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Modélisation de la gouvernance des villes portuaires européennes de taille moyenne

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Résumé : Ce travail présente un modèle d'analyse de la gouvernance portuaire considérant que la capacité des acteurs à adopter des comportements coopératifs constitue l'élément moteur du développement. Il se concentre sur les ports moyens européens ; quinze cas ont été étudiés (plus de 80 entretiens réalisés). Toutefois, si ce matériau riche permet de comparer la gouvernance de deux, voire trois ports, la finesse des relations mises en lumière complexifie considérablement la comparaison au sein d'un ensemble plus important. Aussi cet article propose un traitement semi-automatique participant à pallier cette difficulté au moyen d'un modèle informatique basé sur la théorie des graphes. Il s'agit de modéliser un système en se basant sur les relations entre les entités du système. Ainsi, les relations entre acteurs ont été analysées afin de créer des typologies et d'envisager à terme des modèles types de gouvernance. Afin de territorialiser le propos, six cas **représentatifs** ont été retenus sur les quinze : Le Havre, Nantes-Saint Nazaire, Dunkerque (France), Gdynia (Pologne), Klaipėda (Lituanie), Hamina-Kotka (Finlande).

Tous ces environnements portuaires modélisés selon un même format (i.e. un graphe) donnent lieu à l'application d'un certain nombre de métriques permettant de les comparer. Deux principales métriques ont été présentées à titre illustratif dans le cadre de cet article : la "Densité" et la "S_metric". Elles ont été couplées à d'autres indicateurs (distribution des degrés et nombre de hubs par port) qui ont permis de mesurer l'intensité des relations, la répartition de cette intensité entre les acteurs, d'identifier les acteurs majeurs ou peu influents.

Mots-clés : gouvernance portuaire, gouvernance, parties prenantes, modélisation, théorie des graphes

Classification JEL : R49 - R58 - O20 - C63

Modelling the governance of European medium-sized port-cities

Abstract: The paper presents a model designed to analyse port governance. It considers that the stakeholders ability to adopt cooperative behaviors constitutes the key element to port development. Its focus is on medium-sized European ports and fifteen cases were studied. Each territory was first subject to a qualitative survey and analysis of the contents of local stakeholders discourse (over 80 interviews conducted). The material is rich, allowing for the comparison between two or even three ports, yet the delicate nature of the relations brought to light adds considerable complexity to the comparison within a larger ensemble. The paper, therefore, proposes a semi-automatic treatment which helps to mitigate this difficulty by means of a computer model based on graph theory. It involves a modelling system based on the relations between the entities of the system. In this context, the relations between stakeholders were analysed in order to create typologies and eventually envisage some standard models of governance. In order to territorialize the subject, six **typical** cases out of fifteen were used: Le Havre, Nantes-Saint Nazaire, Dunkirk (France), Gdynia (Poland), Klaipėda (Lithuania), Hamina-Kotka (Finland).

All these port environments modelled according to a single format (i.e. a graph) led to the application of a certain number of metrics which enables them to be compared. Two main metrics were presented in the framework of this paper for illustrative purposes: “Density” and “S_metric”. These metrics originating in graph theory, coupled with other indicators (distribution of degrees and number of hubs per port), allowed to measure the relationships' intensity and the distribution of these intensities among the stakeholders, and to identify the main stakeholders or conversely the least influential.

Keywords: governance, port governance, stakeholder, modelling, graph theory

Introduction

There is a strong correlation between port and urban development. Many cities have grown out of ports (VIGARIE, 1999) and there is often a link between the size of a port and the size of the conurbation in which it is located (RODRIGUE et alii, 2017). Changes in international trade and containerization, however, have led to a transformation in ports, forcing them to move further away from cities. The result is a physical disassociation without any functional associations actually being eliminated (DUCRUET, 2005). This distancing has led to a reshaping of territories which impacts local governance. Medium-sized port-cities are particularly illustrative on the matter. Although they are not often the focus of maritime geography studies, which prefer to concentrate on large ports, as their port-city relationship is particularly strong. The reciprocal impact of the territorial and port dynamics is more evident when comparing it to larger port-cities. The disconnection of port and city, the peri-urbanization, with the perimeters of the port, industry and housing converging and overspreading, have forced local stakeholders to evolve in an environment which has to be constantly renegotiated. Beyond a simple coexistence, therefore, the driving force in the development of these port territories resides in the creation of synergies and stakeholders' capacity to adopt cooperative behaviours (LOUBET and SERRY, 2020).

Our analysis is built upon a research programme¹ based, amongst others, on a European benchmark integrating fifteen medium-sized European port-cities (bloc “Qualitative Analysis, actors interviews”, cf. Fig. 1). Each port was the subject of a qualitative survey and analysis of actors' discourse (over 80 anonymous interviews conducted with the principal stakeholders). This wealth of material makes it possible to compare the governance of two or even three ports. However, taking into account the delicate nature of the relationships brought to light, it is made more difficult to compare on a larger scale. As a consequence, this article will present a computer model analysing relationships between stakeholders, their capacity to influence a decision, so as to facilitate the comparison between a large number of ports, create typologies, and even, in the longer term, develop standard models.

The first phase of the work consists in defining the model (bloc “Graph modelling”, cf. Fig. 1) by basing it on the characteristics of what we understand by “port governance”. The use of the concept of governance in the port domain has been the subject of much research (BROOKS et alii, 2017; CAHOON et alii, 2013; DEBRIE et alii, 2013; NOTTEBOOM et alii, 2013; etc.). This work has helped to clarify the territorial, political, economic, organizational and institutional dynamics at work. Yet a considerable extent of work still remains to be done, especially in identifying the most propitious models as regards efficiency and the development of a port and the territory in which it is located: “One example of this scholarly effort to examine governance structures (i.e., to not only document the experiences of ports in fourteen different countries but to also evaluate the initial effectiveness of the reform programs) culminated in the

¹ Research project XX

publication by BROOKS and CULLINANE (2006). They concluded that there was considerably more work to do to fully understand what models are in place, and which of them are the most effective in delivering the objectives sought”. (BROOKS and PALLIS, 2012, p.491-492).

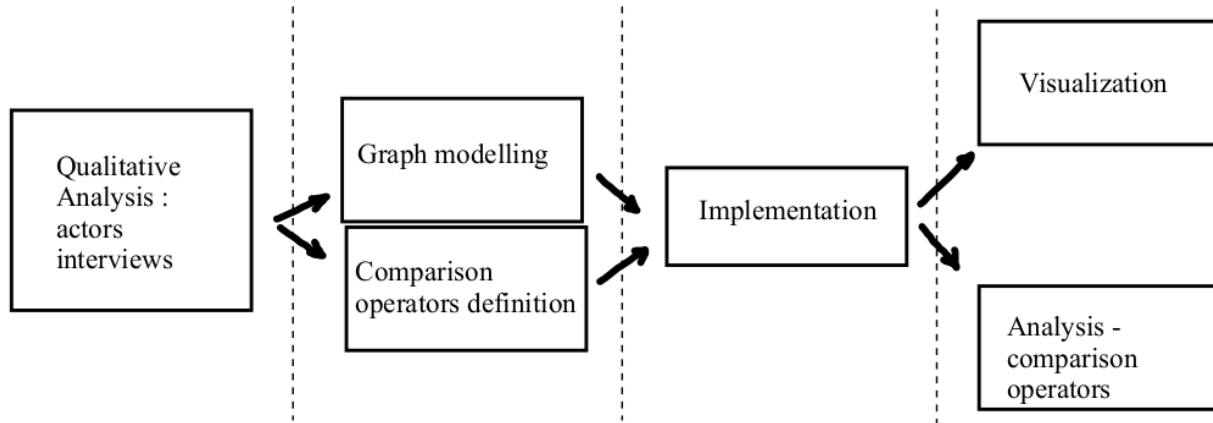
In the framework of this paper, we will focus our attention on the organizational and territorial dimension of port governance by considering in particular the relationships between stakeholders and cooperative dynamics. Beyond the port cluster concept, that names action coordination and resource sharing between interrelated firms inside a given port region (BRETT and ROE, 2010; HAEZENDONCK, 2001; LAMBROU et alii, 2008; DE LANGEN, 2004; MUSSO and GHIARA, 2008; ROH et alii, 2007), we shall mobilize the french concept of “place portuaire”, which is imperfectly translated as “port community”. Indeed, the concept of “place portuaire” broadens the scope to local institutions, town, urban area, region, chamber of commerce and professional organizations, thus getting closer to the hanseatic model of governance for the town-port couple. Last, as they are located in coastal areas with high environmental sensitivity, the coexistence of specific environments, industrial, portuary, urban, logically questions the governance of these complex spaces (LÉVÊQUE, 2016, p. 263). As “place portuaire” and “port community” do not perfectly match, we shall simply use the word “port” inside this article framework.

A conventional way of modelling these interactions between stakeholders in computing science is to use a model based on the graph theory (WEST, 2001) in which the stakeholders are represented by vertices and interactions between stakeholders by edges. This mathematical representation standardizes the definition of every port, making the application of comparison operators possible (blocs “Comparison operators definition”, and “Analysis Comparison operators”, cf. Fig. 1). The challenge is to produce a graph model which would be sufficiently close to the semantics one wishes to convey, so that the comparison can provide pertinent results. The main question will be to specify the types of relationships between stakeholders, essential information for the understanding of port governance. However, the model should also produce a representation which is abstract enough for the automated calculations of comparison to be feasible. The idea is not to imagine getting rid of experts when analysing the results but to enable them to reason simultaneously on a greater area of terrains, through an appropriate visualization of the findings of pertinent metrics (blocs “Visualization” and “Analysis - comparison operators”, cf. Fig. 1). **Thus the main contribution of this paper is the synergy between a governance problematic and a graph based model. If the model itself is a new one (according to the semantic of the governance application), it draws upon known concepts like hypergraphs and classical graph metrics.**

The general workflow of the work developed in this paper is illustrated in Fig. 1. The first part of this paper will present the different methodological stages which led to the conception of the graph model. In the second part, the model will be defined and we shall put forward the

application of comparison metrics between the graphs representing the governance of the different ports. All the metrics whose result we shall present have been calculated using an application that we developed. Lastly, the results obtained will be discussed and the research perspectives of the work presented, focusing in particular on a reinforcement of the use of semantics present in the graphs in order to define new comparison metrics.

Fig. 1 General workflow



Authors, 2023

1. Material and methods: modelling port stakeholder relationships

The sampling method of the medium-sized port-cities will be set out beforehand, as well as an outline of the qualitative survey and elements structuring the computer model.

As was touched on above, this work is done in the context of an ongoing research project. Intermediate results of the qualitative survey have already been published (XX, 2020; XX, 2020; XX, 2019; XX, 2022; etc.). They will not be presented in detail but will feed into the discussion in the second part. We shall, however, offer a succinct description of the method developed in this survey as it conditions the modelling, the subject of our paper. These interviews have been conducted during 2017-2019. Since then, territorial and port contexts may have been the subject of deep recompositions. The strengthening of HAROPA² in the Havre case illustrates this phenomenon. Thus, the issue is not to give an account of the actual situation (2022) but to study

² The organization HAROPA aims at merging, inside a large sea river port the three ports of the Seine axis, Paris, Rouen, Le Havre.

the logics, representations and relationships between stakeholders at the time the speeches were collected (hence avoiding anachronisms).

1.1 Defining the medium-sized European port-city

“Unidentified real objects” (BRUNET, 1997, p.188), describes medium-sized cities as being difficult to understand. In Europe, a medium-sized city might have a population of between 100 000 and 500 000, according to certain studies (GIFFINGER et alii, 2007). But this scale varies depending on the author and national contexts. For example, Frédéric SANTAMARIA (2000) and Frédéric TESSON (2012), from case studies in the UK, France, Portugal and Spain, propose definitions that emphasize different dimensions. The first focuses on the demographic variable, the second on the domination of the metropolis over medium-sized towns. The ORATE/ESPON batch 1.4.1 programme (2006) also develops a functional approach through various case studies in Austria, France, Germany, Italy, Poland, Spain and Sweden. Similarly, François TAULELLE (2010) proposes going beyond the demographic criterion alone and defining the “medium-sized city” according to the extent of its urban functions.

In the port domain, the diversities of configurations and the many exploitable criteria in the definition of medium-sized ports (BIRD, 1971) also obscure this intermediary dimension. Indeed, several indicators can be used: “an institutional criterion can be used, since large ports are often under national supervision and smaller ones are administered at local level. Such a definition, however, ignores spatial or national disparities, such as the presence of private ports or sometimes even the major role of municipal jurisdiction. The tonnage is certainly the most widely used instrument. The *European Association of Maritime Ports* defines medium-sized ports by traffic of between 10 and 50 million tonnes (VERHOEVEN, 2010). But this procedure also has its limits, like consideration not being given to the value added to the goods. Above all, it is worth putting the notion of size into perspective depending on the diversity of seaboard: a small Chinese port would be likened to a large South American harbour. Consequently, using tonnage to differentiate between large seaports and medium-sized ones is specifically regional (COMTOIS et alii, 1993)” (LOUBET and SERRY, 2020).

Associating these two objects with irregular outlines, therefore, adds complexity to the analysis all the more so as, according to C. DUCRUET (2004), the port-city itself (of whatever size) is not subject to a consensual definition. As a consequence, in a context where urban-port configurations vary greatly from one country to another, it is difficult to define what “a medium-sized port-city” is. There are many port-city typologies. The approach taken by J. MARCADON (1997) combines size, function and relationships with the urban environment; M. HESSE (2010) cross-references the dynamics of port activity (decline, stability, growth, etc.), organizational strategies, the impact on the hinterland and the regional economy.

In the context of this article, we shall take another look at the criteria of the research project XX. “Medium-sized port-cities” have been defined according to a dual component (urban and port) in

accordance with conventional quantitative indicators (taking account, however, of national specificities). The medium-sized port-cities included subscribe henceforth to the following model (cf. Fig. 2):

- cities of between 100 000 and 250 000 inhabitants with maritime traffic exceeding 10 million tonnes;
- and cities of over 20 000 inhabitants and fewer than 500 000 inhabitants with port traffic of between 10 and 50 million tonnes.

Fig. 2 Medium-sized port-cities in Europe



XX, 2020

1.2 The port governance

The concept of governance becomes during the eighties a precious tool for the analysis of collective action. The port field does not escape this dynamic and also makes use of this concept: “More and more port reforms in the international arena are analyzed under the light of port governance. Meanwhile, some theoretical or base studies are emerging with focuses on the basic issues associated with port governance, such as the port governance model (BROOKS and

CULLINANE, 2006), the relationship between port governance model and port performance (BROOKS and PALLIS, 2008), the interactions between institutions, port governance reforms and port authority routines (NOTTEBOOM et alii, 2013) and the common characteristics of the port governance reform processes (BROOKS et alii, 2017). Despite extensive analysis of port governance, port governance studies remain incipient and it is hard to answer the four basic questions surrounding the port governance, namely who governs, what is governed, how is it governed, and for what purpose (VIEIRA et alii, 2014)” (ZHANG et alii, 2018, p.51 There is no consensus on the very definition of "port governance". The complexity and vagueness of the scope of governance (ZHANG et alii, 2019), is largely due to the orientations that are valued according to the cultures of the different disciplines. (cf. Table 1):

Table 1 Summary of the main multidisciplinary fields of study in the scientific literature on port governance

Main academic authors	Fields of study	Main discipline
BRAUDEL (many references); MARNOT (2012); DUCRUET (many references); LEROY-LADURIE (1978); BUCHET (1998)	Accumulation and transmission of port governance knowledge	History
VIGARIÉ (many references); BIRD (1971); CHARLIER (1985); SLACK ET COMTOIS (many references); WANG (2017); DEBRIE (2017); LACOSTE (2008); RODRIGUE (2017, 2018); SERRY (2019); LOUBET & SERRY (2020, 2022a, 2022b)	Spatial scales, decentralisation and territories of port governance	Geography
THORRANCE (2014, 2019); GROSIDIDIER DE MATONS (1999); THE WORLD BANK (many references); JUHEL (2001); BAIRD (2004); CHAPON (1993)	Regulatory engineering and financial optimisation of port governance	Finance
GROSIDIDIER DE MATONS (1971, 2012); REZENTHEL (many references); SUPIOT (2008); DUPUIS (1978); LICHERE ET MARTOR (2007); SANCHEZ (2020); SANCHEZ & PEREZ-SALAS (2020)	Legal construction and organisation of public-private partnerships in port governance	Law
CASS (1996), BAIRD (1995, 2000), SUYKENS (1995); NOTTEBOOM (many references); HARALAMBIDES (2017, 2018); (KNATZ, 2020); EVERETT (many references); HEAVER (1995)	Privatisation, competitive pricing, productivity and performance of port governance	Economy

BROOKS ET CULLINANE (2007, 2017); BROOKS & PALLIS (2012); PALLIS (many references); DE LANGEN (2007, 2017); TALLEY (1998, 1994); LAM (2016); VERHOEVEN (2012, 2017)	Divestment, deregulation, corporatisation and stakeholder management in port governance	Management
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(Source: based on work by Daudet, 2021; translation by the author).

However, despite this lack of consensus and the protean nature of the concept, "governance" is a central element in the analysis of a port's development process: "Governance principles are most important in the case of ports. Ports are critical infrastructure for an economy, contributing to the realization of trade and movement. At the same time, port management, operations, and development are capital intensive, consume (public) scarce land, generate externalities (noise, emissions), and involve many decision-makers and stakeholders such as the port authority, terminal operators, rail operators, trucking companies, logistics providers, and port-cities " (PALLIS, 2022, p.281).

So we share Jason Monios' observation, although a different conceptual apparatus is mobilized in our work. The author considers that current static models of port governance place too much value on hierarchy and internal formal structures (mostly the government, the port authority and the port terminal operator), to the detriment of explicitly including informal organisations (e.g. citizens and environmental groups) and external stakeholders (e.g. carriers, shipping regulators) in a more dynamic conceptualization (MONIOS, 2019, p.26).

1.3 The qualitative analysis as preliminary element to modelling.

Our work is based on the study of fifteen ports. In this paper, we shall deal succinctly with six **typical** cases chosen in view of their closeness similarities in terms of governance or conversely their major differences: Le Havre, Nantes-Saint Nazaire, Dunkirk (France), Gdynia (Poland), Klaipėda (Lithuania), Hamina-Kotka (Finland). This phase of the survey is based on individual, anonymous interviews with leading stakeholders. We believe that leaders (NEGRIER, 2001; FAURE, 2001; BARAIZE, 2001) shape governance, influencing decision-making and cooperative dynamics over and above other stakeholders. **In fact, the "territorial configuration" (BARAIZE, 2001) [here urban-port] is strongly determined by the personality, methods and aims of the leaders in charge. Territorial construction, actor learning, decision-making and leadership structuring all seem to be correlated. (LOUBET, 2019).** In order to define the level of leadership and the role of port stakeholders we shall transpose the method used to other configurations: the analysis of inter-municipal governance of the conurbations of Toulouse and Le Havre (XX, 2012 and 2019), respectively ranked 4th and 15th French cities in terms of numbers of inhabitants.

As a consequence, in the port context, the level of leadership materializes the position of actors according to their institutional standing, but above all the role played in the port decision-making process. Their presence in the chain of command in the different bodies has been identified as well as their levels of participation in (leadership) decisions. Here, the informal rationale and stakeholder representations impose themselves on official organizational charts and our assessment is essentially the fruit of an analysis of the contents of the interviews (DRISKO and MASCHI, 2015) and the mixture of responses from the actors as a whole to the questions below:

- position occupied by the actor questioned (What is your job, your role in the organization? / Your degree of investment / The status of your organization in the port?...);
- decision-making process and governance (How are decisions made within the port? And by whom? / How could the decision-making mechanism be improved?...);
- What is the nature of the forces present? (Who are the stakeholders or groups of leading players / The other groups of actors? / The stakeholders at the centre of the organization? / The actors at the margin distancing themselves from the official objectives of the port project? / Difficulties in finding agreements? Which? Why? Who is opposed to whom?) / What is your position in this process? / According to you, how are you identified by the other actors? / What influences do the different groups of actors have on the port dynamics?...);
- Relationships with the other territories, other territorial scales, management of the port-city interface;
- impacts of municipal policies on port activities;
- conversely, we questioned the elected representatives on the impacts of port activity on the development of the territory for which they are responsible;
- *etc.*

In total, following the creation of this interview guide, 33 interviews were conducted with **leading** stakeholders from the six ports.

Table 2 Survey methodology

Period	Studied ports (bold : ports studied in this paper)	Methods and tools	Type of actors surveyed
2017-2019	Le Havre	For the 6 ports : 33 interviews For the 15 ports : 80 semi-directive interviews	representatives of port authorities
	Dunkirk	These interviews, under the cover of anonymity, have been recorded then integrally transcribed.	port worker union representative

	Nantes-Saint Nazaire	Data analysis thanks to : - content analysis - comparative analysis, aimed at identifying the respective positions of each player in relation to a set of identified themes (breaking down the discourse into thematic units) (<i>Nvivo</i> software)	representatives of federation which federate professional organizations of the Port
	Gdynia		port professionals (operators, logisticians, handlers...)
	Klaipėda		managers of organizations for the defence of business interests (Chamber of commerce and industry-CCI in France, lobbying group, economic development agency...)
	Hamina-Kotka		elected officials
	Tallinn		department heads of the territorial authorities
	Tarragone		academics
	Leixoes		experts
	Southampton		
	Livourne		
	Gand		
	Zeebruges		
	Trieste		
	Liverpool		

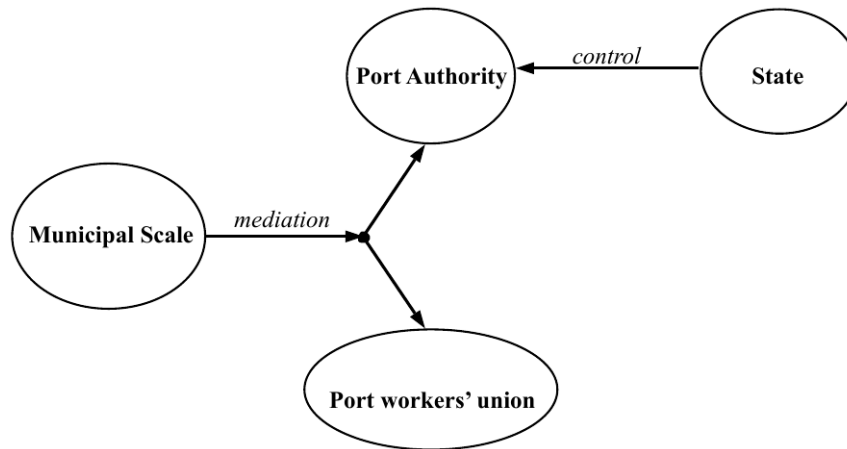
Authors, 2023

These interviews were then encoded and a textual analysis performed on the stakeholders’ discourse so as to identify the nature of their relationships, their games and strategies. **During this stage, one textual analysis software package (“NVivo”)³ was employed.** The interviews were processed by means of contents analysis followed by a comparative analysis highlighting the convergences, divergences and strong trends.

As regards the following stage, it was based on the creation of a computer model. It aimed to align the representation of each of the port governances so as to be able to compare them. In this context, the use of a model based on the theory of graphs enabled us to easily model the actors and their interactions. For example, the graph in Fig. 3 represents four stakeholders (*municipal scale, port authority, state, unions*) and two relationships (“mediation”, “control”; the nature of the relationship appears here as a result of the prior qualitative analysis). This made it possible to summarize the essential information obtained from the interviews as well as to standardize it for each of the ports. The model expressivity should be able to represent all the characteristics of the interviews deemed necessary for the comparison of governances of the different ports.

³ “NVivo”, a qualitative data analysis (QDA) computer software package produced by QSR International.

Fig. 3 An example of interactions between stakeholders.



Authors, 2023

Work was done to define an adequate graph model. This is a directed graph because some of the stakeholders' relationships have a direction. They are "unilateral" relationships (versus "bilateral": cf. Table 3): in Fig. 3, for instance, the stakeholder *state* controls the stakeholder *port authority*, whereas the reverse has not been proven. Reciprocity in relationships is not necessarily the rule. Moreover, hyper-graphs must be used (AUSIELLO and LAURA, 2017; DEVEZAS and NUNES, 2020) since relationships are not solely relationships between two stakeholders. They can, for instance, be relationships between stakeholder A and two stakeholders B and C (e.g. Fig. 3 the "mediation" relationships, where the stakeholder at the *municipal scale* carries out a "mediation" between *port authority* stakeholders and *port workers' unions*). All these types of relationships were retained, and their descriptions are available Table 3. For each of the relationships, the degree of intensity is specified (as for the nature of the relationship, the degree of intensity of the relationship appears as a result of the previous content analysis). In fact, the graph is labelled by the type of relationships (arcs) and the category of stakeholder (vertices), and weighted, on the one hand by the intensity of relationships (arcs) and on the other by the level of leadership on the part of the stakeholders (vertices).

The formalization of this model is presented in the following part (1.4). It is clear that the use of directed hyper-graphs will have a significant impact on the definition of the metrics thereafter (AUSIELLO and LAURA, 2017; DEVEZAS and NUNES, 2020), but it is necessary in order to capture as well as possible the semantics expressed by the interviews.

Table 3 Definition of the different relationships between stakeholders

Nature of the relationship	Relationship	Type of relationship (observation)	Intensity level	Definition
Powers	“Control”	Unilateral	Low, Moderate, High	The organization (most often represented by its leader) dominates another organization. It can compel it to do what it wishes.
	“Influence”	Unilateral	Low, Moderate, High	The organization acts on the decisions of another and in part determines the choices thereof.
Powers & Cooperative Dynamics	“Mediation”	Unilateral	Easy, difficult	The organization acts upon the relationships fostered between other organizations in order to limit conflicts and encourage cooperative dynamics.
Cooperative dynamics	“Partnership”	bilateral**	Low, Moderate, High	Relationship based on (or aiming to establish) a close collaboration between organizations associated within a system
	“Defends the interests”	unilateral	Low, Moderate, High	The organization preserves and strengthens the position of another organization including vying with competing organizations (or antagonistic interests).
	“Negotiations”	Bilateral	Easy, difficult	The organizations have discussions in order to handle a business deal, a project, negotiate the terms of a contract, etc. The objective being to reach an agreement.
	“Is in competition”	bilateral	Low, Moderate, High	Several organizations target the same object or pursue the same goal (including on the symbolic market: “powers”)
Participation in decision-making scenes	“Is included”	bilateral		An organization (embodied by its representatives) sits or participates in a (formal or informal) decision-making scene
*“unilateral”: non-reciprocal ** “bilateral”: reciprocal.				

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1.4 Modelling of port governance using a semantic graph

Modelling port governance means being capable of capturing the relationship between different stakeholders that it comprises. Graphs, as well as hyper-graphs, come from discrete mathematics,

and have established themselves as an unrivalled tool in the modelling of interactions (WEST, 2001; AUSIELLO and LAURA, 2017). Examples are countless in the literature. For instance in the field of maritime transport, one may cite the multidisciplinary book edited by DUCRUET (2016), where the use of graphs to model maritime networks provide new insights into the history, spatial distribution, vulnerability... of such networks. Semantics can also be associated with graphs quite naturally. In PINSON et al (2019) an example of the use of semantic graphs for urban networks can be found, it models technical networks (electricity, water, railway etc.) at different levels of granularity (component, infrastructures, urban system) and the semantic interaction between these elements (inter-dependencies) potentially spatialized. The model based on a graph (G) proposed in this paper takes account of all the actors identified in the framework of the qualitative analysis and represents them through the definition of its vertices.

Let V_{port} be all the stakeholders for a given port.

Each stakeholder belongs to a certain category, let C_a be all these available categories.

A relationship between stakeholders is represented by an arc between the corresponding vertices, let E_{port} be all the relationships identified between the stakeholders of a given port.

Each arc is labelled by the appropriate type of relationship, let T_r be all the available types of relationships. A level of leadership is potentially associated with each stakeholder ($N_1 = \{1, \dots, n\}$, $n \in \mathbb{N}$) and to each arc a level of relational intensity ($N_i = \{high, moderate, low, easy, difficult\}$).

Our qualitative analysis (section 1.3) enabled us to identify $C_a = \{State, Port Authority, Municipal Scale, Inter-municipal Scale, Port Workers' Unions, Private operators in the port sector, Organizations for the defence of business interests, Shipowners, Intermediary territorial level, Local port groups, Decision-making scene for regulating relationships, Strategic council, Economic and Social Council, Local bodies, Industrial firms\}$ and $T_r = \{Control, Defends the interests, Is in competition, Is included, Influence, Mediation, Same person, Same organization, Negotiations, Partnership\}$.^{4 5}

Therefore, for a given port, the formal directed weighted hyper-graph: $G_{port} = (V_{port}, E_{port}, \alpha, \gamma)$ with:

$$E_{port} = \{(T, HE) : HE \subset V_{port} \ T \subset V_{port}\}$$

⁴ This list of stakeholders is the result of the questionnaire survey (section 1.3). It enabled us to identify the key stakeholders and rank them according to their ability to influence port decisions (leadership). Among other things, we asked each actor interviewed to rank the leading stakeholder in their port, from the most influential to the least influential. We then cross-checked their results to obtain an overall ranking for each port.

⁵ Each port was the subject of a content analysis. The aim of this article is to formalize the analysis. We therefore identified the types of relationships observed in all the ports studied (as part of the XX research project and in our various publications) and categorized them in order to create the model.

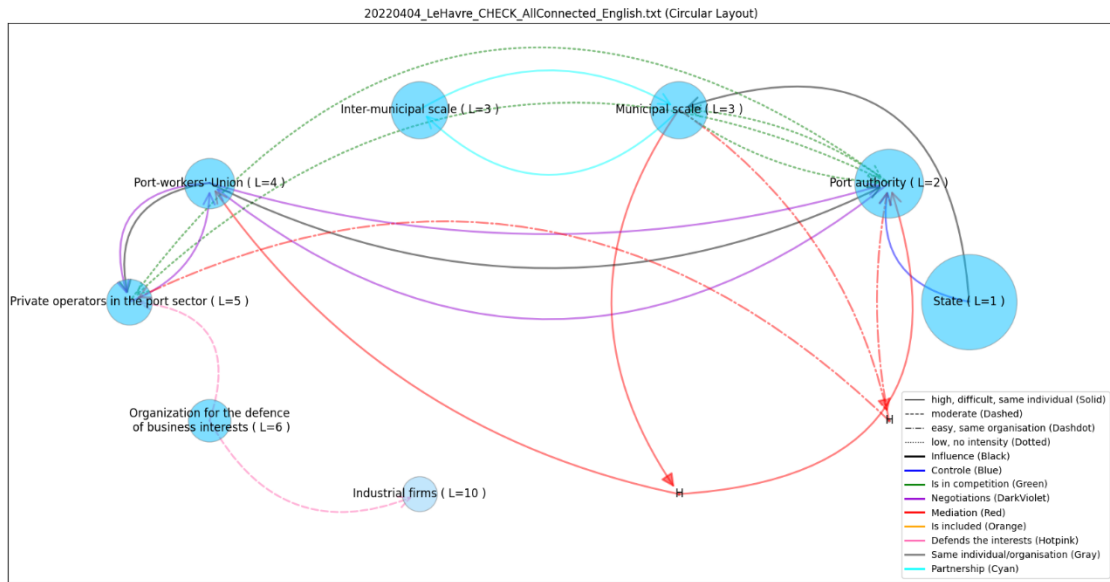
T is called *tail* (source) and HE is called *head* (target) of the hyper-arc (T, HE), and in our case, $T \neq HE$. (DEVEZAS and NUNES, 2020)

$$\alpha : V_{port} \rightarrow C_a, N_l$$

$$\gamma : E_{port} \rightarrow T_r, N_i$$

If one instantiates this model on the example of the port of Le Havre one obtains the Fig. 4 representation (the graphs representing the six ports studied are available in the annex). For reasons of legibility the decision-making scenes and the relationships associated are not represented. The vertices ‘H’ are not stakeholders, they are only introduced to help with the visualization of a hyper-arc and linked to the use of an image library⁶. Here, for instance, the *municipal scale* stakeholder carries out a “mediation” (“difficult”, solid line) between *the port workers’ union* and *the port authority*. The *municipal scale* stakeholder conducts another mediation (“easy”) between *the port authority* and the private operators sector. These two mediations are presented alone in Fig. 5 to reinforce the explanation of the representation of the hyperlinks in the application.

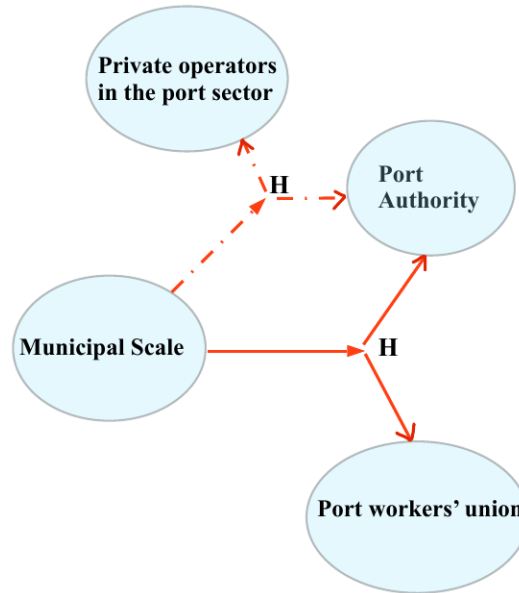
Fig. 4 Graph of the port governance of Le Havre.



Authors, 2023

⁶ <https://networkx.org/>

Fig. 5 Examples of the representation of hyperlinks in the application (here two mediations)



Authors, 2023

Let us add that this article is a general presentation. Its format does not allow us to present all the possibilities of the model. We have therefore chosen to present and discuss only certain indicators (cf. 2.2). In the context of this first paper, we chose to momentarily evade the institutional dimension by not mentioning the decision-making scene (both formal and informal). Yet the analysis of port governance might gain from a set of metrics relative to this dimension (cf. conclusion).

2. Results and discussion: a model for comparing port governance

Our work aims to identify over time the processes of the most suitable governance for encouraging cooperative dynamics and, as a result, the development of ports and their territory. The first sub-part (2.1) will highlight the link between governance and development concisely. A lengthy development of a correlation at the basis of local development and territorial development, as well as economical geography, and generally speaking of regional sciences, is out of scope of this paper. The second (2.2) will attempt to demonstrate the benefit of computer modelling making it possible to qualify the governance of the ports studied.

2.1 Governance and development

This part analyses the way relationships between stakeholders mould the ports and impact territorial development. Indeed, territorial development is based here on two main engines: governance and production (TORRE, 2018). According to the author, relationships between stakeholder are at the core of these two dimensions. They materialize a territorialized mechanic producing decisions, that defines governance. They structure the production according to two central decisions: technical innovation, and the systematic character of local relationships. Therefore the stakeholders capacity to adopt cooperative behaviors at the heart of the territories appears as a critical element.

As mentioned above, the approach proposed is in keeping with the philosophy of “territorial development” which associates territorial governance and development: “Work in the field of territorial development focuses more on the role of the mechanisms of governance on territorial dynamics. What the many definitions of territorial governance share is putting the accent on forms of partnership between public and private actors, on the interactions between levels and the role of networks, but also on the modalities of implementing participation in a context of growing partnership heterogeneity, leading to a “*mosaic of stakeholders*” (TORRE, 2011)” (REY-VALETTE and MATHÉ, 2012).

In this we take a particular interest in the first (organizational and territorial) dimension of the concept of governance suggested below by M.R. BROOKS and K. CULLINANE (2007), inside their works on port research. Indeed, these authors point out four main components which structure the concept and direct the work in this field: “In essence, therefore, the systems, structures and processes that organize groups of individuals to a common purpose can be perceived as constituting the governance structure of the group, society or voluntary organization. At the other end of the continuum, the legislation and regulations that the government imposes on a business or not-for-profit entity also shape the governance structure within which such organizations operate. The structures and processes put in place by national laws, such as the requirements for open procurement processes, do form part of the governance of government. Most frequently, however, the term governance is used to refer more specifically to corporate governance, an area that is widely researched” (BROOKS and CULLINANE, 2007, p.10-11).

In addition, we shall make use of the term “good governance”. At the end of the 1980s, the expression “good” governance entered the vocabulary of the international community (BANERJI, 2015). Very soon there evolved a correlation between “governance” and “development”. K. ANNAN, former Secretary General of the UN, stated⁷ that good governance was without doubt the most important factor in the promotion of development. Developing good

⁷ Statement made by the Secretary General, Mr Kofi Annan, delivered on 28 July 1997 at the opening meeting of the International Conference on Governance for Sustainable Growth and Equity at the UN Headquarters On line: <https://www.un.org/press/en/1997/19970728.SGSM6291.html>

governance was to become a qualifying principle for certain countries, especially developing ones, for them to obtain subsidies.

In the context of this paper, however, we shall not retain all the criteria that structure the notion of “good governance” according to the institutions, most of which are international (World Bank Institute, UN, OECD, etc.). When applied to the port, we consider that “good governance” is a relational and decision-making system that encourages cooperation between port actors and hinders conflicts. As mentioned above, we consider that “good governance” is favourable to port and territorial development. In this we promote the organizational dimension of the concept and maintain the very essence of this notion in its territorial dimension: the necessary cooperation between actors for the purpose of development.

Thus, with regard to the relationships we have identified in Table 3 and Fig. 4, it seems that there are relationships that are more or less favourable to the emergence of "good governance. Table 4 presents these **links** observed in the different port terrains.

Table 4 Assessment of the quality of governance according to the types of relationships between organizations (vertices)

Relationships favourable to “good governance”	Varies according to the contexts and depending on the original stakeholder	Relationships which are unfavourable to “good governance”
“Partnership”	“Control”	Difficult “negotiations”
“Mediation”	“Influence”	“Is in stiff competition”
Easy “negotiations”	Is in low, moderate “competition”	
“Defends the interests”		

Authors, 2023

Our objective in this paper is to demonstrate the interest of computer modelling in this applicative framework, through the application of metrics, on the graphs representing ports. In the first instance, the metrics we propose are relatively simple but make it possible to validate the approach. Over time, metrics will be proposed that will be based more on the semantics of the relationships. They will make it possible to tend towards the final objective of characterizing “good” or “bad” governance (more precisely “governance unfavourable to territorial development”). We shall give some pointers in the conclusion to this paper.

2.2 Selection of two metrics: density and S-metric

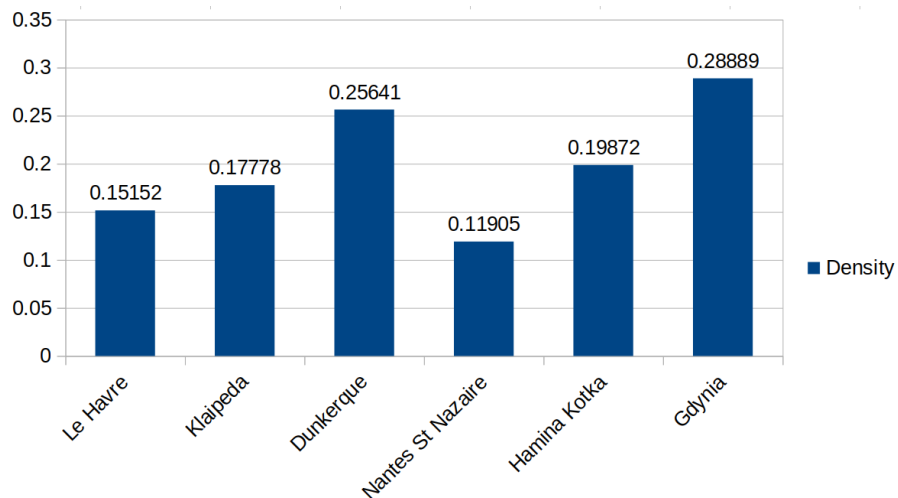
The number of stakeholders and the relationships between the different stakeholders vary significantly depending on the port. This variation gives us information on the intensity of governance, in other words, stakeholder participation in decisions which commit port development in absolute values (the degree of openness to a multiplicity of stakeholders) and in relative values (to what extent stakeholders communicate and interact with one another). The idea is to be able to categorize the ports and be able to tell if two ports have a similar intensity of governance or conversely, a very different one. The metric we have chosen to do this is **density**. The general definition of density on a simple graph $G = (V, E)$ is expressed as follows:

$$d = (2 * |E|) / (|V| * |V - 1|)$$

Note that, if $||$ expresses cardinality, $|V| * (|V| - 1) / 2$ is the maximum number of edges in a graph. As a consequence, the density is a rational number of between 0 and 1. As our data are represented by hypergraphs, we made the choice for these first results to transform the data for the calculation of this metric. A hyperedge is replaced by as many simple edges as necessary, e.g. the hyperedge $(A, \{B, C\})$ will be replaced by (A, B) and (A, C) . This transformation was already suggested in AUSIELLO and LAURA (2017) in particular.

The results are presented in Fig. 6.

Fig. 6. Density of the graphs relative to each port, taking account of all the vertices



Authors, 2023

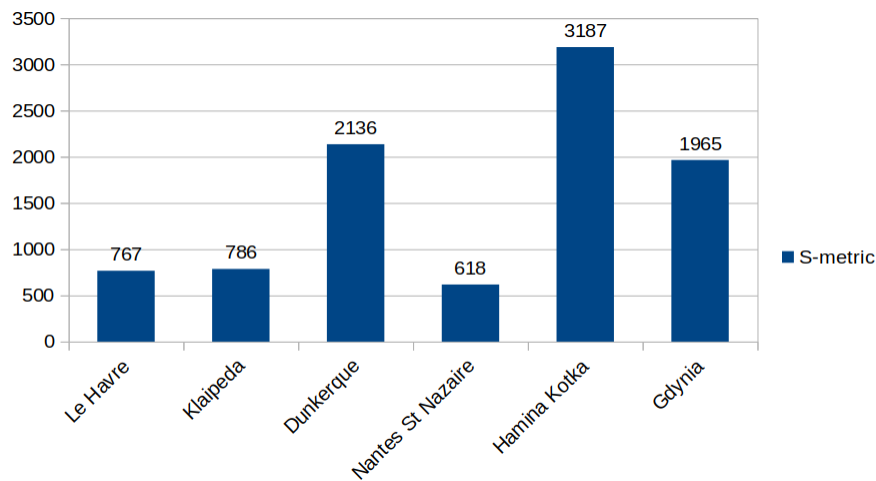
We note that there are ports for which links are more developed. In the light of Fig. 6, and especially Fig. 7, Table 5 and the S_metric, which will be presented later, we shall demonstrate that a segmentation in two groups can be implemented. A “group 1” (Dunkirk, Hamina-Kotka and Gdynia) characterized by more developed links; a “group 2” (Le Havre, Klaipeda, Nantes-Saint Nazaire) not as well equipped in the matter.

The density, however, provides only one piece of information on the intensity of relationships generally and none on the distribution of this intensity. Another metric may complete this first indicator - the **S_metric** (LI, 2005). Using this metric can identify the prominent stakeholders in a governance. This makes it possible to identify if the decision is in the hands of a small group of stakeholders (low S-metric) or, on the contrary, if the governance is more participatory, associating a wider circle of stakeholders (high S-metric). The S_metric is calculated as follows:

$$s = \sum_{(i,j) \in E} d_i * d_j$$

with d_i and d_j the degrees of the corresponding vertices, in other words, the number of respective connections of these vertices. The results are presented in Fig. 7.

Fig. 7 Calculation of the S_metric for each port



Authors, 2023

In order to verify the results relative to this metric we calculated the number of **hubs** contained in these graphs for every port, that is to say the number of prominent stakeholders. The definition of a hub has not really been normalized so we chose to apply the following definition:

Let $avg(d_g)$ be the average of the degrees calculated on a graph, let $avg_{Gn}(avg(d_g))$ be the average of the $avg(d_g)$ on the graphs processed as a whole. A vertex is considered as a hub if its degree is above this threshold $avg_{Gn}(avg(d_g))$.

The results are presented in table 5.

Stakeholders acting as hubs in the ports ($>$ Average of the Average Degrees, $avg_{Gn}(avg(d_g)) = 4.33162$)

Table 5 Synthesis of the hubs – number and contents per port

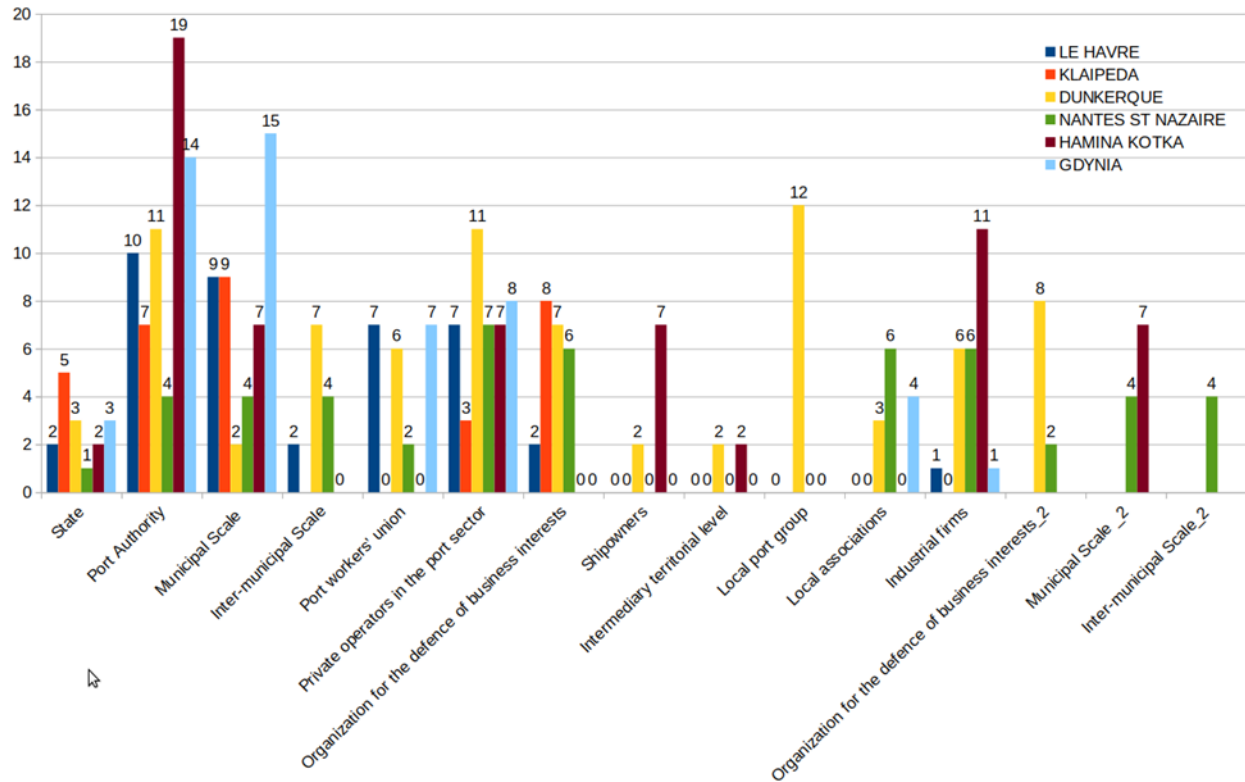
Port	# Hubs	Stakeholder	Degree	Average Degree of Hubs
Le Havre	4	Port Authority Municipal Scale Port workers' union Private operators in the port sector	10 9 7 7	8.25
Klaipeda	4	State Port Authority Municipal Scale Organization for the defence of business interests	5 7 9 8	7.25
Dunkirk	8	Port Authority Inter-municipal Scale Port workers' union Private operators in the port sector Organization for the defence of business interests Local port group Industrial firms Organization for the defence of business interests 2	11 7 6 11 7 12 6 8	8.5
Nantes St. Nazaire	4	Private operators in the port sector Organization for the defence of business interests Local associations Industrial firms	7 6 6 6	6.25
Hamina Kotka	6	Port Authority Municipal Scale Private operators in the port sector Shipowners Industrial firms Municipal Scale 2	19 7 7 7 11 7	9.67
Gdynia	4	Port Authority Municipal Scale Port workers' union Private operators in the port sector	14 15 7 8	11.0

Authors, 2023

The analysis of the S_metric (Fig. 7) confirms the segmentation set out beforehand in view of the density indicator. In effect, the S_metrics of Dunkirk (2136) and Hamina Kotka (3187) are very high compared to group 2 (723 on average for this group). Consequently, 8 and 6 hubs respectively are identified (Table 5) in these two ports. The connectivity is therefore high and shows a greater distribution.

At Dunkirk, the overall intensity of relationships is therefore strong (high density) and the port governance is exercised by means of relationships between a large number of stakeholders (high S_metric). The capacity to influence the port dynamics is therefore shared, although a chain of command can be seen among its leaders. Consequently, the institutional stakeholders are in a rather conventional position of power in the leader rankings (cf. Fig. 12 in the annex) in the different ports observed (the *state* ranked first, *the port authority* second, and finally the local scales, *the municipal scale* or *inter-municipal scale* in 3rd or 4th place). However, the analysis of the S_metric and degrees enable us to go further than the analysis based solely on stakeholder leadership. It highlights finer dynamics; the power play around stakeholders not necessarily occupying the highest positions in the ranking. Consequently, *the local port group (Norlink)* (degree 12, cf. Table 5), *the private operators in the port sector* (degree 11) constitute hubs around which gravitate a large number of stakeholders. Interestingly enough, among the six ports studied, the port of Dunkirk is the only one where *the local port group* stakeholder constitutes a hub which, more significantly, is of great importance (cf. Table 5 and Fig. 8).

Fig. 8 Actors' degree compared by ports



Authors, 2023

The *local port group* emerges as a central vertex in the governance of this port, notably multiplying the “*mediation*” relationships between the different stakeholders (cf. Fig. 12 in the annex). In effect, according to the work on “the cognitive analysis of public policies” the process of “mediation” (MULLER, 1995, p.153) is accompanied by a take-over of power by the “mediators”⁸ (HALL, 2015; MULLER, 1995). As for the *port authority* (degré 11), it is once again positioned in the top three. As a consequence, simply cross-analysing, in terms of “leadership” and “S_metric”, may prove to be highly instructive. There remains the port of Gdynia which has a strong S_metric (1965) but few hubs (4). This means that in this port there is a strong connectivity (also confirmed by the density value Fig. 6) which is not widely distributed. The analysis of these three metrics combined (i.e. density, number of hubs, S_metric) enables us to infer that the four stakeholders concerned are prominent ones for this port (in particular the *port authority* and *municipal scale*).

⁸ “it is because he defines the new referential that a stakeholder takes on the leadership of the sector by asserting his hegemony but, at the same time, it is because this stakeholder asserts his hegemony that his world view progressively becomes the norm” (MULLER, 1995, p.165). Therefore, through the active promotion of the referential [which could be understood according to the following terms in our case: it is necessary for the actors as a whole to cooperate in order to develop the port community] the mediator “acquires force and exerts influence by virtue of its capacity to specify the roles of various actors in a system of relationships, conferring on them not only meaningful identities, but also influence, since this system invariably embodies relationships of power” (HALL, 2015, p.240).

The group 2 ports (Le Havre, Klaipedia and Nantes-Saint Nazaire) are of the same order of magnitude on these metrics. They show relatively low S_metrics compared with the ports in group 1 (cf. Table 5). Furthermore, there is a similar number of hubs (4) in these three ports, which signifies that connectivity is not very uniform, as well as being poor (see the result in terms of density (cf. Fig. 6). These elements corroborate the results of our qualitative (XX, 2022; XX, 2021; XX, 2020; XX, 2019; etc.).

To finish our analysis and so as to territorialize further the subject in question we shall propose a concise illustration of the use of the S_metric with a short study of the cases in group 2.

At Le Havre⁹, governance is structured around some stakeholders who concentrate powers and struggle to exchange words outside a limited circle (S-metric: 767, confirmed by a number of limited hubs (4)). *The state* appears to be the most influential stakeholder, notably through the management board of *the port authority* (degree 10, cf. Table 5) which it controls. The Prime Minister (Édouard Philippe at the time of processing the data) was formerly the mayor of Le Havre and this reinforces the particular interest shown in the development of this port of national strategic interest¹⁰. The *municipal scale* (Le Havre) (degree 9, cf. Table 5) comes in second position. A large number of informal relationships between the president of the *port authority* of the Major Seaport (*Grand Port Maritime*) of Le Havre¹¹ and the mayor (also president of the inter-municipal scale of greater Le Havre (*le "Grand Havre"*)) enables the latter to weigh heavily on strategic directions involving the port.

In this context, the "quadripartite" (a powerful decision-making body, informal, but known to all) materialises the cooperative relationship between the representatives of the State (in particular the Port Director) and the Mayor:

“The Quadripartite, a meeting which takes place three or four times a year and brings together the mayor of Le Havre, the president of the CODAH¹², who is in fact one and the same, the president of the CCI and the president of the port board of directors [...]. This is a powerful, yet totally informal, decision- making body [...]. On sensitive questions, where a choice must be made between several scenarios, where arbitration is absolutely essential, that's what it's there for. Sometimes there's no need to be four - in

⁹ The GPM (Grand Port Maritime – Major Seaport) of Le Havre was the first port to be the subject of analysis of its governance in the framework of our study. During interviews with the leading stakeholders (2018), HAROPA (the organization aiming to merge the three ports of the Seine axis: Paris, Rouen and Le Havre, within a large fluvio-maritime port) was never cited by the stakeholders who had an impact on the governance of the port of Le Havre. A second phase of interviews will update the results and certainly give more weight to HAROPA.

¹⁰ The port of Le Havre is the first container port of France, second in terms of overall traffic.

¹¹ The 2008 law for port reform constituted an institutional change which impacted French ports in a differentiated way. The three self-governing French ports analysed in this paper became “*grands ports maritimes*” (*GPM*) or major seaports in English. They are among the seven *GPM*, state-owned establishments, which assume sovereign functions as well as development of the port domain, which they own.

¹² “*Communauté d'agglomération du Havre*”: inter-municipal scale of greater Le Havre

fact there are three - and sometimes it's just city and port". A councillor of Le Havre, 2017.

"That's where [at the quadripartite] discussions take place and then, depending on the decisions, well, decisions are taken at that level". A Grand Port Maritime of Le Havre representative, 2017.

This dynamic is strengthened in view of the close ties between the current mayor and his predecessor, prime minister at the time the data were processed and returned once again as mayor since then. In second place come the *port workers' unions* (degree 7) after *the state* and *the municipal scale* which are particularly influential. According to the stakeholders interviewed, their leadership is very important in view of their capacity to carry out national blockades and the effects that strikes have on the port dynamics. This tendency is especially identifiable in the discourse of *the private operators in the port sector* representatives (degree 7):

« If the unions don't like the State's decision, you've got a month of strike action, a month without work and a few million euros lost... so I would have said that, in terms of the forces at work: effectively, the unions come first.... ». UMEP¹³ representative, 2017.

In the case of the port of **Nantes-Saint-Nazaire**¹⁴ it reflects similar dynamics in terms of density and a concentration of relationships to just a few stakeholders (S-metric 618, number of hubs 4). This French port subscribes to the *GPM* model, with at its head the port authority's *management board* heavily controlled by the *state*. Yet given the hubs calculated and the degrees of connections by the stakeholders associated, the importance of the *state* or its relay the *port authority* does not emerge (cf. Table 5, degree 4 versus 10 for Le Havre). In effect, contrary to the case of Le Havre, the model of governance at Nantes-Saint-Nazaire was developed more in line with "horizontal cooperation". An example of the dynamics is illustrated in the *Be My Port* cluster (cf. Fig. 10 in the annex) associating local economic stakeholders in particular.

The recent creation of this port promotion cluster seems to have had an impact on the decision-making process. This local initiative brings together public and private players¹⁵ in an effort to promote and unite the port community. However, in addition to the promotional dimension, informal exchanges and monthly meetings foster proximity between stakeholders and the process of collective reflection on port strategy (XX, 2022).

¹³ Union Maritime et Portuaire du HAVRE: is a maritime and port federation which federate professional organizations of the Port of LE HAVRE

¹⁴ In 1966 the ports of Nantes and Saint-Nazaire merged and became "*Port Autonome*" (self-governing port) before obtaining the status of *GPM* in 2008. It is the fifth French port in terms of overall traffic, third in terms of liquid bulk and possesses the largest methane terminal in Europe (Montoir-de-Bretagne).

¹⁵ The cluster comprises *GPM* management board, the Union Maritime Nantes Ports (UMNP), the Chamber of Commerce and Industry (CCI), the territorial authorities and their organizations (inter-municipal scale of greater St Nazaire region, inter-municipal scale of greater Nantes, Département and Region), and the PASCA association (Plateforme régionale d'innovation des Pays de la Loire who develops the competitiveness of businesses and territories by optimizing logistics and purchasing strategies).

" We had the impression that everyone was working in their own corner: the CCI on one side, the Port on one side, us on the other, and the local authorities on the other. It's true that if we can get everyone working together, it would be fantastic! It's not going to be easy, because it's not easy to coordinate all that, but if we set ourselves a few major strategic priorities and we all agree on them, and then put in place the actions we need to take in relation to the strategic priorities we've set, we'll have taken a big step forward ". The manager of a port service company, 2019.

" Territorial promotion means working with port stakeholders [...] it's one of the current issues, between the Union Maritime, the CCI... It's clear that everyone is working on economic development issues, there's the Regional Agency... So in the end, we're hunting in packs! The term is perhaps a little aggressive, but it's there.". A manager within the GPM, 2019.

Therefore, if institutional organization of the *GPM* generally finds it difficult to integrate local businesses and industries in major decision-making scenes, it is different at Nantes-Saint Nazaire. As opposed to Le Havre, *industrial companies* (degree 6) and *the private operators port sector* (degree 7) have partly overcome this deficit by a clever use of representation provided by *organizations for the defence of business interests* (degree 6), as the cluster Be My Port¹⁶ (see Fig. 10 in appendix). Similarly, in a territory that has experienced strong mobilization (in light of the domestic downturn) against the building of the Notre-Dame-des-Landes airport project, *local associations* (degree 6) are capable of bearing influence on urban-port governance, namely where environmental issues are concerned.

Lastly, the institutional management of the port of **Klaipeda** (S-metric: 786, number of hubs 4) has certain similarities with that of French ports. A greater presence of central government can be noted. The *state* (degree 5), therefore, represented by the *port authority*¹⁷ (degree 7) enjoys very strong leadership in the port.

“We are a state- run business and were set up by the ministry of transport. We are like a subsidiary of the ministry of transport”. A manager of Klaipeda’s port authority, 2017.

In this context, the *municipal scale* (degree 9) has experienced difficulty in guiding the development of the territory in a direction that conforms to municipal policy.

“If I said that we have no impact on the port, this would almost be the truth. Lithuania only has one port. It’s a state- run port and the municipality has no rights over it; other than the fact that we are convened to two advisory councils. The port council in which we don’t have the right to vote. There’s also the council for development in which we have

¹⁶ However, this type of local cooperation remains delicate, and this cluster disappeared in 2022.

¹⁷ Under the direct trusteeship of the *state* through the Lithuanian transport ministry.

four seats out of 23 and in which nobody pays any attention to us”. The deputy mayor of Klaipeda, 2017.

Here, the qualitative dimension of our analysis should be developed so as to explain certain dynamics observed, which elude the sole breakdown in terms of degree, which might appear paradoxical. In effect, as in numerous territories, local and central powers can be opposed on different issues concerning the port (land tenure, conflicts of use). Therefore, if we return to the terminology in Table 3, the relationships here have been qualified as “are in stiff competition”. The difficulties in local governance can also be observed in the relationships between the *municipal scale* and the *Organizations for the defence of business interests* (degree 8) (relationships qualifying as “difficult negotiations”, cf. Table 3). These (associations, lobbies) take an active part in the management of port territories. They negotiate and cooperate with the government (cf. Fig. 14 in the annex where relationships between *Organizations for the defence of business interests* and the *state* are qualified as “easy negotiations”, “strong influence”). With central government, these organizations constitute coalitions which have the effect of marginalizing the *municipal scale* concerning the challenges relating to port development. In this context, “the lack of concertation, the imbalance in the capacity to influence between the port authority and the municipality encourage the municipality to adopt a defensive stance (perhaps to the detriment of port development)” (LOUBET and SERRY, 2020, p.648). As a consequence, this case illustrates the need to take into consideration “the relationships” and the “level of intensity” (cf. Table 3) in the analysis of the connections between stakeholders. In effect, the *municipal scale* seems particularly linked to other stakeholders. Yet these relationships, qualified as “unfavourable to good governance” (cf. Table 4), testify to a relational system where the organization is in a weak position faced with the other leaders in coalition.

3. Conclusion

Considering that cooperative dynamics and local development go hand in hand, we have analysed the organizational and territorial dimension of the governance of six European ports. By means of a comparative approach, we qualified and measured the intensity of relationships between stakeholders. Our previous work provided us with rich material, enabling us to compare the governance of two or three ports. However, as we stated in the introduction, given the delicate nature of the relationships, comparison on a larger scale (multiplying the cases) seemed difficult. As a consequence, it was appropriate to resort to computer modelling.

In the framework of this paper, we proposed a model based on graph theory. This made it possible to take into account the essential characteristics of port governance, but above all to compare them semi-automatically. The first piece of work (still being developed) presents a certain number of metrics. In order to illustrate the model, we chose two principal metrics which

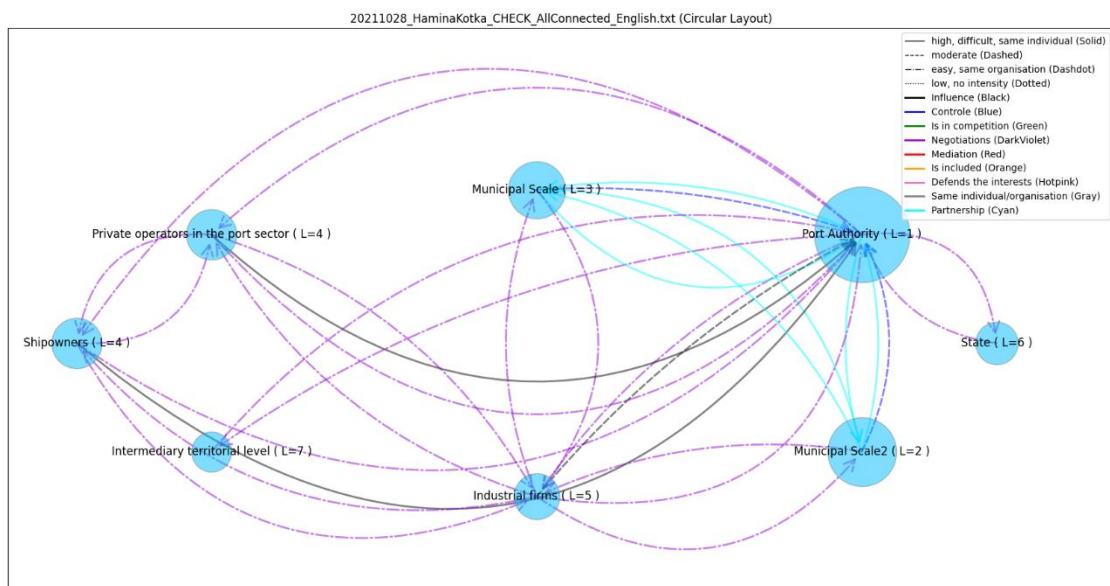
validate the general philosophy of the approach. In fact, we managed to establish a classification of the ports in two distinct groups according to their capacity to develop a more or less participatory governance in absolute as well as relative values (cf. section 2.2 metrics Density and S_metric). The analysis of the intensity of relationships was completed by a study of the number of connections between stakeholders (distribution of degrees) and the number of hubs per port. The use of the S_metric coupled with these other quantitative indicators made it possible to identify the extent of active participation in decision-making, by the major stakeholders and those with little influence. If the density calculation allowed us to establish a classification of the general intensity of relationships between stakeholders, the S_metric put the calculation into perspective in terms of distribution. In effect, if a strong S_metric provides information about the strong distribution of the intensity of relationships, a weak S_metric implies that the intensity of the relationships is concentrated on a limited number of stakeholders. We confirmed this metric by calculating the number of hubs, which confirms the prominence of certain actors. This part of the analysis via these metrics enabled us to carry out an initial semi-automatic comparison of ports. The model also facilitates a comparative reading (in terms of density, S-metric, and semantic metrics, etc.) of the role of a specific stakeholder (*the state, the region, the local port group, etc.*) in the governance of the different ports studied.

Lastly, a more territorialized approach aimed to show the relevance of the model by re-examining our previous results (XX, 2022; XX, 2021; XX, 2020; XX, 2019; etc.) against the first metrics selected. This short piece of work shed light on numerous convergences. Paradoxical elements also appeared, however, which forced us to refine and nuance our previous conclusions (which did not benefit from the inputs of the model presented in this paper). Stakeholders we had judged to be secondary in our previous analyses appear to play a significant role in local governance when one looks at it against the indicators in question. The case of Dunkirk is particularly illustrative. The *local port group*, initially identified as a very subsidiary actor, appears as a central vertex of governance notably multiplying the “mediation” relationships between stakeholders. Besides the inputs of the two metrics studied, this example shows how important it is also to take account of the nature of the relationship and therefore the semantic aspect. The example of Klaipeda is also part of this observation. As a consequence, the model could be upgraded subsequently by the introduction and processing of semantic metrics, that is to say metrics taking account of the semantics of the arcs, in other words the types of relationships involved. It would therefore propose to the expert a semi-automatic categorization of the typologies of governance, finer, more in accordance with the criteria. Identifying the greater or less favourable relationships for the emergence of “good governance”, as presented in Table 4, constitutes a pre-requisite to this approach. Similarly, as pointed out in section 1.4, in the context of this first paper, we chose to momentarily evade the institutional dimension by not mentioning the decision-making scene (both formal and informal). Yet the analysis of port governance might gain from a set of metrics relative to this dimension. “The number of decision-making scenes”, “the “formal” or “informal” character of decision-making scenes”, “the number of participants

taking part in these decision-making scenes”, “the level of leadership of the participants”, “the presence of “decision-making scenes governing relationships”, etc. provide multiple possibilities for cross-referencing and interpreting the results.

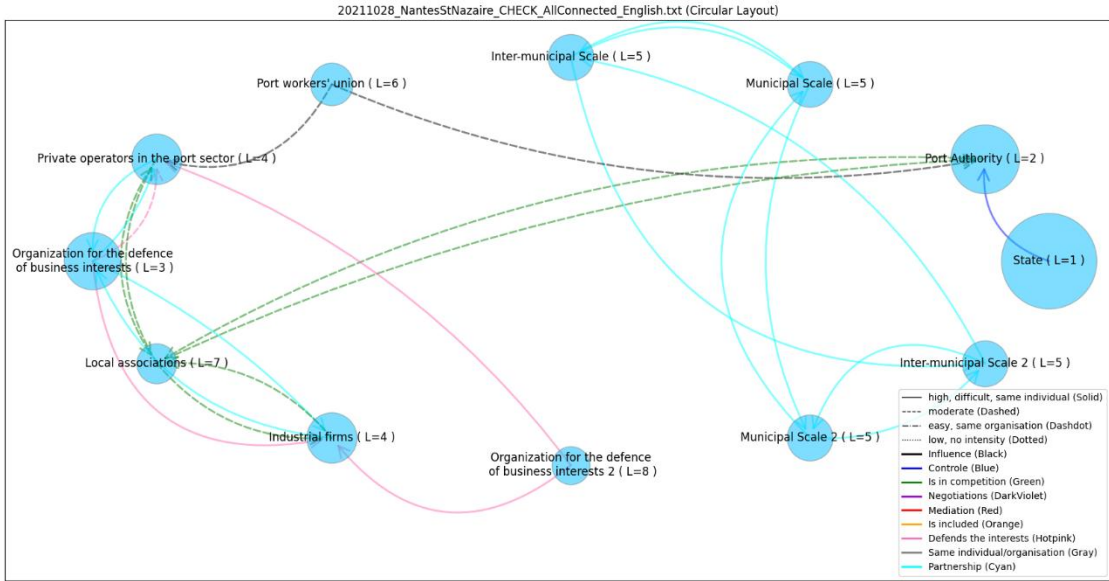
APPENDICES

Fig. 9 Graph of the port governance of 'Hamina Kotka



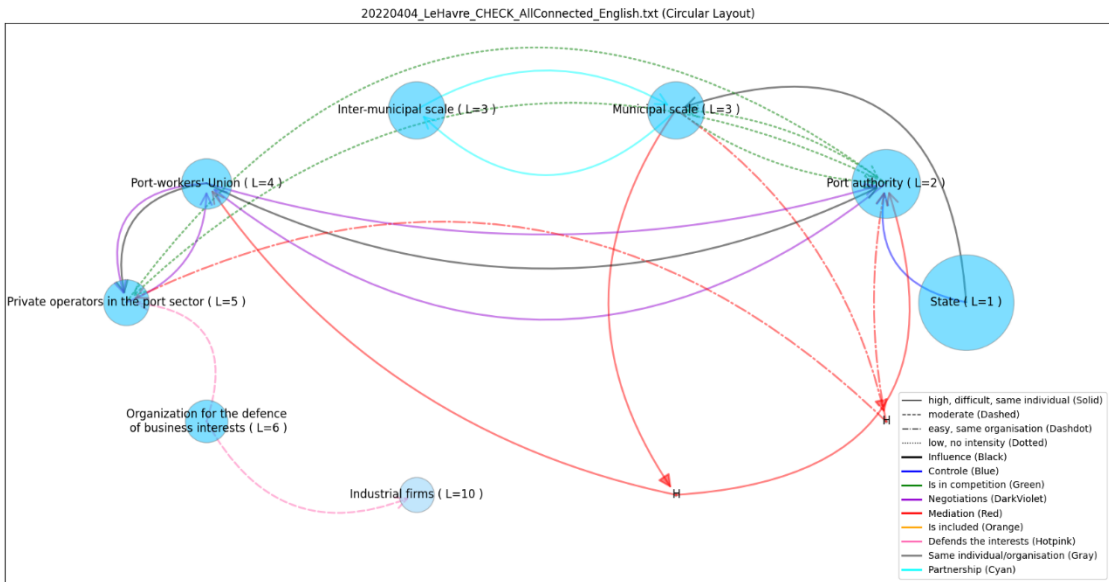
Authors, 2023

Fig. 10 Graph of the port governance of Nantes - Saint Nazaire



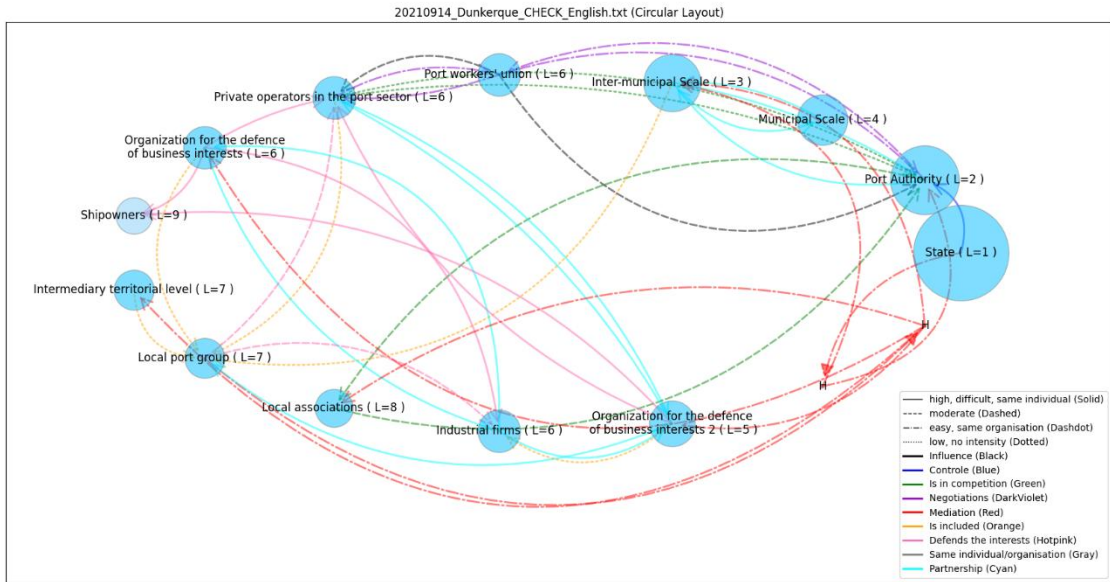
Authors, 2023

Fig. 11 Graph of the port governance of Le Havre



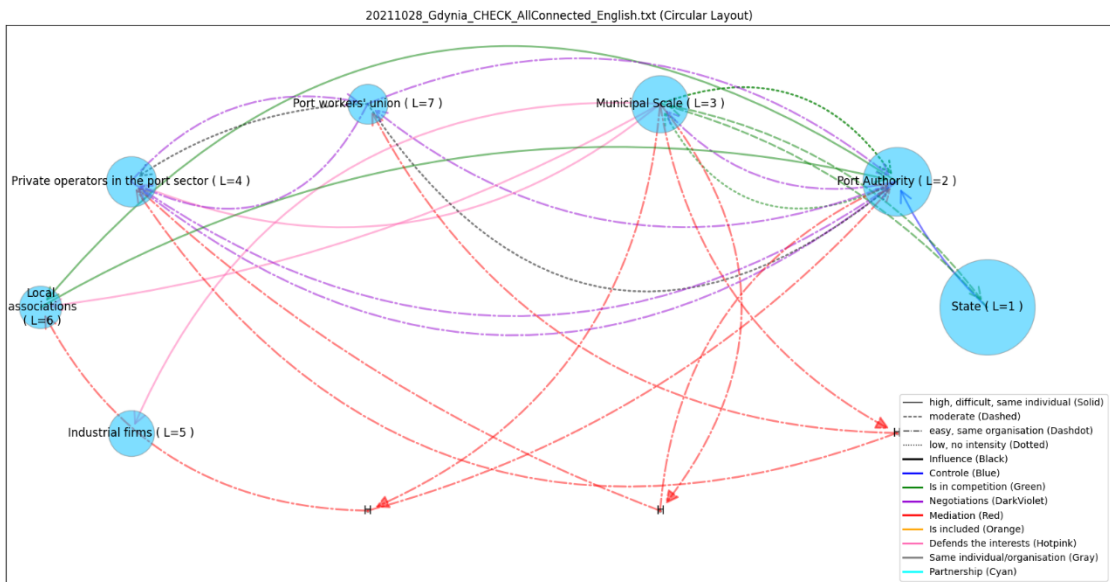
Authors, 2023

Fig. 12 Graph of the port governance of Dunkirk



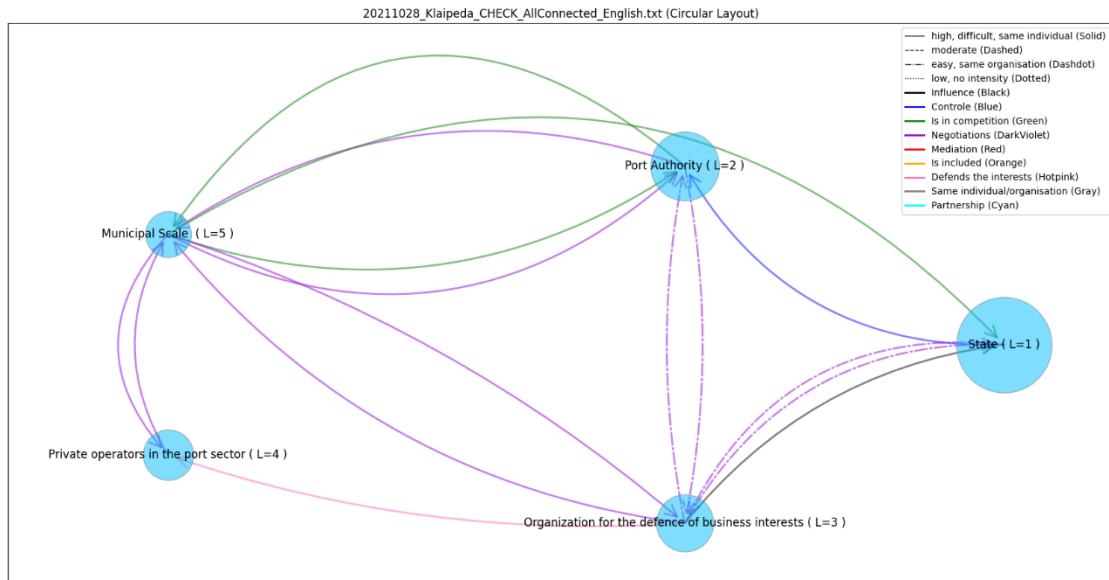
Authors, 2023

Fig. 13 Graph of the port governance of Gdynia



Authors, 2023

Fig. 14 Graph of the port governance of Klaipeda



Authors, 2023

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