Analysis of synergic relationship in a Chilean medium-sized port: an approach from the simulation of the transformation matrix of eigenvalues

C.A. Durán
Department of Industrial Engineering
University of Santiago de Chile
Santiago, Chile
claudia.duran@usach.cl

F.M. Córdova
School of Industrial Engineering
University Finis Terrae
Santiago, Chile
felisa.cordova@gmail.com

***Abstract*— Ports can be considered as a mixed network composed of different stakeholders such as private service provider companies, public organizations, professional and social associations. Each of them has its own aims and the port community exercises the role of coordinator, taking on responsibility for governance. In general, the interaction among the different actors generates strategic synergy, contributing to the achievement of greater efficiency in the port system. This study presents a method to identify the degree of synergy in a Chilean medium-sized port in the context of a micro and macro environment. Synergy involves political, economic, social, technological and environmental factors, including risk and organizational learning, which are evaluated as a multi-criteria system. A diagnostic research is done, including stakeholders and associated experts' opinions, by applying a survey designed and based on an array of relationships among the actors. The results are processed to obtain the eigenvalues and eigenvectors of the matrix, which are interpreted as linear dependence/independence strategic relationships among the actors involved. To analyze the information obtained from the survey, a Correlation Matrix is created where we can identify synergy relationships. So, degrees of synergy between the Port Community and the other actors that integrate the Chilean medium-sized port system are explored. As a conclusion, a direct relationship exists between the degree of strategic synergy and the actors' linkage to port operational activities.**

Index Terms-synergic relationship; port strategies; correlation; eigenvalues; eigenvectors

I. INTRODUCTION

Organizations constituting a generic Chilean medium-sized port system develop complex relationships, determined by how and what they perceive their micro- and macro-environment. Their connecting links bring about mixed networks due to the interaction of varied public and private entities, of different nature at corporative, business and operational levels; the port mixed network is made up of actors linked to private service provider corporations, labor unions, social groups and components of public organizations [1]. Their inter-organizational links are complex and a lack of collaboration and integration becomes apparent between public and private actors; thus, preventing the Port Administrator from playing a role of governance. On the other hand, the Port Administrator and the external and internal Port Terminals, comprising the Port Community, have a difficult task when they intend to make decisions efficiently and effectively since they are unaware of the extent of their relationships and which are determined by the exchange of strategic information, developed in their mission and strategic lines.

Synergy can be understood as the attribute of a system to optimize the use of its organizational components to achieve its goals. In other words, it is made visible when a superior purpose or objective of the system becomes a priority above the purpose of its individual components. This same idea can also be extended throughout a system of inter-related corporations when they are oriented to a common objective [2].

Concerning the actors in each Chilean port, they are permanently linked to an uncertain environment, interacting with this micro- and macro-environment which may present different degrees of synergy in their strategies. The achievement of common objectives and cooperation between components of a system is demonstrated through high synergy, as well as the ability that can show the system to adapt to the external environment [2] [4]. Synergy can be a source of relationships among corporative strategies where skills, resources, knowledge, risks and compromises are shared among the system components [5] [6].

Particularly, those skills related to the capacity to acquire technology generate synergy between the way they are learned to use it and the technology available in corporations; we can observe different evolution stages for learning which are important for organizations since they can use advanced technologies and, at the same time, enhance innovation [1][7].

A port system having cooperative links is prone to producing synergic relationships; these may emerge from different relationships oriented to share information among the actors in aspects such as contracts, exchange of resources, different levels of accomplishment, alliances among the involved projects, and contributions for the benefit of other actor in different periods of time. It is worth noting that both

the environment and the industrial sector could hold a symbiotic relationship in the port network in order to stimulate synergic relationships which could foster the adaptation capacity of the port system in the event of facing external aggression [10].

Absence of synergy may lead to malfunctioning of the port network, posing constraints at investment level and collective learning processes. Likewise, lack of associativity among private and public enterprises and among the actors involved in the export/import logistics chain generates poor synergy among the Port Community actors [9] [10].

By assessing the degree of synergy in a port system where different organizations share valuable information, cooperating for a common purpose, we can study the correlation of information and interpret the multivariate dependence between the attributes of variables. It is essential to identify all those synergy relationships indicating efficiency, adaptability and effectiveness in a port system to transfer them all into category sets; taking into account that an effectual answer would mean survival on varied stages

Concerning the research, in the context of Linear Algebra, we are using a Transformation Matrix with eigenvalues to seek and find eigenvalues and eigenvectors to independently represent the behaviour of a system [11] [12]. To determine synergy relationships we use the Pearson Correlation Matrix since we can link collaboration among the port actors with it [13] [14].

II. STRATEGIC RELATIONSHIPS IN A CHILEAN MEDIUM-SIZED PORT

A. Specification of the Chilean medium-sized port.

The generic Chilean port system under research comprises 49 public and private actors. The Port Community comprises private enterprises (granted by government concession), such as: Port Authority who manages and coordinates actions related to daily port operational activities, an externalized Port Terminal and other internal Terminal which administrate Terminals and the port. The Port Community is the coordinator of a mixed network comprising private service provider enterprises, government public organization components, and social groups. Social groups include labor unions coming from the export and import logistics chains and public and private trade associations.

As shown in Fig. 1, we can identify and determine the system components of the Chilean medium-sized port according to their degree of relationship with the operational activities [1] [15]. The connecting link among the actors can be directly or indirectly related to the Core of the business in the operational context [1].

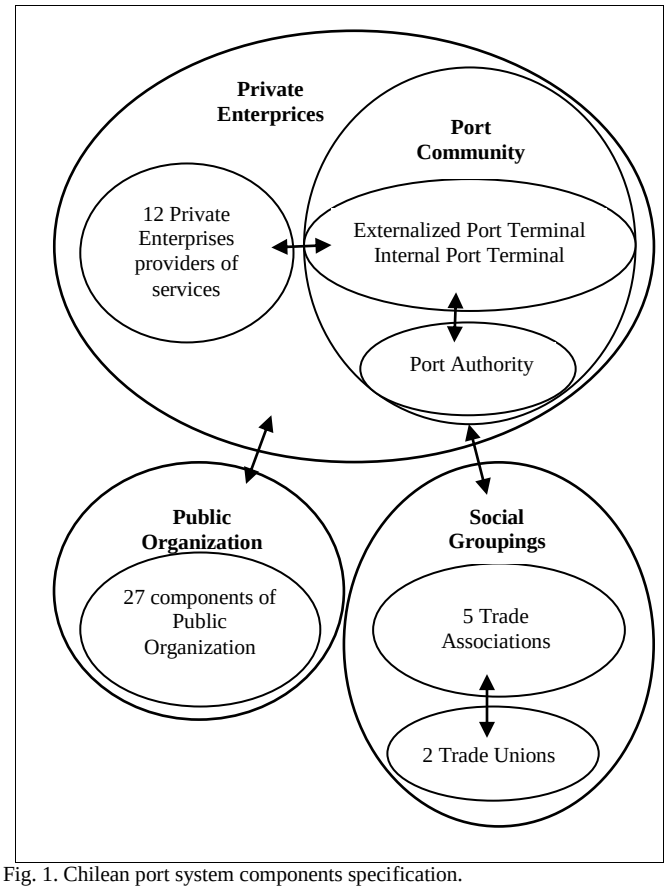

Fig. 1. Chilean port system components specification.

In the Chilean medium-sized port system, private enterprises integrate import and export logistics chains; hence they have a greater degree of relationship with the port operational activities. Regarding public organization components, they present a direct relationship with the Port Community, providing economic resources for infrastructure and technological development investment projects. Social groups tend to promote rationalization, development and protection of port activities.

B. Analysis of the Strategic relationship in the Chilean Medium-sized port.

TABLE I. LIKERT SCALE FOR A CHILEAN MEDIUM-SIZED PORT

Degree of port strategies	**Scale and semantic value from the port system**	
	Scale	***Semantic value of the relationship***
0.00	0	Without relationship
0.25	0 a 30%	Very weak
0.50	>30% y ≤50%	Weak
0.75	>50% y ≤90%	Enough
1.00	>90% y ≤ 100%	Closely related

In order to analyze the existing linkages among private and public actors in the medium-sized port network, in Table I we

use the Likert Scale to design and classify the degrees we can find in the researched system.

With the aim to determine which actors in the mixed network present strategic synergy among them, we have collected data through the expert judgment qualitative instrument from two relevant Chilean ports; the strategic relationships are entered into the matrix, that is, the experts' perceptions about the connecting links at strategic level among all the actors involved in Fig.1. We should say that perceptions have been classified according to the Likert Scale, as shown in Table II.

In Table II we can see that matrix A is symmetric and contains 49 columns and 49 rows where each column and row represent a public or private actor from the port system and his/her relationships.

By using the Matlab tool, a method of transformation for eigenvalues (from Linear Algebra) is applied to the matrix of strategic relationships among actors as shown in (1):

$$\vec{x}^{T} A \vec{x} \geq 0 \quad (1)$$

$\forall \vec{x} \in R^{n,}$ with n=49 and $\vec{x}$= eigenvector of Matrix A.

As show in Fig. 2, a number of 49 real scales attribute roots or eigenvalues $\lambda \in R$ are obtained. It can be observed that the eigenvalues are real and may represent a degree of sequential dependency between two actors of the port, which can be evaluated through indicators [12].

By using the power method for approximating eigenvalues and the convergence rate for the eigenvector, we choose the greatest dominant eigenvalue $\lambda 1 = 18.3745$ which has the same direction as the eigenvector $\vec{x}$ [16] [17] [18] [19]. These results are shown in Fig.2.

TABLE II. MATRIX OF STRATEGIC RELATIONSHIPS IN A CHILEAN MEDIUM-SIZED PORT

Strategic relationships between actors	**Public or private actors from the port system**							
	A1	***A2***	**…**	***A9***	**…**	***A38***	**…**	***A49***
Port Authority (A_1)	1	0,75	…	0,75	…	0,25	…	0,75
Externalized Port Terminal (A_2)	0,75	1	…	0,75	…	0,25	…	0,75
…	…	…	…	…	…	…	…	…
Transport enterprise (A_9)	0,75	0,75	…	1	…	0,25	…	0,25
...	…	…	…	…	…	…	…	…
Department of Maritime Transport (A_{38})	0,25	0,25	…	0,25	…	1	…	0
…	…	…	…	…	…	…	…	…
Customs Agents Association (A_{49})	0,75	0,75	…	0,25	…	0	…	1

Eigenvalue λ	***Eigenvector x →***
18.3745	0.21313667
4.9629	0.223726662
-3.3055	0.223726662
-1.6634	0.185355321
-1.6157	0.185355321
…	…
0.7500	0.134482477
0.5000	0.127879093
0.5000	0.132188651
0.5000	0.09387876

Fig. 2. Eigenvalues and eigenvector of Matrix for strategic relationships

The eigenvector which is shown in Fig. 2 is made up of real numbers, which can be the same or different among them. Their components are interrelated proportionally in their contribution to the eigenvector. In relation to the port system under research, we can observe that those components contributing in greater proportion to the eigenvector are in line with the port experts' opinions, who express a greater degree of strategic relationship among the actors linked to the Port Community. Therefore, the greater collaboration among the actors in the port mixed network, showing also some degree of synergy, is generated among the actors integrating the Port Community.

III. SYNERGY IN STRATEGIC RELATIONSHIPS IN A CHILEAN MEDIUM-SIZED PORT

A. Medium-sized Port analysis of synergy in strategic relationships between port actors

Define For the purpose of analyzing the existing synergy among the actors who integrate the port mixed network, we apply the Matlab tool to the matrix of strategic relationships among port actors to obtain a Pearson R49*49 correlation matrix that explains the strategic alignment between the actors [13] [14]. The Pearson correlation coefficient is presented in (2)

$$r_{X,Y} = \frac{\sum_{i=1}^{49}(X_i - \mathbf{X})(Y_i - \mathbf{Y})}{\sqrt{\sum_{i=1}^{49}(X_i - \boldsymbol{X})^2}\sqrt{\sum_{i=1}^{49}(Y_i - \boldsymbol{Y})^2}} \quad (2)$$

$$\boldsymbol{X} = \frac{1}{49}\sum_{i=1}^{49} X_i \qquad \boldsymbol{Y} = \frac{1}{49}\sum_{i=1}^{49} Y_i$$

As shown in Table III, the correlation matrix for port actors has components r X,Y both positive (white) and negative (black), the positive ones indicate that the linear projection increases together with the variable, but the negative ones indicate the opposite.

In the correlation Matrix under study, only positive components have been chosen since they can show a degree of synergy among the port actors who have cooperative links and share the necessary strategic information to carry out their operational activities [8] [20] [21] [22].

The connecting links can be evaluated through indicators which can represent the existence of correlations between two indicators showing the degree of dependence between two variables [12].

TABLE III. CORRELATION MATRIX OF PORT ACTORS IN A CHILEAN MEDIUM-SIZED PORT

Correlation matrix between port actors	**Public or private actors from the port system**							
	A1	***A2***	**…**	***A9***	**…**	***A38***	**…**	***A49***
Port Authority (A_1)			…		…		…	
Externalized Port Terminal (A_2)			…		…		…	
…	…	…	…	…	…	…	…	…
Transport enterprise (A_9)			…		…		…	
...	…	…	…	…	…	…	…	…
Department of Maritime Transport (A_{38})			…		…		…	
…	…	…	…	…	…	…	…	…
Customs Agents Association (A_{49})			…		…		…	

In the context of organization communities we state the existence of a high tendency to set up networks that link those actors who establish relationships following common patterns, showing dependence and correlations between their input and output [23].

B. Relations of synergy for the port community

Based on results obtained in Tables I and III, Fig. 3 represents the classification of port actors according to the degree of synergy in the strategic relationships, between the Port Community and the other port actors in the mixed network. It should be noted that we have only chosen actors who are part of the port mixed network and who present positive correlations.

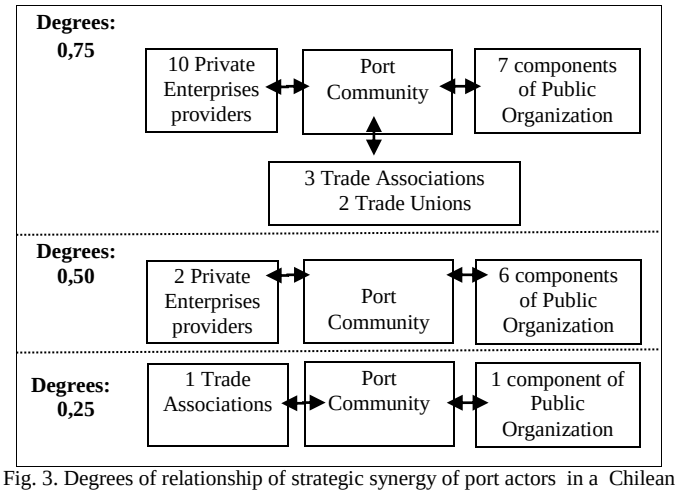

Fig. 3. Degrees of relationship of strategic synergy of port actors in a Chilean medium-sized port

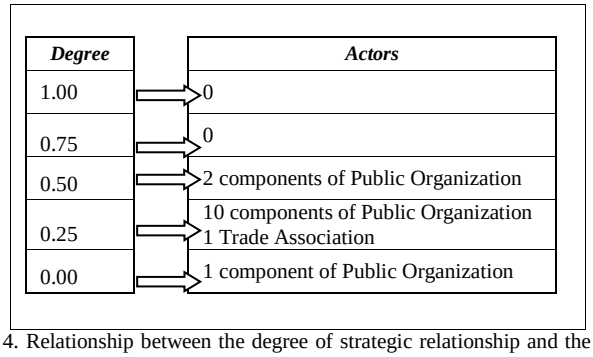

Fig. 4. Relationship between the degree of strategic relationship and the lack of strategic synergy

On the other hand, Fig. 4 shows the classification of actors comprising the port system but who have a negative correlation, for this reason, no relationships of strategic synergy between the Port Community and the actors of the port mixed-network are presented.

We can observe that the actors who do not show synergy with the Port Community represent 48% out of the components from public organizations.

The research results were confirmed by port experts. They agree with the relationship presented in Fig. 4. In fact, some of the Trade Associations, Trade Unions, and Port Community also the Private Enterprises have a high degree of synergy. Also, some of the Public Organizations have a high degree of synergy.

IV. CONCLUSIONS

There is a relationship between the degrees of perception collected from experts, which turned to be the data for Matrix A, and the existing synergy relationships in the port mixed network. If a greater degree of linkage is perceived among enterprises and organizations of a port system, there may be a greater number of organizations that express synergic cooperative linkage.

The Port Community presents synergy with actors who are more directly related to the operational activities, such as service provider enterprises, trade associations and labor unions. It is necessary to increase the synergy relationship

with the public components for they have a regulatory role and/or support primary activities.

We should emphasize that the results show the existence of strategic synergic relationships in the Chilean port system and which may form a Cluster. Because the highest strategic synergy is generated in the Port Community, it is possible to arrive at a conceptual model of it, taking into account synergic linkages between the Port Community and all the other actors who belong to the Chilean port mixed network.

For future research, it will be necessary to analyze the synergy relationships that exist in the port system including the micro and macro environment, so as to find multi-attribute behavior patterns and their link to political, economic, social, technological, environmental, risk and learning aspects.

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