes or network configurations to ensure more resilient CSSCs in the future.

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APPENDIX 1: Snowballing process

https://docs.google.com/spreadsheets/d/1XtuLReejnqvhRSfcGcXH0q7SgPYznZaoZ425W7a0w5U/edit?usp=sharing

APPENDIX 2: Interview guide

Interview-guide – Front page

About the Interview

This document outlines the main themes and core questions that will be covered during the interview.

The interview is semi-structured and will be based on a typical containerized import flow to Sweden that your company handles. The flow does not need to refer to a specific customer but can represent how similar setups are generally organized in practice.

The purpose is to understand how these flows function operationally – from origin to final destination in Sweden – with particular focus on:

- flow structure
- waiting times and lead time variability
- storage and buffer functions
- bottlenecks
- the interaction between sea transport, port operations and hinterland transport

In addition to the main questions, follow-up questions may be asked to clarify or further explore certain aspects. Not all questions will necessarily be asked, as the interview will be adapted to the discussion and the available time.

The interview is expected to take approximately 30–40 minutes.

Recording and Data Handling (GDPR)

With your consent, the interview will be recorded for transcription purposes. The recording will only be accessed by the interviewer and will be deleted after transcription.

All collected data will be treated confidentially and used solely for academic research within the scope of the master's thesis.

Participation is entirely voluntary, and you may withdraw from the interview at any time without providing a reason.

Link to all questions: https://docs.google.com/document/d/1pbfGk0GV7U4DjfjInOCvbQMdf-Cu2cXQ6ybmBC6Q4nI/edit?usp=sharing

APPENDIX 3: Respondents

Interview ID	Date of interview	Experience	Actor type	Role in CSSC
I.1	2026-02-09	5 Years	Logistics provider (Sea/Inland)	Coordinate: End-to-end → Sweden (customer delivery)
I.2	2026-02-17	10 Years	Logistics provider (Sea/Inland)	Coordinate: End-to-end → Sweden (customer delivery)
I.3	2026-02-12	40+ Years	Logistics provider + Shipping line (deep-sea/feeder)	End-to-end transport & logistics solutions → Sweden
I.4	2026-02-19	30+ Years	Academic	Professor in logistics & shipping, end-to-end perspective.
I.5	2026-02-25	30+ Years	Shipping line (deep-sea/feeder/short sea)	Global end-to-end services → Sweden (sometimes inland as well)
I.6	2026-03-06	25+ Years	Shipping line (feeder/ short sea)	Maritime transport, European ports → Swedish ports
I.7	2026-03-06	30+ Years	Rail operator (Inland)	Port → inland distribution (Sweden)
I.8	2026-03-09	5 Years	Shipping line (feeder/ shortsea)	Maritime transport, European ports → Swedish ports
I.9	2026-03-11	20+ Years	Swedish Port/Terminal	Terminal operations, Discharge → hinterland connectivity
I.10	2026-03-18	35+ Years	Industry Expert	Cross-segment expertise across the entire CSSC
I.11	2026-03-19	40+ Years	Swedish Port/Terminal	Terminal operations, Discharge → hinterland connectivity
I.12	2026-03-19	5 Years	Importer/Goods owner	Demand-side actor (inbound logistics, Service procurement & coordination)
I.13.	2026-03-19	15+ Years	Swedish Port/Terminal	Terminal operations, Discharge → hinterland connectivity
I.14.	2026-03-23	20+ Years	Importer/Goods owner	Demand-side actor (inbound logistics, service procurement & coordination)
I.15	2026-03-24	20+ Years	Importer/Goods owner	Demand-side actor (inbound logistics, service procurement & coordination)

APPENDIX 4: Thematic analysis table

https://docs.google.com/spreadsheets/d/1ACTQO8Dh7j7ADN2cfG-on-b1983rrG4qDLlnI8h_xbM/edit?usp=sharing