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# ANALYSIS OF THE PORT ENVIRONMENT FOR THE EXPORT OF GREEN HYDROGEN

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***Abstract.*** *The present article aims to investigate the feasibility for the transport, storage, and export of green hydrogen in a port environment. For this purpose, this study will map and study the port environment in seven aspects: Hinterland, Umland, Vorland, Foreland, Inland, Gotland, and Stadthafen, thus identifying the resistances to the flows that make up the green hydrogen supply chain. A framework were presented to help the user to analyze and decide which port terminals have conditions and feasibility for* $H_2$ *storage and flow, and identify the carbonization level of the chain under study and infer whether this chain is in the process of decarbonization. As well as classifying the level of resistance to logistical flows according to the fluidity of communication between the links. The framework and the interactions between the players can give key informations to the evaluator to help him to determine where and which changes can be made to improve the flow, once the port terminal depends heavily on traffic flows.*

***Keywords:*** *Green Hydrogen, Supply Chain, Port Environment.*

## 1. INTRODUCTION

Several countries are in the transition phase from a carbon-based to a low-carbon matrix, in response to the Paris Agreement. In view of this, green hydrogen ($GH_2$) emerges as a clean energy alternative, being a favorable option to advance in the current process of decarbonization of global economies (especially in the transport sector). Countries with ambitious goals have shown interest in green hydrogen, which is produced from electricity generated through renewable sources (without greenhouse gas emissions), based on an electrolysis process (Delgado and Costa, 2021).

Brazil, in turn, prepared an energy expansion plan to compose its matrix with a 45% share of clean energy by the year 2030, however, with regard to the use of green hydrogen as a direct source of energy or energy vector, the country is still in an incipient stage of research and development (R&D) and so far does not have a specific strategy for regulation, production, consumption, transport, storage and export, which allows the incorporation of hydrogen into the country's energy matrix. The proof is that the National Energy Plan (PNE) 50 is dedicated only to the basic concepts for this energy alternative.

Despite this, it is important to note that Brazil stands out as a natural candidate for a future exporter of green hydrogen due to its potential to generate the basic raw materials for $GH_2$ – water and energy from renewable sources (such as wind, solar, photovoltaic and hydro). For this reason, the development of studies on $GH_2$ in Brazil is of great importance, as it is an energy alternative with new technology, but still with challenges to be overcome, especially those related to the supply chain (transport and storage).

In this context, the present article aims to evaluate the conditions and feasibility of Port Terminals for the storage and flow of hydrogen, knowing that the production of its "green" form will occur in the near future and that developing the mapping of the port environment it is fundamental. For that, the criteria will be considered: Hinterland, Umland, Vorland, Foreland, Inland, Gotland, and Stadthafen, thus identifying the resistances to the flows that make up the green hydrogen supply chain.

## 2. GREEN HYDROGEN ($GH_2$)

$H_2$ has been highlighted as an important alternative in the substitution of fossil fuels. This replacement will take place gradually, especially in Europe, due to dependence on gas supply from Russia and the need to reduce Greenhouse Gases (GHG) emissions in its energy matrix, in order to meet the goals established at the UN Conference of the Parties (COP 21).

Currently, the production of hydrogen gas ($H_2$) is obtained in several ways, and what will confer the degree of sustainability of the process will be the raw material (RM) and the source of energy used in its production, for which it is designated by colors, as grey, blue, green etc. The gray and blue hydrogens are products originating from the steam reforming process of natural gas, the difference is that the gray generates $CO_2$ and this is freely released into the atmosphere, while the blue one captures this component for reuse in other industrial processes. $GH_2$ is generated through the electrolysis of water (the only raw material), using electricity from renewable sources (*e.g.* wind, solar photovoltaic) and the only waste from the process is $O_2$.

Brazil stands out for having the essential conditions required for the production of green hydrogen: abundant sources of fresh water and a large capacity to generate renewable energy (wind and photovoltaic). Currently, hydrogen is already produced in industrial processes on a reduced scale, but for its application as a source of energy to replace fossil fuels, it faces some challenges, since there is a need to develop technologies that enable its transport over long distances and large volume storage. Thus, this study intends to analyze the commercial viability of exporting $GH_2$ using shipments via the port terminal. As the technology for the production of green hydrogen on a large scale is under development, this study will consider the export of the generic product, since the chemical component is unique, hydrogen gas, and what will vary is the origin of the energy used in its production and the structure of the logistic chain, which must be green.

As a reference, the Australian Fortescue Future Industries (FFI) and the German E.ON, signed a memorandum of understanding on March 29, 2022 to deliver up to five million tons/year of $GH_2$ to Europe by the year 2030. Fortescue also intends to develop large-scale green hydrogen production projects in Brazil, with a view to exporting to the European continent. Here, the company has two memorandums of understanding in this regard: one with Ceará, for the construction of a green hydrogen production plant, in the Pecém Complex, and the other with Açu Port, in Rio de Janeiro, also aimed at the development of the component in the green modality.

### 2.1 The Supply Chain

The concept of Supply Chain (SC) dates back to the 1950s, when logistics emerged as an administrative science. Supply chain management consists of managing an interconnected network that involves the entire product and service procedure required by the customer. It is the process of moving goods, and customer order, encompassing from the acquisition of raw materials, production, to their distribution. In other words, the concept comprises the processes of purchase, storage, transformation, packaging, transport, internal movement of distribution and all the necessary support to make it happen.

According to Ballou (2004), supply chains are sets of functional activities (transportation, inventory control, etc.) that repeat themselves over and over again along a channel through which raw materials are converted into finished products, to which value is added to the product.

#### 2.1.1 The length of the supply chain

Another supply chain management practice has to do with the number of links in the chain. Long chains allow for greater relationship between links, however, it can have devastating effects in case the chain fails to function. A supply chain must be configured to respond to a possible disruption (chain resilience). The length of the supply chain increases exposure to risk. Logistics professionals have a maxim that says: goods in motion are goods at risk. In other words, the greater the transport distance to be covered, the greater the number of possible risks (greater resistance to flows), as well as the deadline for delivery of the order in case of cargo loss or delay.

The consequences of high levels of resistance to supply chain flows between Europe, Asia and the Middle East are considerable. Several countries that implemented long chains suffered the most from the COVID-19 pandemic, with stockouts, bullwhip effect, lack of ship capacity, and high freight rates. Moreover, despite the reopening of the channel, the side effects, which entailed increased congestion at seaports, continued six months after the phenomenon started.

### 2.2 Decarbonizing the Supply Chain

A traditional supply chain adds negative impacts along the process, which is through the emission of $CO_2$, a reflection of a developed economy in the post-industrial period, which is based on carbon. Even use and disposal, which have traditionally been considered consumer issues, are heavily influenced by decisions made in the development phase of a Green Supply Chain (GSC) project. Thus, a product design dictates the energy expenditure (and carbon footprint) as products move through the supply chain, the health impacts of consumers, and how it will be recycled.

It is also known that the studies and protocols regarding the production chain of this fuel in the "green" form started asynchronously. Each project in the chain is moving forward as the degree of technological certainty and economic equation in the production of $H_2$ increases. New production, storage, and transportation technologies are becoming available and new plants are being announced around the world. The transportation area also announces the production of suitable ships with the technical characteristics required by $H_2$.

### 2.3 Green Hydrogen Supply Chain

For Salmon and Bañares-alcántara (2021), the production of $GH_2$ only needs water and electricity as raw material and input. In addition, during the production process, there should be no combustion step, so there is no formation and emission of polluting gases based on carbon and sulfur, for example. However, the authors point out that there is a considerable lack of detail on the relationship between the $GH_2$ production, and transportation. In general, the articles detail the complexities of production and neglect the interaction with the complexities of transporting and storing this product.

According to Donato (2012), the same analysis made on the supply chain of the oil, gas, and biofuels industries should be used to define the green supply chain, and as a proposal cites the following classification:

- **Upstream Logistics:** concerns the inputs, the way in which raw materials and inputs reach the company. In this sense, it involves issues such as the relationship with suppliers, crucial for an assertive purchase of raw materials, aiming to meet customer needs (Donato, 2012).
- **Midstream Logistics:** this is the stage where the transformation of raw material into finished product (FP) takes place and everything that this encompasses and requires, such as preparations, packaging, supply of the production line, maintenance support, removal of packaging waste from the line and alike (Donato, 2012).
- **Downstream Logistics:** is the way in which the product or service will reach the customer, such as the definition of the means of storage, displacement and delivery. At this point, it is essential to value punctuality, quality and adequate quantity (Donato, 2012).

### 2.4 The Port Environment

The ports are defined by Valentine and Gray (2002) as complex organizations with a diversity of inputs and outputs, embodied in different physical, logistical, access and legal aspects. This makes it difficult to study and directly compare apparently homogeneous ports. For Bichou and Gray (2004), ports are multipart and complex organizations in which institutions and functions usually intersect at various levels.

According to Tolley and Turton (1995), ports are a component of the physical distribution of goods and provide a sea-land interface for export and import activities. This sea-land interface is directly related to the process of analyzing the port environment, which involves different actors in the logistics chain: i) the shipowners, who define the ports of call on each route; ii) the shippers (exporters/importers), who define the ports of embarkation and disembarkation in their operations; and iii) the freight forwarders, who support and assist exporters and importers in the port selection process. In the case of exporters and importers, the analysis of the port environment is conditioned to the sales modality agreed between the parties (Incoterm – International Commercial Terms).

With regard to the criteria for analyzing the port environment, it can be seen that they vary according to the perspective of the actor to be considered. The criteria considered in the analysis of the port environment are diverse and can be classified into two types: quantitative factors and qualitative factors. Quantitative factors are those that can potentially be objectively measured and compared, and are grouped into three broad categories: i) route factors; ii) cost factors; and iii) service factors (D'este and Meyrick, 1992). Qualitative factors, on the other hand, include subjective influences such as flexibility and ease of use, the port's marketing efforts, tradition, personal contacts, and the level of cooperation that can be developed between the user and the port.

The original port sites, commonly located adjacent to downtown areas, have become obsolete. This was also marked by changes in the spatial relationships between Porto and the urban core. Numerous opportunities to reconvert port facilities to other uses (waterfront parks, housing, and commercial developments) have been created.

In the current stage of increasing specialization of cargo handling, both export and import, the increasing size of ships, and the growing demand for space for cargo handling and storage in port areas, have resulted in the implementation of port activity in places far from the urban coastal facilities. From the initial port location, the expansion of ports took place as a result of the evolution of maritime technology and improvements in cargo handling.

In this context, three major phases identified so far in the port development process involve reconfiguration, expansion, and specialization. Colonetti (2017) mentions that the port environment can be analyzed in four phases (*Hinterland, Umland, Vorland*, and *Foreland*).

For the purposes of this paper, the analysis of the port environment will be carried out by classifying the port environment into seven factors, namely: *Hinterland, Stadthafen, Umland, Vorland, Foreland, Inland*, and *Gotland*, which are detailed below:

**A. Qualitative Criteria**

- **Hinterland –** The area that surrounds a port center, from which the loads come, *i.e.*, the port's potential business generator (area of influence).
- **Foreland –** The scope of the trade relations of a Port.
- **Inland –** This term refers to the location of a port in relation to the coast, *i.e.*, whether it is located in a fluvial region, located inland or on the sea coast.
- **Gotland –** This is the concept where a direct land connection is established between a land cargo terminal and the coastal port. These are the inland areas, also known as dry ports.

**B. Quantitative Criteria**

- **Stadthafen –** It is the proximity of a city to a port (urban port). In this case, distance is considered.
- **Umland –** The physical environment of the Port, *i.e.*, its facilities, infrastructure, and other factors that characterize its operation (quality of services, tariffs, etc.). In this case, the number of installations is considered.
- **Vorland –** It is the area of maritime coverage of a Port, and is related to a greater or lesser distance from the main navigation routes. Considering that the main commercial maritime routes are in the Northern Hemisphere, we can assume that the ports in Northeast Brazilian have a greater vorland than the other national ports. In this case, distance is considered.

### 2.5 Resistance to Logistical Flows

According to Ammer (2013), the path of least resistance to a flow is the easiest method, way, or course of action. The path of least resistance is described as the physical path that provides the least opposition to the movement of a given object or entity, among a set of alternative paths (Neto, 2004). In physics, the path of least resistance is preferably taken by objects moving in a system. For example, water flowing downward follows the path of least resistance, since it is pulled downward by gravity.

In the early 20th century, the first works on the study of flows of goods began to appear, and in the thirties, more precisely in 1927, Ralph Borsodi published the book "The Distribution Age", in which he addressed the topic of physical flows of materials, under the name "distribution". For Rogers and Tibben-Lembke (2001), physical transport flows can be either forward or reverse. There is, therefore, an interesting parallel between the flows studied by physics and the flows of product distribution.

The load driving systems are accelerated by the driving force of the conveyor units, but due to flow resistances, they eventually reach an average speed that is inversely proportional to the channel resistances. As mentioned by Neto (2004), resistance to logistical flows in transport channels is the set of restrictions or inhibitions, both physical, economic, and legal, that affect the performance of the logistical flow and that occur during circulation on transport routes.

In attempts to implement an export flow of $GH_2$, companies are running into logistical difficulties. Scholars call these difficulties in implementing a flow as resistance to logistical flows. The more steps the chain needs for its development, the greater the resistance to flows.

## 3. METHODOLOGY

In this section, a model for analyzing the port environment for $GH_2$ exports was developed, where the most relevant criteria are examined, such as the seven criteria for analyzing the port environment, the classification of the green supply chain, and the analysis of resistance to flows. The criteria are investigated with a focus on resistance to logistical flows and the classification of the green supply chain.

### 3.1 Supply Chain Analysis

Supply chain management (SCM) is an integrated definition with the objective of coordinating the flows of a distribution channel (Helo and Szekely, 2005). The purpose of the supply chain in turn is to design an ecosystem of collaboration with the entire network involved through mutual trust, as well as to eliminate existing communication obstacles and ensure that different companies are connected in order to achieve an integration of the entire supply network in a fluid manner (Korpela *et al.*, 2017).

Green logistics is the term used to define strategies that aim to eliminate carbon emissions and reduce the impacts generated during the operation of supply chains, and thus reduce the possibilities of impacting the environment. Although the word green is widely used to speak only of improvements in sustainable marketing, it represents much more, such as betting on initiatives that bring gains for everyone along the production chain.

A production chain focused on low carbon emissions by the transport vehicles is indicated for the green hydrogen production chain. It makes no sense to name the product $GH_2$ and the transportation to be carried out using the concepts and means of transportation based on fossil fuels.

Caglayan *et al.* (2021), employ a green approach for fully renewable use of the European Energy System by 2050, for this they envision the use of pipelines to transport liquid hydrogen. This approach is being considered in defining the $GH_2$ chain in Europe.

Lamb *et al.* (2019), present the possibility of transporting and storing $H_2$ in ammonia ($NH_3$) and identify advantages of this method such as the absence of carbon, high ammonia production efficiency, and use of existing infrastructure around the world.

Green means of transportation bring many benefits, both for companies and individuals. Some are definitive to understand how important this cause is and why it should become a flag for all of us. Check out some of them:

- Reduction in the emission of greenhouse gases;
- Increase in the credibility of companies (competitive advantage);
- Cost reduction;
- Loss reduction;
- Increase in the quality of life of the affected population.

#### 3.1.1 $GH_2$ Supply Chain Analysis

It is the process of evaluating each step of a logistics chain. This method requires an evaluation of each step, from the moment the business purchases raw materials or supplies from suppliers to the moment the company delivers the final product to customers.

For a better understanding of the $GH_2$ supply chain, the same analysis methodology used in the supply chain of the oil, gas and biofuels industry was adopted – upstream, midstream and downstream logistics.

### 3.2 Analysis of the Port Environment

Port environment analysis is the exercise of evaluating each stage of the process, assuming the premise that the Port is a business environment and not a non-profit state enterprise. This process can be analyzed from the perspective that a series of products is being delivered to customers. The analysis process requires an evaluation of each step, from the analysis of the potential load generator in the region, to the moment the company buys the product (port service) to the moment the company receives/ships the loads.

From the traditional port, with side piers adjacent to the city center, the ports adequacy for export/import of $H_2$ becomes a product of the evolution of port technology with improvements in loads handling and safety. After carrying out the analysis of the port environment, three main conclusions can be identified in the Port under analysis: reconfiguration, expansion and/or specialization. The three conclusions portray well the stage that the Port is in, especially the traditional ones. However, the proposed model presents some weaknesses to explain the adequacy of the contemporary port environment.

The analysis of the port environment begins with the mapping of the process steps that should not be reduced or neglected, in order to reduce the time needed to perform the analysis without sacrificing product quality or service level. A conceptual perspective on the port environment for $H_2$ exports could be made by analyzing the seven criteria for the port environment analysis.

#### 3.2.1 *Hinterland*

When analyzing the port *hinterland* for the $GH_2$ industry, one must analyze the scope of load generation in the region where the Port is installed, taking as an example the generation of similar products such as petrochemicals, petroleum products, natural gas production, grains, cellulose and other products that, if produced in large scale, make the *hinterland* of a region viable.

In the analysis of a port's *hinterland*, the verification of how the loads will be received must also be taken into account. The analysis of the land coverage, the rail connections, and the availability of good roads and pipelines are fundamental for the development of the port *hinterland*.

### 3.2.2 *Stadthafen*

This criterion analyzes whether a city effectively has an urban port in operation. It defines the interaction, safety, proximity, and interconnection of the city with the Porto. In the *stadthafen* analysis, the risk that the loads may exert on urban settlements must be considered.

### 3.2.3 *Umland*

The better structured a region is, the higher the quality of the service provided tends to be. To this end, the physical environment of the region must be analyzed, *i.e.*, the facilities and infrastructure of other factors that characterize logistics operations (quality of services, tariffs, etc.). This criterion considers the infrastructure (roads, railroads, pipelines, airports, docks, draft, etc.), the superstructure (handling equipment, terminals, warehouses, etc.), the operation costs (tariffs and transport expenses), and the quality of the services provided. It is necessary to verify the existence of this logistical infrastructure, since it will act in the flow of the final product.

### 3.2.4 *Vorland*

The *vorland* is related to the logistics coverage area, that is, it is related to a greater or lesser distance from the main transportation routes. When planning a certain supply or flow route, the closest points that have the capacity to receive/offload the loads are chosen as the stopping point. Considering that the main trade routes are close to the coastal region, we can assume that the metropolitan region of Salvador has a higher *vorland* than the other regions.

### 3.2.5 *Foreland*

It is the scope of commercial relations in a region, that is, the projection in which the region maintains commercial ties, it is the set of markets reached through connections and partnerships. The foreland represents the commercial coverage area of a micro-region in relation to the others. This aspect is related to the set of markets reached, through installed companies, with which there are regular commercial exchanges.

### 3.2.6 *Inland*

This criterion analyzes the location of a port in relation to the coast, *i.e.*, if it is in a fluvial region, located located inland. This argument takes advantage of the advantages of intermodal transport and the improvements in transhipment efficiency of port terminals. These *inland* ports are integrated with the *hinterland* services of coastal ports through transport services by land, barges, or smaller ships. This is particularly the case along the Rhine/Scheldt delta, where fluvial barge ports act as feeders to delta ports such as Rotterdam and Antwerp.

### 3.2.7 *Gotland*

This is the concept where a direct land connection is established between a land load terminal and the coastal port. These are the inland areas, also known as dry ports. Land terminals tend to have more space available where it can provide a variety of logistics services, such as consolidation and deconsolidation, for load shipped from coastal ports that are normally congested. The developed *hinterland* favors Port to have a good *gotland*.

## 4. RESULTS AND DISCUSSION

### 4.1 Green Logistics Chain Analysis for a Port Environment

To analyze the port environment for the export of green hydrogen, a framework was developed that simultaneously correlates the following concepts:

- Criteria for analyzing a Port
  - Evaluation of the following criteria: *Hinterland, Stadthafen, Foreland, Umland, Vorland, Inland* and *Gotland*.
- Analysis of resistance to flows
  - Identification of bottlenecks and other impediments to GSC flows.
- Green supply chain analysis
  - Identification of GSC levels by stage: Upstream, Midstream, and Downstream.

Table 1 correlates the analysis of the port environment with the level of the green logistics chain, necessary for the movement of $GH_2$. With the information available in Table 1, it is possible to classify the length of the chain according to the quantity of existing levels (the more levels, the longer the chain), within each criterion related to the port environment.

**Table 1.** Framework for analyzing the port environment: analysis criteria x GSC levels.

| **$GH_2$ Production Chain** | **GSC Classified.** | **Upstream** | | | **Midstream** | **Downstream** | | |
|---|---|---|---|---|---|---|---|---|
| | **Chain Level** | **level 3 RM Supplier** | **level 2 Transport of RM** | **level 1 RM / Supplies Storage** | **level 0** | **level 1 Storage** | **level 2 Transport** | **level 3 Virtual Stage** |
| **Criteria for analyzing the Port Environment** | *Hinterland* | Availability of RM | Ability to process RM | Infra. to store from RM | Infra. of production | Infra. to store the $GH_2$ | Infra. to drain the $GH_2$ | Use of SCM software |
| | *Stadthafen* | Access lead time | Risk in loading | Availability $GH_2$ | Load Lead Time | Risk Loaded | _ | Use of risky software |
| | *Vorland* | Proximity to supplier | Proximity to the RM and input supplier | FP Inventory Management - Customer Relationship | _ | _ | _ | Use of ERP software |
| | *Umland* | Infra. of access | Infra. to store RM | Infra. To store RM and inputs | Infra. from Porto | Infra. to store $H_2$ in the port area | Infra. To transport $H_2$ | Use of ERP software |
| | *Foreland* | Stock management | Relationship with suppliers | Purchase of RM and supplies | Relationship with customers | Relationship with Consumer Market | Relationshi p with carrier | Use of SCM software |
| | *Inland* | _ | _ | Distance from the port to the urban center | The fluvial port | _ | _ | Use of ERP software |
| | *Gotland* | _ | _ | Existence of a bonded area | Bonded Area | _ | _ | Use of ERP software |

The criteria for analyzing the port environment must vary according to the perspective of the actor (link in the chain) to be considered. In this way, with Table 1, Table 1the user will carry out quantitative analysis, on the route factors; of cost; and service; and qualitative analysis such as flexibility and ease of use, the port's marketing efforts, the port's commercial maturity, personal contacts and the level of cooperation that can be developed between the user and the port.

In the end, the port environment framework will present the user with a more comprehensive view of the flows for $H_2$ export at given port, identifying the dimension of the physical environment (related to the infrastructure for $H_2$ storage and load handling, the potential area of greatest influence, the commercial scope, and the most optimized routes, in relation to distance (shorter supplier-port and port-customer mileage) and logistics costs (which is influenced by the commercial maturity of the technologies used in $H_2$ transportation and storage)). This analysis will help the user during the decision making about which port terminals have conditions and feasibility for $H_2$ storage and flow.

Table 2 shows the correlation between the analysis of the port environment and the level of the green logistics chain, necessary for the movement of $GH_2$.

**Table 2.** Framework for analyzing the port environment: carbon use by GSC levels.

| **$GH_2$ Production Chain** | **GSC Classified.** | **Upstream** | | | **Midstream** | **Downstream** | | |
|---|---|---|---|---|---|---|---|---|
| | **Chain Level** | **level 3** RM Supplier | **level 2** Transport of RM | **level 1** RM / Supplies Storage | **level 0** | **level 1** Storage | **level 2** Transport | **level 3** Virtual Stage |
| **Use of $CO_2$** | | Yes | Yes | Yes | Yes | Yes | Yes | No |

The analysis model proposed for the green hydrogen supply chain, presented in Table 2, demonstrates that this chain has seven levels, being an intermediate level. The model proposes that the user uses the Table 2 to compare the levels of carbonization present along the chain under study.

The user must fill out the framework according to the possibility of using carbon at each level and infer whether it meets the total or partial environmental requirement, or if the item does not fit. From there, it is possible to identify the carbonization level of the chain under study and infer whether this chain is in the process of decarbonization.

### 4.2 Resistance to Logistics Flows in the Chain

The number of levels in the supply chain defines the resistance to the logistical flows of the chain under analysis, as shown in Table 3.

**Table 3.** Number of levels x level of resistance to flows.

| Number of Chain Levels | Resistance Level | Description |
|---|---|---|
| **<= 3 levels** | Low Resistance | Chain with a low number of levels greater operational ease. |
| **> 3 < 5 levels** | Medium Strength | Chain with a medium number of levels, attention to communication between the links in the chain. |
| **> 5 levels** | High Resistance | Highly resistant chain, provision must be made for communication between the links in the chain. |

What will classify the level of resistance to logistical flows will be the fluidity of communication between the links. Thus, the greater the number of levels identified, the greater the number of contacts between the links, therefore, the greater the resistance to flows.

This happens because the restrictions or inhibitions, both physical, economic, and legal, that affect the performance of the logistic flow, and that occur during the circulation in transport routes, tend to increase according to the number of actors that are involved in commercial negotiations within the chain. As a consequence, a delay in inter-network communication occurs, and thus, promotes a reduction in the flow speed of logistics channels. Thereby, the fewer steps the chain needs for its development, the lower the resistance to flows.

### 4.3 Influence of the Concepts Used in the Analysis of the Port Environment

First, the concepts used seek to explain the recent increase in port terminals that act mainly as transshipment centers in extensive hub-and-spoke maritime and collection and distribution networks. The increase in the availability of loading has triggered changes in the size of ships, in the schedule of regular services and in the structure of liner shipping. The carriers and alliances have redesigned their liner shipping networks by introducing new types of end-to-end services, round-the-world services and pendulum services, especially on major east-west trade routes. As a result, a new generation of terminals has emerged along east-west shipping routes in unlikely places, far from the immediate *hinterland* that has historically guided port selection. These locations were selected to serve the market flow of the continents and for transshipment at transit points on trade routes.

The port terminal depends heavily, sometimes completely, on traffic flows that are generated at a distance by the interaction of widely places separated and stimulated by the location or intermediation of the port en route. The model does not provide a basis for explaining the emergence of hub terminals in 'offshore' or island locations with limited or non-existent site *hinterlands*.

## 5. CONCLUSION

The logic behind the analysis of the port environment is that the more flexible a port is, the more likely it is to respond to customer needs. Several other benefits can be identified with companies that undergo an analysis of the port environment. These benefits include the analysis of whether the Port environment generates enough load to supply large ships.

The analysis of the port environment through the mapping of the port process, through the upstream, midstream and downstream stages, allows the identification of resistance to logistical flows, since a Port with resistant logistical flows implies high management costs, which can make operations unfeasible. Another way to identify resistance to flows is by measuring the length of the supply chain, and the longer the length (number of levels) the greater the resistance to flows in this chain.

With the mapping of the process, stackholder interactions are mapped, such as how raw materials get to the business.

An assessment of the framework and the interactions between the players helps the evaluator to determine where changes can be made to improve the flow. While the cost of raw materials may be a bit higher, the cost of shipping and delivery can drop dramatically and having the supplies come from a supplier can also speed up the delivery process.

Port environment analysis works in conjunction with supply chain management – how the product or information flows from one point in the process to another. Logistic analysis and port environment analysis allow business managers or owners to determine how to accelerate the transfer of goods and information at each point in the process. This speeds up the placement of the product on the market, which makes the business make money.

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