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Modelling the governance of European medium-sized port-cities

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The paper presents a model designed to analyse port governance. It considers that the stakeholders' ability to adopt cooperative behaviours constitutes the key element in 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 territorialise the subject, six typical cases out of fifteen were used: Le Havre, Nantes-Saint-Nazaire, Dunkirk (France), Gdynia (Poland), Klaipėda (Lithuania), and Hamina-Kotka (Finland). The modelling of all these port environments 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), made it possible 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

Modélisation de la gouvernance des villes portuaires européennes de taille moyenne

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. 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-t-il un traitement semi-automatique participant à pallier cette difficulté au moyen d’un modèle informatique fondé sur la théorie des graphes. Il s’agit de modéliser un système en s’appuyant 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 : Le Havre, Nantes-Saint-Nazaire, Dunkerque (France), Gdynia (Pologne), Klaipėda (Lituanie) et Hamina-Kotka (Finlande). Tous ces environnements portuaires modélisés selon un même format (graphe) donnent lieu à l’application d’un certain nombre de métriques permettant de les comparer. Deux principales métriques sont présentées à titre illustratif : la « Densité » et la « S_metric ». Elles sont 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, et 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

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Introduction

There is a strong correlation between port and urban development. Many cities have grown out of ports (Vigarié, 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 al.*, 2017). Changes in international trade and containerisation, 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-urbanisation, 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 programme (PORTERR)¹ based, amongst others, on a European benchmark integrating fifteen medium-sized European port cities (bloc "Qualitative Analysis, actors' interviews", see figure 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, considering the delicate nature of the relationships brought to light, it is more difficult to compare on a larger scale. Consequently, 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", see figure 1) by basing it on the characteristics of what we understand as "port governance". The use of the concept of governance in the port domain has been the subject of much research (Brooks *et al.*, 2017; Cahoon *et al.*, 2013; Debie *et al.*, 2013; Notteboom *et al.*, 2013; *etc.*). This work has helped to clarify the territorial, political, economic,

¹ "PORTERR – Ports and Territories", directed by Lilian Loubet and Arnaud Serry.

organisational, and institutional dynamics at work. Yet a considerable amount 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 publication by Mary R. Brooks and Kevin Cullinane (2006b). 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).

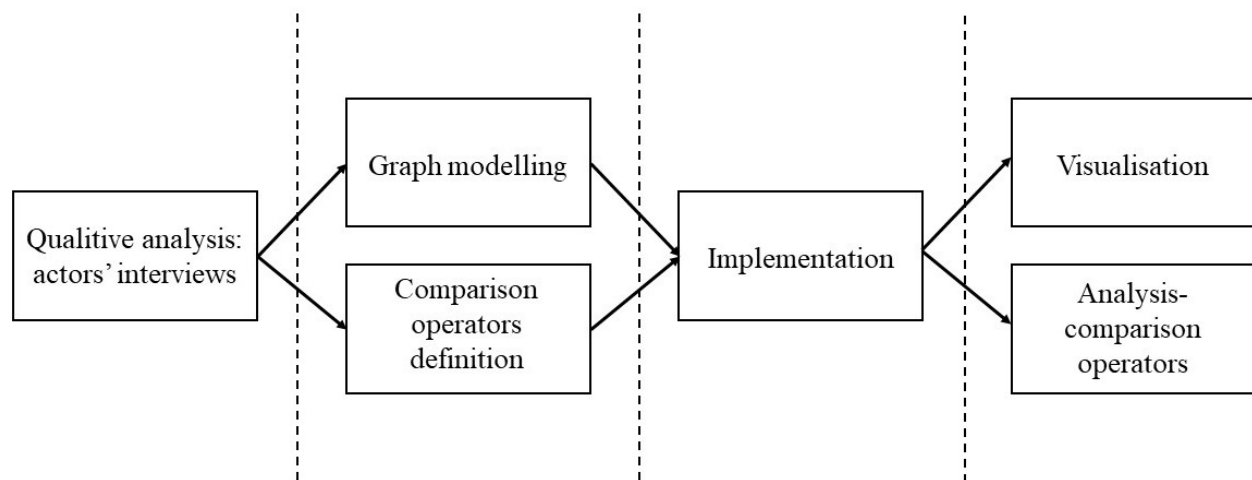
In the framework of this paper, we will focus our attention on the organisational and territorial dimension of port governance by considering in particular the relationships between stakeholders and cooperative dynamics. Beyond the port cluster concept, that names action coordination and resource sharing between interrelated firms inside a given port region (Brett and Roe, 2010; Haezendonck, 2001; Lambrou *et al.*, 2008; De Langen, 2004; Musso and Ghiara, 2008; Roh *et al.*, 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 organisations, 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 match perfectly, we shall simply use the word “port” inside this article’s 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 standardises the definition of every port, making the application of comparison operators possible (blocs “Comparison operators’ definition”, and “Analysis-comparison operators”, see figure 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 terrain, through an appropriate visualisation of the findings

of pertinent metrics (blocs “Visualisation” and “Analysis-comparison operators”, see figure 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 figure 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.

Figure 1: General workflow



Source: 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 (Loubet and Serry, 2020; 2022a; 2022b; Serry and Loubet, 2020; 2021; 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 Le Havre case illustrates this phenomenon. Thus, the issue is not to give an account of the actual situation (in 2022) but to study the logics, representations, and relationships between stakeholders at the time the interviews 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 al.*, 2007). But this scale varies depending on the author and national contexts. For instance, definitions that highlight different dimensions were proposed by Frédéric Santamaria (2000) and Frédéric Tesson (2012), based on case studies in the UK, France, Portugal, and Spain. The former emphasises the demographic variable while the latter centres on the domination of the metropolis over medium-sized towns. A functional approach was also developed in the ESPON/ORATE batch 1.4.1 programme (2006) through various case studies in Austria, France, Germany, Italy, Poland, Spain, and Sweden. Similarly, François Taulelle (2010) suggests surpassing the demographic criterion and defining the “medium-sized city” based on the scope 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

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

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 seaboards: 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 al.*, 1993). (Loubet and Serry, 2020)

Associating these two objects with irregular outlines, therefore, adds more complexity to the analysis since, according to César Ducruet (2004), the port city itself (of whatever size) is not subject to a consensual definition. Therefore, 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 Jacques Marcadon (1997) combines size, function, and relationships with the urban environment; Markus Hesse (2010) cross-references the dynamics of port activity (decline, stability, growth, etc.), organisational 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 “PORTERR”. “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 (see figure 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.

Figure 2: Medium-sized port-cities in Europe



Source: Kerbiriou and Serry, 2020.

1.2 Port governance

During the 1980s, the concept of governance became a valuable tool for analysing collective action. The port field is not exempt from this trend and also utilises this concept:

More and more port reforms in the international arena are analysed 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, 2006b), 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 al.*, 2013) and the common characteristics of the port governance reform processes (Brooks *et al.*, 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 al.*, 2014). (Zhang *et al.*, 2018, p. 51)

The definition of “port governance” remains unsettled, with no consensus among scholars. The complexity and vagueness of governance scope can be attributed to the varying orientations valued by different disciplines’ cultures, as demonstrated in table 1 (Zhang *et al.*, 2019).

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 (2004)	Accumulation and transmission of port governance knowledge	History
Vigarié (many references); Bird (1971); Charlier (many references); Slack and Comtois (many references); Wang <i>et al.</i> (2007); Debrie <i>et al.</i> (2017); Rodrigue (2017); Serry (2019); Loubet and Serry (2020, 2022a, 2022b)	Spatial scales, decentralisation, and territories of port governance	Geography
Thorrance (many references); Grosdidier de Matons (1999); The World Bank (many references); Juhel (2001); Baird (2004); Chapon (Multiples références)	Regulatory engineering and financial optimisation of port governance	Finance
Grosdidier de Matons (many references); Rezenthel (many references); Supiot (2008); Dupuis (2015); Lichère <i>et al.</i> (2006); Sánchez (2020); Sánchez and Pérez-Salas (2014)	Legal construction and organisation of public-private partnerships in port governance	Law
Cass (1996), Baird (1995), Suykens (1995); Notteboom (many references); Haralambides (2017); (Knatz, 2020); Everett (many references); Heaver (1995)	Privatisation, competitive pricing, productivity and performance of port governance	Economy
Brooks and Cullinane (2006a); Brooks, Cullinane, Pallis (2017); Brooks and Pallis (2012); Pallis (many references); De Langen (many references); Talley (many references); Lam (2013); Verhoeven (many references)	Divestment, deregulation, corporatisation, and stakeholder management in port governance	Management

Source: based on work by Daudet, 2021; translation by the author.

However, despite the multifaceted nature of the concept and the lack of unanimity, “governance” continues to be a crucial aspect in the examination of port development:

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)

We therefore agree with Jason Monios' (2019, p. 26) observations, although our methodology utilises an alternative conceptual framework. Monios 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 conception.

1.3 Qualitative analysis as a 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 and similarities in terms of governance or conversely their major differences: Le Havre, Nantes-Saint-Nazaire, Dunkirk (France), Gdynia (Poland), Klaipėda (Lithuania), and Hamina-Kotka (Finland). This phase of the survey is based on individual, anonymous interviews with leading stakeholders. We believe that leaders (Négrier, 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 configuration] is significantly influenced by the personalities, methods, and objectives of those in leadership positions. There is a correlation between territorial construction, actor learning, decision-making, and leadership structuring (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 (Loubet, 2012; 2019), respectively ranked 4th and 15th French cities in terms of numbers of inhabitants.

Consequently, in the port context, the level of leadership materialises 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 organisational charts and our assessment is essentially the fruit of an analysis of the contents (Drisko and Maschi, 2015) of the interviews 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 organisation? Your degree of investment? The status of your organisation 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 organisation? 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? Etc.
- 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: 2017-2019)

Studied ports	Methods and tools	Type of actors surveyed
<ul style="list-style-type: none"> • Le Havre • Dunkirk • Nantes-Saint-Nazaire • Gdynia • Klaipėda • Hamina-Kotka • Tallinn • Tarragone • Leixões • Southampton • Livorno • Gand • Zeebrugge • Trieste • Liverpool 	<p>For the 6 ports studied in this paper: 33 interviews.</p> <p>For all 15 ports studied: 80 semi-directive interviews.</p> <p>These interviews, under the cover of anonymity, have been recorded then integrally transcribed.</p> <p>Data analysis thanks to:</p> <ul style="list-style-type: none"> • 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) (NVivo software). 	<ul style="list-style-type: none"> • representatives of port authorities; • port worker union representatives; • representatives of the federation of the professional organisations of the Port; • port professionals (operators, logisticians, handlers...); • managers of organisations for the defence of business interests (Chamber of commerce and industry-CCI in France, lobbying groups, economic development agencies...); • elected officials; • department heads of the territorial authorities; • academics; • experts.

Source: Authors, 2023.

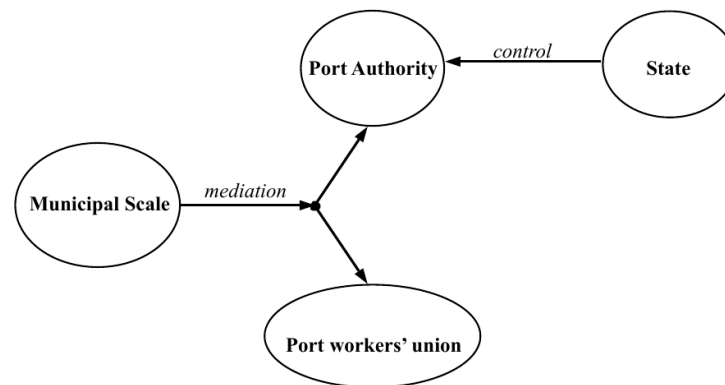
These interviews were then encoded and a textual analysis performed on the stakeholders’ discourse to identify the nature of their relationships, their games and strategies. During this stage, one textual analysis software package (“NVivo”)³ was employed. The interviews were processed by means of contents 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 in order 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 figure 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 summarise the essential information obtained from the interviews as well as to standardise it for each of the ports. The model expressivity should

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

be able to represent all the characteristics of the interviews deemed necessary for the comparison of governances of the different ports.

Figure 3: An example of interactions between stakeholders



Source: 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": see table 3): in figure 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. in figure 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 in 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 formalisation 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 organisation (most often represented by its leader) dominates another organization. It can compel it to do what it wishes.
	“Influence”	Unilateral	Low, moderate, high	The organisation acts on the decisions of another and in part determines the choices thereof.
Powers & Cooperative dynamics	“Mediation”	Unilateral	Easy, difficult	The organisation acts upon the relationships fostered between other organisations 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 organisations associated within a system.
	“Defends the interests”	Unilateral	Low, moderate, high	The organisation preserves and strengthens the position of another organisation including vying with competing organisations (or antagonistic interests).
	“Negotiations”	Bilateral	Easy, difficult	The organisations 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 organisations target the same object or pursue the same goal (including on the symbolic market: “powers”).
Participation in decision-making scenes	“Is included”	Bilateral		An organisation (embodied by its representatives) sits or participates in a (formal or informal) decision-making scene.

*“unilateral”: non-reciprocal; ** “bilateral”: reciprocal

Source: Authors, 2023.

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 in the literature are countless. 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, and 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 which 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 spatialised. The model based on a graph (G) proposed in this paper takes into account 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 ($N_1 = \{1, \dots, n\}$, $n \in \mathbb{N}$), $N_1 = 1$ being the highest level, $N_1 = 2$ the second highest and so on, and to each arc a level of relational intensity ($N_i = \{\text{high, moderate, low, easy, difficult}\}$).

Our qualitative analysis (section 1.3) enabled us to identify $C_a = \{\text{State, Port Authority, Municipal Scale, Inter-municipal Scale, Port Workers' Unions, Private operators in the port sector, Organisations for the defence of business interests, Shipowners, Intermediary territorial level, Local port groups, Decision-making scene for regulating relationships, Strategic council, Economic and Social Council, Local bodies,$

Industrial firms} and $T_r = \{\text{Control, Defends the interests, Is in competition, Is included, Influence, Mediation, Same person, Same organisation, Negotiations, Partnership}\}$.^{4 5}

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

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

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).

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

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

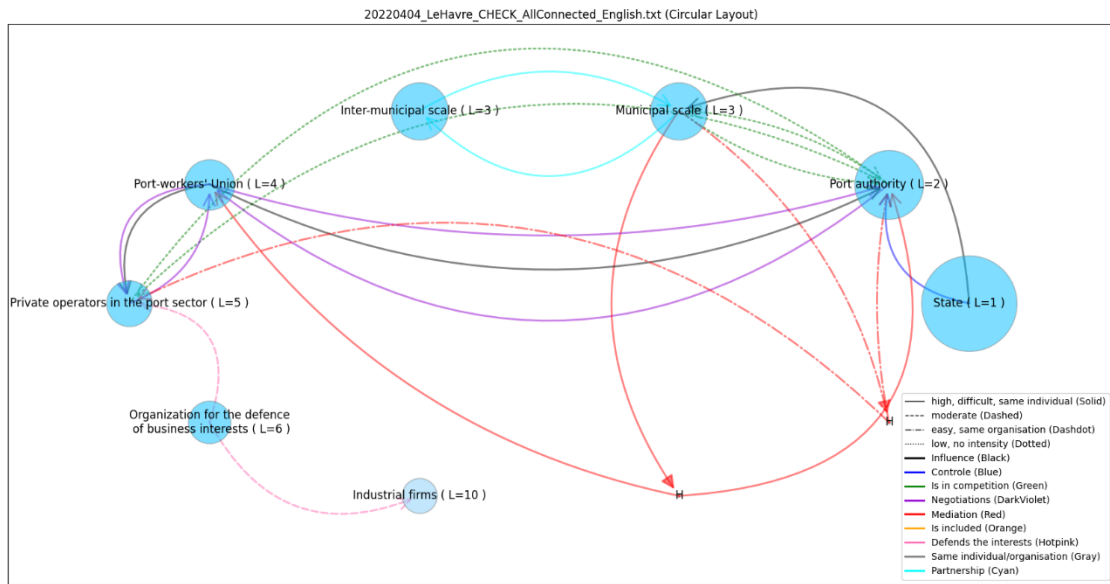
If one instantiates this model on the example of the port of Le Havre, one obtains the figure 4 representation (the graphs representing the six ports studied are available in the annex). For reasons of legibility the decision-making scenes and the relationships associated are not represented. The vertices “H” are not stakeholders; they are only introduced to help with the visualisation of a hyper-arc and linked to the use of an image library.⁶ 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 figure 5 to reinforce the explanation of the representation of the hyperlinks in the application.

⁴ This stakeholder inventory was compiled through the questionnaire survey (section 1.3) which allowed us to recognise and order the primary stakeholders in terms of their impact on port decisions (leadership). We requested all interviewees list the most powerful stakeholder in their respective port, ranked in order of influence. Their responses were then compared to generate the final ranking for each port.

⁵ Every port underwent content analysis. The objective of this article is to systematise this analysis. Consequently, we identified the types of relationships examined in all the ports under investigation (as part of the PORTERR research project and our different publications) and categorised them to form the model.

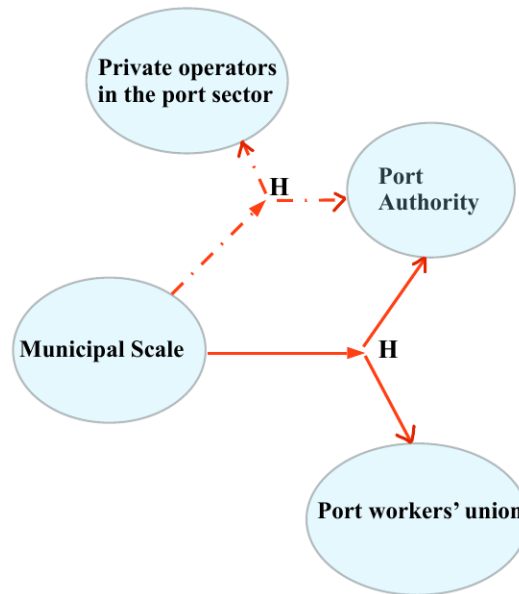
⁶ NetworkX, Network Analysis in Python, online: <https://networkx.org> [accessed 18 March 2024].

Figure 4: Graph of the port governance of Le Havre



Source: Authors, 2023.

Figure 5: Examples of the representation of hyperlinks in the application (here two mediations)



Source: 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 (see section 2.2). In the context of this 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 (see 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 regional sciences generally, is outside the scope of this paper. The second sub-part (2.2) will attempt to demonstrate the benefit of computer modelling which makes 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 André Torre, relationships between stakeholders are at the core of these two dimensions. They materialise a territorialised 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 behaviours at the heart of their 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 (organisational and territorial) dimension of the concept of governance suggested below by Brooks and Cullinane (2006a), 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, 2006a, 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”. Kofi Annan, former Secretary General of the UN, stated that good governance was without doubt the most important factor in the promotion of development.⁷ Developing good 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

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, online: <https://www.un.org/press/en/1997/19970728.SGSM6291.html> [accessed 18 March 2024].

organisational 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 figure 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 organisations (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”		

Source: 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 characterising “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

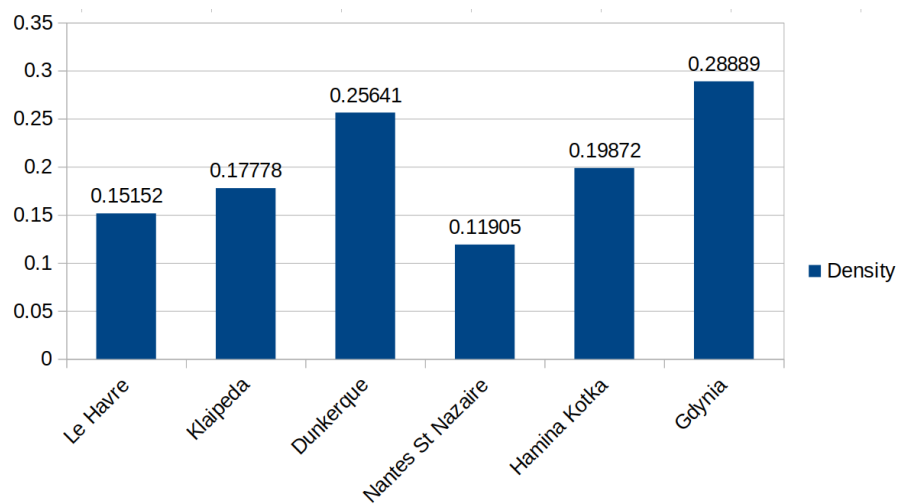
The number of stakeholders and the relationships between the different stakeholders vary significantly depending on the port. This variation gives us information on the intensity of governance, in other words, stakeholder participation in decisions which commit port development in absolute values (the 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 categorise 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 $| \cdot |$ expresses cardinality, $|V| * (|V|-1)/2$ is the maximum number of edges in a graph. Consequently, 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 figure 6.

Figure 6: Density of the graphs relative to each port, taking into account all the vertices



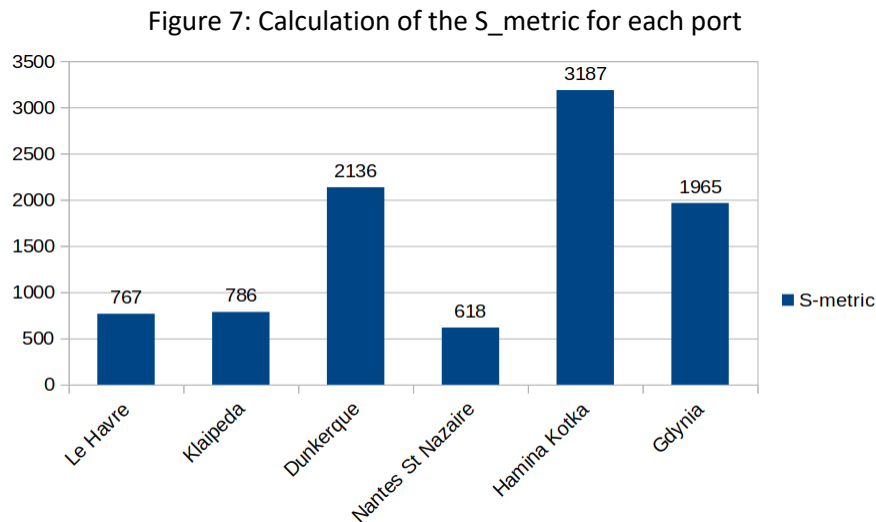
Source: Authors, 2023.

We note that there are ports for which links are more developed. In the light of figure 6, and especially figure 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) characterised by more developed links and a “group 2” (Le Havre, Klaipėda, 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 *et al.*, 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 figure 7.



Source: 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 normalised 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

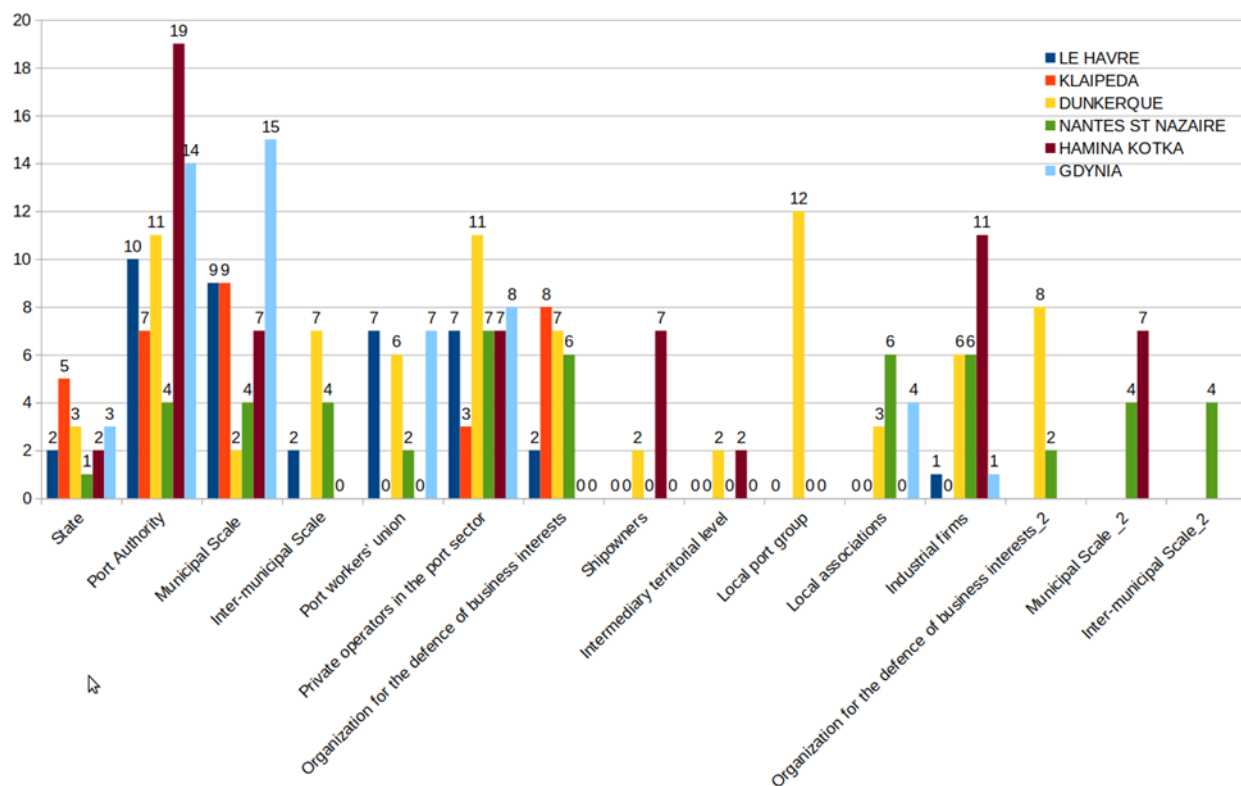
Port	# Hubs	Stakeholder	Degree	Average degree of hubs
Le Havre	4	<i>Port Authority</i> <i>Municipal Scale</i> <i>Port workers' union</i> <i>Private operators in the port sector</i>	10 9 7 7	8.25
Klaipėda	4	<i>State</i> <i>Port Authority</i> <i>Municipal Scale</i> <i>Organisation for the defence of business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

Source: Authors, 2023.

The analysis of the S_metric (figure 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 (see figure 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 where the power play around stakeholders does not necessarily occupy the highest positions in the ranking. Consequently, *the local port group (Norlink)* (degree 12, see 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 (see table 5 and figure 8).

Figure 8: Actors' degree compared by ports



Source: 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 (see figure 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” (Hall, 2015; Muller, 1995).⁸ As for the *port authority* (degree 11), it is once again positioned in the top three. Consequently, 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, see figure 6) which is not widely distributed. The

⁸ “[I]t 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)

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*).

The group 2 ports (Le Havre, Klaipėdia 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 (see 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, see figure 6). These elements corroborate the results of our qualitative analysis (Loubet and Serry, 2020; 2022a; 2022b; Serry and Loubet, 2020 and 2021; etc.).

To finish our analysis and so as to territorialise 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 Havre, 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]).⁹ *The state* appears to be the most influential stakeholder, notably through the management board of *the port authority* (degree 10, see 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 interest.¹⁰ *The municipal scale* (Le Havre) (degree 9, see 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.

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 organisation aiming to merge the three ports of the Seine axis: Le Havre, Rouen and Paris, 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.

In this context, the “quadripartite” materialises the cooperative relationship between the state representatives, particularly the port director, and the mayor. The quadripartite is a powerful, informal decision-making body widely known by all stakeholders.

The Quadripartite convenes three to four times annually, comprising 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 strong decision-making body, despite its informal nature [...]. 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 fact there are three—and sometimes it’s just city and port. (A councillor of Le Havre, 2017)

That’s where discussions take place at the quadripartite level, and subsequently, decisions are made based on the outcomes of those discussions. (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)

The case of the port of Nantes-Saint-Nazaire¹⁴ 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

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

¹³ Union maritime et portuaire du Havre is a maritime and port federation of professional organisations of the Port of Le Havre

¹⁴ In 1966 the ports of Nantes and Saint-Nazaire merged and became a “*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).

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 (see 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 associating local economic stakeholders in particular.

The recent establishment of the port promotion cluster is believed to have influenced the decision-making process. This initiative unites public and private players to promote and enhance the port community. In addition to its promotional elements, the informal interactions and monthly meetings amongst stakeholders encourage closeness and support collective reflection on port strategy (Loubet and Serry, 2022a and b).

We thought that each group was working separately: the CCI on one side, the Port on another side, us on another, and the local authorities on the other. If we can unite all efforts, it would be wonderful! It won't be simple to coordinate everything, but if we define a few key strategic priorities and reach a consensus, and then implement the necessary actions corresponding to the priorities we set, we'll make significant progress. (The manager of a port service company, 2019)

Promoting a region involves collaborating with port partners. It's a priority, particularly for the Union Maritime and the CCI. It's evident that economic growth is central to the efforts, with involvement from the Regional Agency. Ultimately, everyone is working closely together toward these goals. Perhaps the phrase "hunting in packs" is slightly severe, but it's there. (A manager within the GPM, 2019)

Therefore, if institutional organisation 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 in the port sector* (degree 7) have partly overcome this deficit by a clever use of representation provided by *organisations for the defence of business interests* (degree 6), as in the cluster *Be My Port*¹⁵ (see figure 10 in appendix). Similarly, in a territory that has experienced strong mobilisation (in light of the domestic downturn) against the building of the Notre-

¹⁵ However, this type of local cooperation remains delicate, and this cluster disappeared in 2022.

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 Klaipėda (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*¹⁶ (degree 7) enjoys very strong leadership in the port.

We are a government-owned company established by the transport department. We function as a branch of the transport department. (A manager of Klaipėda'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 four seats out of 23 and in which nobody pays any attention to us. (The deputy mayor of Klaipėda, 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 *organisations for the defence of business interests* (degree 8) (relationships qualifying as "difficult negotiations", see table 3). These organisations (associations, lobbies) take an active part in the management of port territories. They negotiate and cooperate with the government (see figure 14 in the annex where relationships between *organisations for the defence of business interests* and the *state* are qualified as "easy negotiations", "strong influence"). With central government, these organisations constitute coalitions which have the effect of marginalising the *municipal scale* concerning the challenges relating to port development. In this context, "the lack of

¹⁶ Under the direct trusteeship of the *state* through the Lithuanian transport ministry.

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). Consequently, this case illustrates the need to take into consideration “the relationships” and the “level of intensity” (see 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” (see table 4), testify to a relational system where the organisation is in a weak position faced with the other leaders in coalition.

Conclusion

Considering that cooperative dynamics and local development go hand in hand, we have analysed the organisational 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. Consequently, 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 developed¹⁷) presents a certain number of metrics. 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 more or less participatory governance in absolute as well as relative values (see 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

¹⁷ Bangate Julius, porterrGRAPH, online: <https://gitlab.insa-rouen.fr/jbangate/porterrgraph> [accessed 18 March 2024].

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 territorialised approach aimed to show the relevance of the model by re-examining our previous results (Loubet and Serry, 2020; 2022a; 2022b; Serry and Loubet, 2020 and 2021). 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 into account the nature of the relationship and therefore the semantic aspect. The example of Klaipėda is also part of this observation. Consequently, 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 categorisation of the typologies of governance that would be finer and 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 prerequisite to this approach. Similarly, as pointed out in section 1.4, in the context of this 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.

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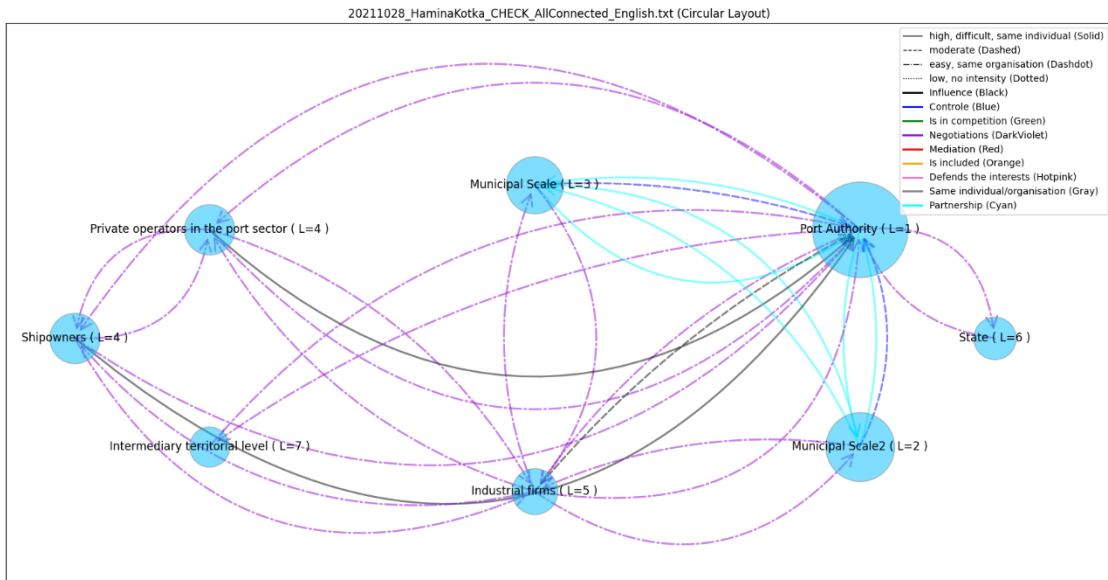
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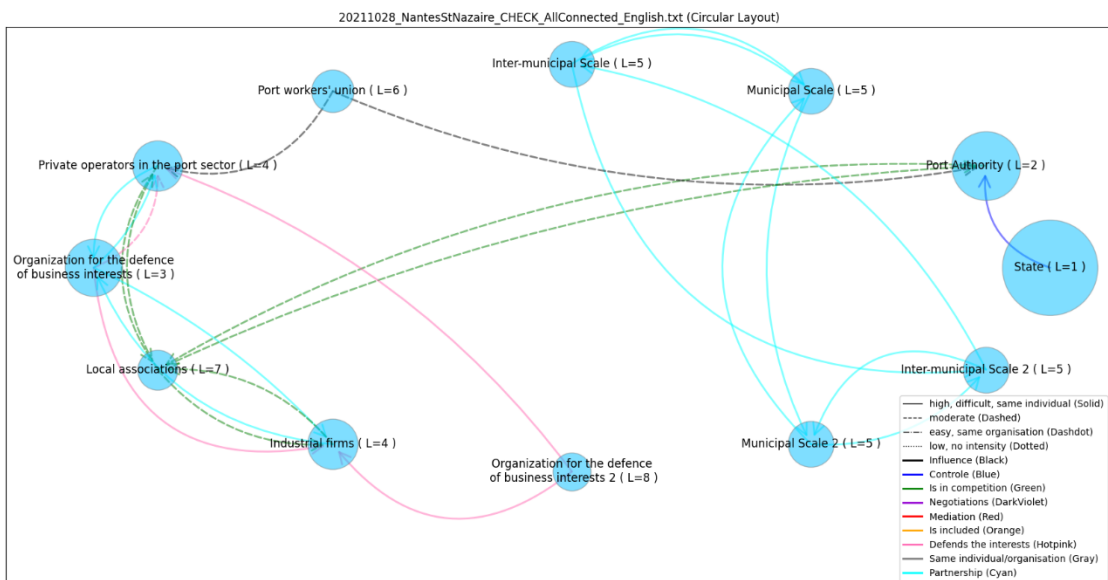
Appendices

Figure 9: Graph of the port governance of Hamina-Kotka



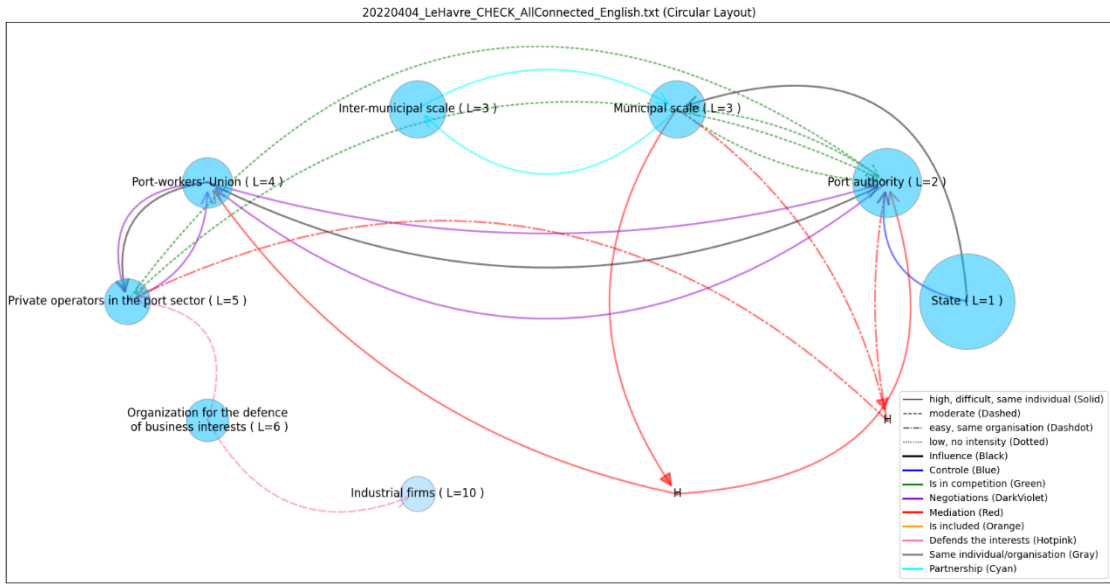
Source: Authors, 2023.

Figure 10: Graph of the port governance of Nantes-Saint-Nazaire



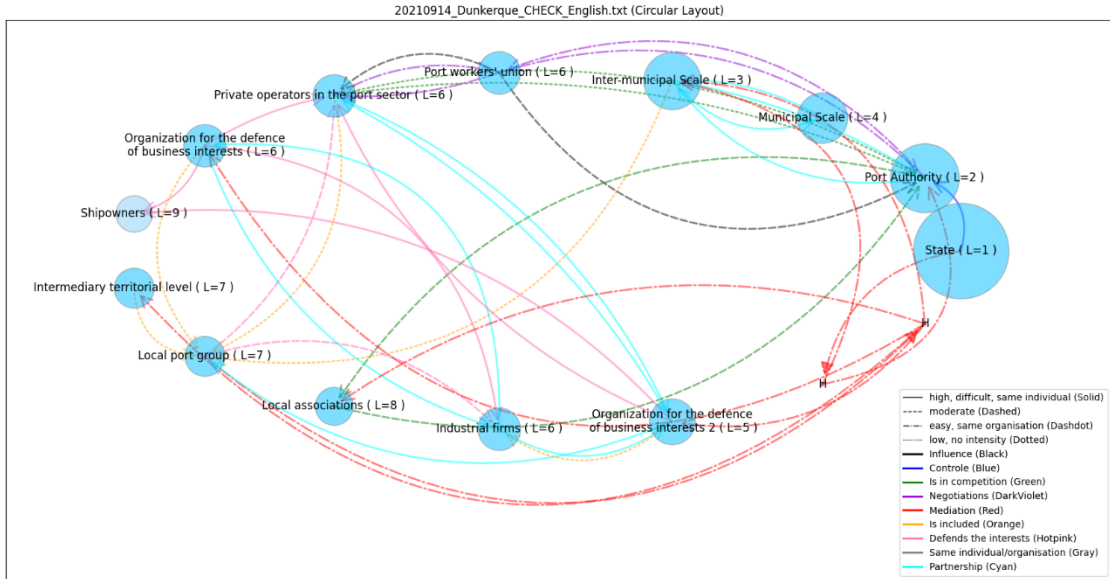
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Figure 11: Graph of the port governance of Le Havre



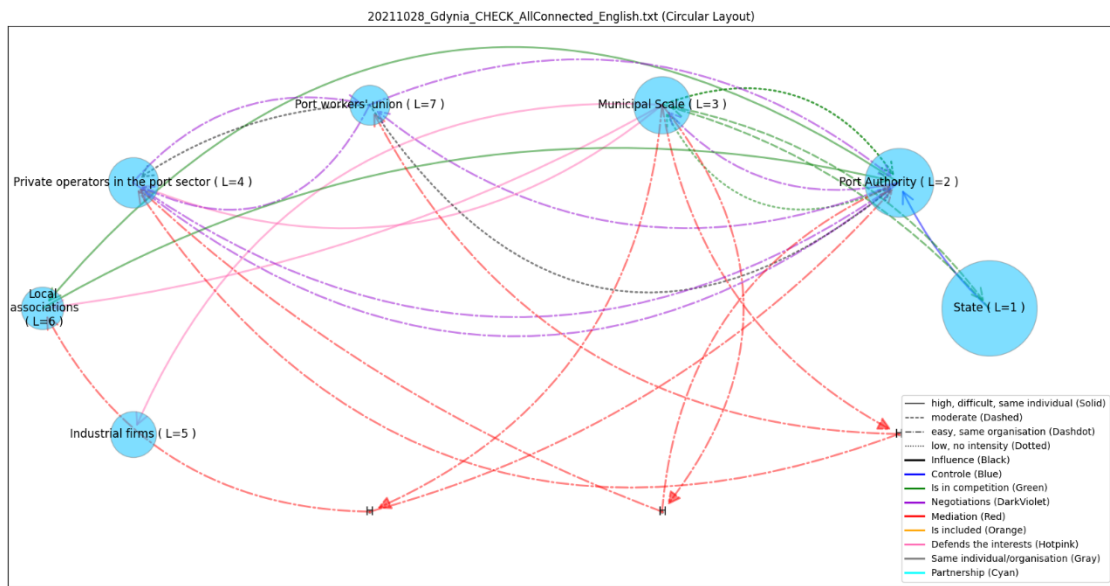
Source: Authors, 2023.

Figure 12: Graph of the port governance of Dunkirk



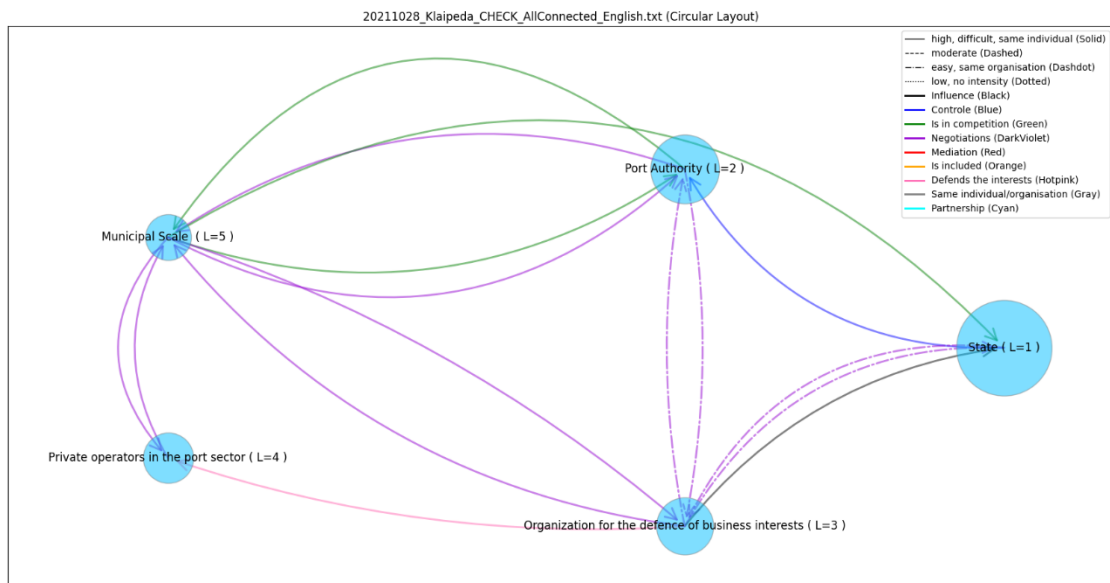
Source: Authors, 2023.

Figure 13: Graph of the port governance of Gdynia



Source: Authors, 2023.

Figure 14: Graph of the port governance of Klaipėda



Source: Authors, 2023.