
Traffic Forecasting in Moroccan Ports

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A port's performance requires rigorous and methodical planning to optimize the supply port infrastructure in terms of docking and handling equipment. This planning is based on a mastery of the potential traffic and requires the establishment of contingency plans to deal with the traffic.

In Morocco, the port sector has undergone a great change in order for it to be adapted to the evolving socioeconomic environment (internal development, new context of globalization, etc.) and to meet the new economic challenges (institutional, technological, environmental, and maritime).

Many opportunities could be offered by this sector if the effectiveness of the maritime logistics chain and if the quality of project's planning and programming are improved. Predicting traffic is a helpful tool to achieve such objectives. We will discuss within this article the relationship between the governance and the port traffic forecasting process. We use the example of Moroccan ports and examine the characteristics of the port traffic in Morocco in order to deduce a "good estimator" of future traffics.

Keywords: National Ports Agency (ANP), Delphi method, forecast, investment, port sector, Tangier-Med Special Agency (TMSA).

Introduction

In the port sector, infrastructure development and the acquisition of handling equipment are justified mainly by the potential traffic. Meeting this demand is the purpose of any investment in a commercial port. Thus, we can't easily expect the development of any port without first proving a minimum of traffic to be handled. Thus, the quantification of potential traffic is the first step to build a rational process of decision making. Indeed, a good investment policy leads to a best management of future demand. On the contrary, ineffective forecasting of traffic will lead to errors in project design.

The quantification of the forecasted traffic is also used to manage the operational aspects of the stevedoring and port handling (allocation of berths, handling equipment, preparation of conditions in terms of towing and steering teams, etc.).

The forecast can be made in two ways: by using standard techniques found in demand forecasting in general or by using specific models developed by (or for) each country. The traffic forecast can also be done by a specialized body as is the case in Tunisia, where the OMMP (Tunisian port authority) appointed in 1995 a consulting firm that specialized in establishing the master plan of Tunisian commercial ports with the aim of modernizing them in 2000, 2010, and 2020 (Ouardani, 2003), or a state body or authority as is the case of Portugal, where the forecasts are done by IMP (Instituto Marítimo-Portuario) (Martins & Cruz, 2003). Forecasts can also be made from time to time in connection with studies conducted by government departments or port authorities.

In all cases, the forecasting depends (or should depend) on the port mode of governance in force in a country. Indeed, the governance mode defines the roles and scope



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of the missions of each participant. It also provides the operating process (relations between authority and operators, operating regulations, government role, etc.). For the service port, for example, where the port authority is responsible for regulating and operating as a commercial entity, forecasting accurate traffic will be possible because the authority has enough information about the chain of transit and can forecast without difficulty. For the landlord port, which means that the port authority controls only administrative activities because the commercial activities are ensured by other private or public operators, the multiplicity of stakeholders makes the task of forecasting more difficult.

Since 2006 Moroccan ports have moved from the service port mode to the landlord port mode. However, the forecasting procedure has remained the same. Within this research, we will try to study the impact of this change on the forecasting process of traffic. For this purpose, we will focus on two concepts: the forecasting of port traffic and the port mode of governance.

This article is organized in three sections. The first is devoted to a review of the literature on port traffic forecasts and their relation to the governance mode. The second is reserved for the presentation of the context of our case study of Moroccan ports. We will study a good estimator of container traffic. In the last section we will analyze the new mode of governance in Moroccan ports by offering a new approach to forecasting.

Ports Governance and Forecasting Processes

The analysis of time series can be used in the port sector to explain the future traffic based on some factors and standpoints (economic, social, demographic, business, etc.). Many models are based on macroeconomic data applied to forecast traffic (Mignerey, 2003). Using gross domestic product (GDP) as a standard measure was too preferred by many models (Dagenais & Martin, 1985 ; Medda &

Carbonaro, 2007 ; Legault, 2001). But for other authors, GDP cannot explain, in and of itself, the behavior of port traffic (Cox, 2010). Some models have tried to link the port traffic to demography (e.g., race, gender, age, and income).

We should therefore distinguish between forecasting techniques (quantitative, qualitative, etc.) and the forecasting process (ad hoc or routine, performed by the state, by an independent body, by the operators, by the regulators, etc.). We will focus in this research on the governance of the forecasting process. But before, we will try to answer two questions: why and how do we forecast port traffic?

What is the relationship between the governance and the port traffic forecasting process?

Why should we forecast port traffic?

We distinguish among three main types of port traffic: the bulk, the unitized, and the conventional traffic. The bulk consists of liquid bulk (oil, chemicals, etc.) and bulk solids (minerals, grains, etc.). Unitized traffic is largely dominated by container traffic, TIR trucks and trailers, and also the traffic of passengers who prefer to travel by sea for reasons of cost or as a tourism preference. In Morocco, passenger traffic is a little more than 4 million people per year. In fact, Moroccan workers in Europe prefer to use the ferries to travel in their holidays. Conventional traffic corresponds to forms of packaging that are neither bulk nor unitized.

Traffic forecasts are used as a basis for investment planning and design of port projects (ports, docks,

shore protection, deep pools). The size and the quality of these investments depend on the handled traffic. They are also used for the day-by-day management (plan loading and unloading, equipment to be assigned, HR, etc.).

Estimates of traffic can be carried out by taking into account several factors. Economic data are often used to explain the trend of port traffic. Indeed, the relationship between port activities and the general economy is shifted along a reaction time variable between economic developments and their effect on inflows and outflows of goods through the ports (Legault, 2001). Most of the ports (or countries) have developed their own models of forecasting traffic.

Port traffic forecasting techniques

There are two traditional methods used to forecast port traffic volumes: the first is based on GDP and the second on field research (Cox, 2010) using either the forecasting methods described previously or performed by international bodies. Some methods are developed for specific aims (e.g., radial models).

Simple regression models

Simple regression models are based on the assumption of linear (or quasi-linear) evolution over time of the tonnage handled by traffic type or form of packaging. We then try to draw a regression line that will estimate the traffic handled per year (or quarter, semester, etc.). We note $y = a.x + b$ where:

y = expected amount or tonnage
 x = year, semester, quarter, month, etc.

a and b = the parameters of the regression line.

This model has the advantage and the disadvantage of being simple and relying on a single explanatory variable: time. However, the trend of port traffic cannot be explained only by time because it depends on several factors.

Multiple regression models

Multiple regression models consider multiple variables of port

traffic and try to make a relationship between changes in the handled tonnage and a set of significant parameters. It is necessary to have data of the previous twenty years or quarterly data for the previous seven years to confirm a meaningful relationship with the tonnage handled, the GDP of countries of origin or destination, spending or consumption, investment, income per capita, development of economic activities, and so on (De Matons, 1999).

In-depth studies could be used to measure the sensitivity of port traffic to the changing economic environment (Dagenais & Martin, 1985). These studies aim to identify the sources of growth in port traffic. Specifically, this involves measuring the sensitivity of the ports to the economic trend based on key national economic indicators (GDP, foreign trade, etc.).

Initially, short-term forecasts can be established for all traffic. These are specified by a division of traffic into three categories, the usual liquid bulk, dry bulk, and general cargo, and then supported by an analysis showing the degree of dependence between the port traffic and the economy. The interest of this study is mainly to anticipate the volume of port traffic and the market responses to a growth rate.

Linear programming

Linear programming is a complex model that uses linear equations with multiple variables and several constraints. These constraints can be the height of stockpiles, linear platform available, the draft, the access channel, the economic hinterland of the ports, and so on. The objectives of such models are various: minimizing the transportation cost, maximizing traffic handling, increasing the port capacity, and so on.

Radial models

Radial models are used by geographers (location theory). They focus on economic activities of a port or of a port area. This type

of model is mostly used in the formalization of port traffic forecast (and is the model used by the port of Rotterdam, Nigeria, and other locations).

Role of state in forecasting port traffic

Before discussing the state's role in forecasting port traffic, it is necessary to explain the basics of the likely modes of port governance. Indeed, the governance determines the fields of action of each stakeholder.

There are two broad classifications of governance modes, depending on the degree of autonomy from the state (Debre-Lavaud & Letilleul, 2010 ; De Matons, 1969) and classification according to the degree of privatization of port activities (World Bank, 2001).

Depending on the degree of autonomy, two major forms of port management are in place: the autonomous ports and the non-autonomous ports. The former can be managed by public or private entities and are independent from the state departments and ministries. The latter is directly managed by the state. Moroccan ports have moved from non-autonomous ports in 1963 to the creation of the board stevedoring at the port of Casablanca (Bouchartat and al., 2011).

As classified by the World Bank, there are four levels of governance modes:

Public service port: The port is oriented towards the protection of public interests. The port authority is under the control of the department of transportation and regulates the administrative and commercial aspects of the port.

Tool port: The port authority develops the infrastructure and superstructure (including handling equipment) and makes them available to private companies. Some services, particularly cargo handling, are ensured by the private sector. Some American and British ports are managed in this way.

Landlord port: This mode of management reconciles between the interests of the public and the

private sector. The port authority plays the role of a regulator and a provider of infrastructure for private companies. At least 88 of the 100 largest container terminals in the world are managed according to this model. Concessionaires are required to develop and maintain the infrastructure and provide the superstructure and equipment required for port operations.

Fully privatized port: This is a business model oriented only towards protecting the interests of private enterprises. It implies a transfer of ownership of a public port to the private sector and therefore a total withdrawal of state control and planning.

The two parameters (autonomy and privatization) determine the degree of state intervention in the port sector (Adolf & Pallis, 2007). If the ports are managed by a single entity, in principle the traffic forecasts should be made by that entity. If the governance enables the sharing of management and port operations with private entities, the task of forecasting becomes more difficult. Although the port authority controls the flows of entry and exit of vessels through the harbor, commercial efforts and strategies of handling operators may be out of its control.

Traffic in Moroccan Ports

The Moroccan port traffic is characterized by

- A predominance of imports, which determines the structure of Moroccan foreign trade
- A predominance of dry bulk because the Moroccan exports focus traditionally on the external market (minerals, phosphates, etc.)
- Sustained development of bulk liquids reflecting political and economic decisions, including liberalization of the energy sector and the development of activities related to phosphates and derivatives
- Confirmation of unitized traffic development, including containers, whose main causes are the movements to liberalize a number of economic sectors and also the transformation of some traffic to become conventionally unitized

Port traffic is subject to several factors, in particular, domestic conditions and sensitivity to the trend of foreign demand (Elfilali, 2003). The most important factors are as follows:

- Climatic conditions: a year of bad climate, drought, or with crop failures leads to massive imports
- Level of stocks of strategic goods (storage policy)
- Trends of prices
- Competitiveness of Moroccan exports, particularly minerals and agricultural products

Ports traffic evolution

The evolution of the main components of Moroccan port traffic from 2000 to 2010 is illustrated in Figures 1, 2, and 3.

Minerals (dry bulk)

Phosphate is the main mineral for export (Morocco is the first producer and the first supplier of phosphates in the world). Exports showed a real decline in 2008 and 2009 due to the combined effect of

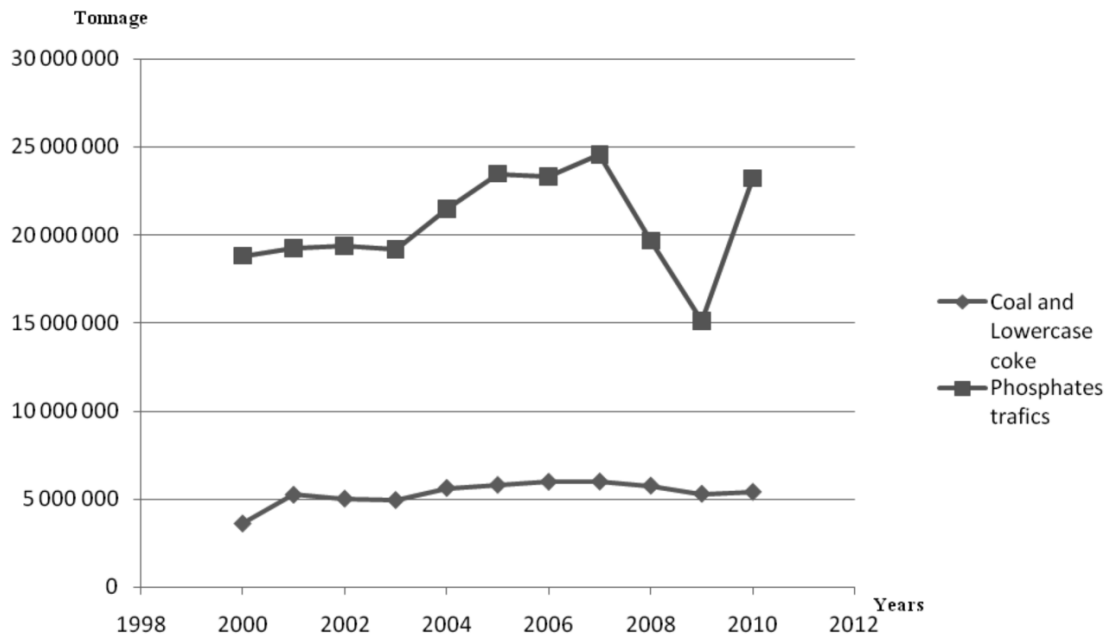
higher prices and the economic crisis.

For imports, coal (and Lowercase coke) occupy the first place and have increased substantially in traffic since the closure of the mine in Jerada. Coal is intended mainly for power stations and use in the cement industry. Coal imports were not affected by the economic crisis.

Main unitized traffic

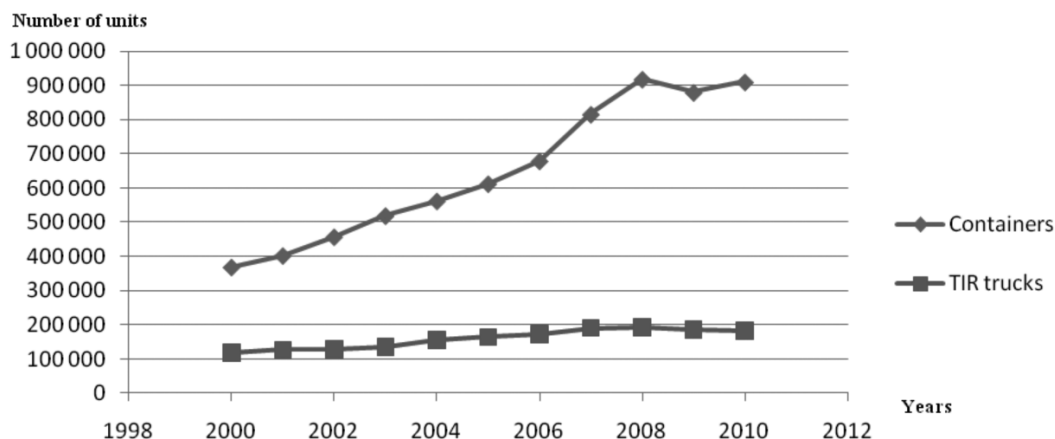
Unitized traffic (containers and TIR - Transport International Routier)

Figure 1
Evolution of the main traffic related to minerals between 2000 and 2010 (in tons)



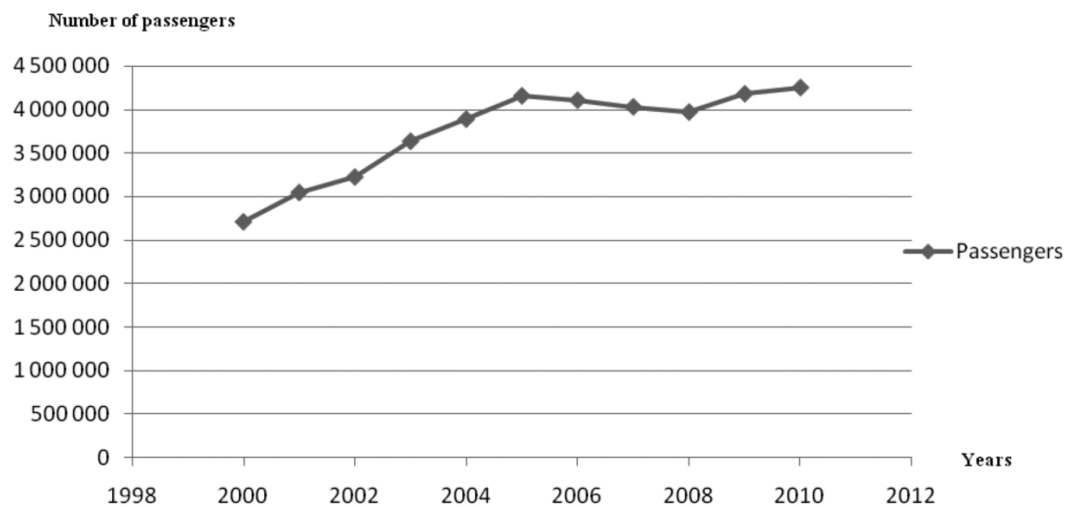
Statistics of the National Ports Agency (ANP) and the Office of Port Exploitation (ODEP)

Figure 2
Evolution of the main unitized traffic between 2000 and 2010 (in units)



Statistics of the National Ports Agency (ANP) and the Office of Ports Exploitation (ODEP)

Figure 3
Evolution of passenger traffic from 2000 to 2010



Statistics of the National Ports Agency (ANP) and the Office of Port Exploitation (ODEP)

Table 1
Evolution of tonnage of containers handled in Moroccan ports 2000-2009

Year	2 000	2 001	2 002	2 003	2 004	2 005	2 006	2 007	2 008	2 009
Import	2,177,768	2,442,163	2,816,039	3,159,170	3,410,570	3,743,256	3,790,652	4,256,092	4,457,531	4,506,850
Export	1,116,728	1,185,848	1,362,026	1,476,047	1,658,950	1,778,604	1,913,336	2,142,215	2,493,276	2,689,623
Total traffic	3,294,496	3,628,011	4,178,065	4,635,217	5,069,520	5,521,860	5,703,988	6,398,307	6,950,807	7,196,473

Statistics of the National Ports Agency (ANP) and the Office of Port Exploitation (ODEP)

Table 2
Evolution of Moroccan GDP 2000-2009 (in millions of USD)

Year	2 000	2 001	2 002	2 003	2 004	2 005	2 006	2 007	2 008	2 009
GDP (MUSD)	37,021	37,725	40,416	49,823	56,948	59,524	65,637	75,226	88,883	91,375

(Source : World Bank Web Site)

shows an average annual increase of 9.5% for containers and 4.4% for TIR trucks. The decrease in 2009 was due to the effect of the economic crisis on some activities related to import/export.

Passenger traffic

Passenger traffic is strongly linked to the increasing number of Moroccans living abroad in addition to cruise traffic in the ports of Casablanca, Tangier, and Agadir. Statistics from 2008, 2009, and 2010 show that traffic has reached its maximum (about 4 million per year). The evolution of passenger traffic is illustrated by Figure 3.

Illustration of a good estimator of port traffic in Morocco

In this section we use a simple regression in order to forecast the traffic of containers handled in Moroccan ports. The aim is to check the assumption of correlation between this traffic and the Moroccan GDP. Table 1 provides statistics (in tonnage) of traffic of containers handled in Moroccan ports from 2000 to 2009 (excluding the effect of Tanger-Med - non transshipment tonnage handled in this port). We try to use a simple linear regression model to forecast the future traffic.

We will then study the link between traffic during the same period with the GDP (see Table 2).

Figure 4 reveals the trend of relationship between traffic volumes (import, export, and total traffic) and Moroccan GDP.

The analysis of these data confirms that GDP is a good estimator of container traffic by the method of least squares. This conclusion is confirmed by the calculation of the index of Bravais-Pearson (r_p) and by the formulation of estimation equation ($Y = a.X+b$):

$$r_p = \frac{\sum_{i=1}^N (x_i - \bar{x}) \cdot (y_i - \bar{y})}{\sqrt{\sum_{i=1}^N (x_i - \bar{x})^2} \cdot \sqrt{\sum_{i=1}^N (y_i - \bar{y})^2}}$$

Figure 4
Correlation between containers traffic tonnage and GDP (2000-2009)

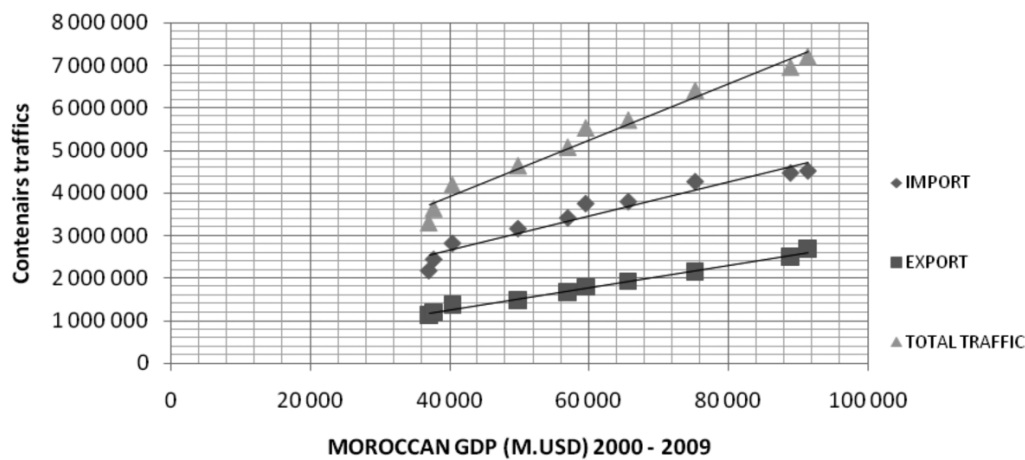


Table 3
Correlation coefficient and estimation parameters

Traffic	The correlation coefficient	Parameter a	Parameter b	Equation of traffic estimation
Import	0.97	35.83	1,316,829.51	$Y = 35.83X + 1,316,829.51$
Export	0.99	23.87	343,553.98	$Y = 23.87X + 343,553.98$
Total traffic	0.99	59.70	1,660,383.49	$Y = 59.70X + 1,660,383.49$

Table 4
Student test parameters

Traffic	r	t	t(8) [*]	Error	Conclusion
Import	0.97	10.84	7.120	<0.001	r is significant
Export	0.99	27.60	7.120	<0.001	r is significant
Total traffic	0.99	16.91	7.120	<0.001	r is significant

*According to the student table; line 8 (number of observations: 2).

$$a = \frac{S_{XY}}{S_X^2} \quad \text{and}$$

$$b = \bar{y} - \frac{\bar{x} \cdot S_{XY}}{S_X^2} = \bar{y} - a \cdot \bar{x}$$

Then we can validate the signification of the Pearson r by the student test with following hypotheses:

H0: there is no linear correlation between GDP and traffic of containers ($H_0 = \{r = 0\}$).

H1: there is a linear correlation between GDP and traffic of containers ($H_1 = \{r \neq 0\}$).

In order to use the student table, we calculate the t parameter for each category of traffic (import, export, and total):

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

From these figures, we can conclude that despite the limited set of observations (10), a strong mathematic linear correlation exists between the container tonnage handled in Moroccan ports (import, export, and total traffic) and the GDP. Therefore, GDP could

be considered as a good parameter for the estimation of containers traffic for Moroccan ports.

Traffic Forecasting Approach Given the New Governance Model in Moroccan Ports

The port planning system in Moroccan ports includes two main components:

- The national port master plan (PDPN), which aims to offer an action plan and the investment needed to meet the needs of port traffic and thus determines the main lines of ports development

- The investment program (Capital Expenditures - capex) of the National Ports Agency (ANP), which is based on general guidelines and results of the PDPN and results of studies done by the agency to determine investment operations to be carried out.

In addition to these two components, each port operator sets its forecasts and draws up its own investment program (TMSA, handling, towing companies, etc.). We can therefore conclude that this kind of forecasting increases the risk of a mismatch between forecasts. Also, it produces less reliable information.

We will try to propose a new traffic forecasting process to accommodate the new responsibilities of each stakeholder.

The new governance model in Moroccan ports

Moroccan port reform initiated in 2006 was mainly motivated by the following reasons (Bouchartat et al., 2011):

- To update and upgrade the legal framework
- To clarify the roles and missions of different public and private stakeholders

- To clarify and separate the regulation and control activities from the commercial activities
- To establish a transparent regulatory framework to ensure the exercise of all port activities
- To create an attractive and encouraging environment for private investment
- To ensure the financial sustainability of the sector
- To ensure the flexibility of the state operator in order to strengthen its competitiveness

In fact, law 15-02 about ports management in Morocco substituted the old port authority ODEP by two entities: the National Ports Agency (ANP) and the Company of Port Exploitation (SODEP). The ANP, which is under the state control, has a legal presence and financial autonomy. The agency operates in all ports except Tangier-Med, which is managed by TMSA.

Consequently, the vision of a supply port has replaced the vision of a demand or need port. Actions and investments were accomplished to meet a demand or a need expressed by the hinterland of the ports. This perception change can be clearly demonstrated by the average annual amount of investment in the

sector, which has increased from one billion Dirhams to over six billion Dirhams after the reform of 2006.

The most important investments realized or planned recently are Tanger Med I & II ports, the third container terminal in the Casablanca port, the multipurpose terminal in Jorf Lasfar, a new port of Safi, the port of Nador West Med, and so on.

The port sector has been characterized by a real upheaval with the transition from one mode of port operator (Office d'Exploitation des Ports - ODEP) to the regime of a landlord port (Agence Nationale des Ports and Société d'Exploitation des Ports). This transition has reinvented the roles of each stakeholder and has established new rules of management and port authority. The objective is to improve port performance through the introduction of "free competition" raises through information about the potential traffic with the following characteristics:

- Availability
- Reliability

This reconfiguration of the port sector should be accompanied by a review of the existing methodology

Table 5
Implications of the new mode of governance on the management of Moroccan commercial ports

	Before reform	After reform
Governance mode	Operator port	Landlord port
Management	Transportation and Equipment Ministry	Transportation and Equipment Ministry
Regulation	Transportation and Equipement Ministry	ANP
Authority	ODEP	ANP TMSA
Exploitation	ODEP	SODEP SOMAPORT MAERSK etc.
Forecasting of traffic	- PDPN - ODEP capex	PDPN Regulation authority capex Stevedores capex Other operators' capex

- for forecasting of traffic in order to
- Establish a permanent forecasting and review of the forecasts
 - Involve the skills of various stakeholders
 - Allow prioritization of interventions
 - Adapt the forecasting process to the responsibilities of each stakeholder

Table 5 presents a comparison between the mode of management of commercial ports before and after the creation of Tanger-Med and the 2006 reform.

We can conclude according to this comparison that the changes have affected all aspects of port management with the exception of the forecast and the availability of information on the potential traffic.

Our objective is to provide a prediction approach that could take into account the responsibilities of port stakeholders and considers their contribution to the estimation of traffic forecasts.

Suggestions of how to approach forecasting traffic in Moroccan ports

In order to suggest an approach to forecasting traffic in Moroccan

ports and given the new changes, we attempt to combine data and views of stakeholders and operators and to use the expertise of each one to make a forward plan for traffic port. This plan will be used to set tools and to develop strategies by each stakeholder.

Our analysis is based on the Delphi method, which has existed since 1948 (it was created by the American Rand Corporation). This institute performed research and development in the security and defense fields. The Delphi method was first used for military ends and then evolved into multiple applications for civil studies, particularly health public services and the predicted evolution of the science (Rowe, 2007).

The Delphi method is used particularly in project management and economical previsions. The main idea of the method is that the estimations of a structured group of experts are more accurate than those realized by a non structured group or by individuals.

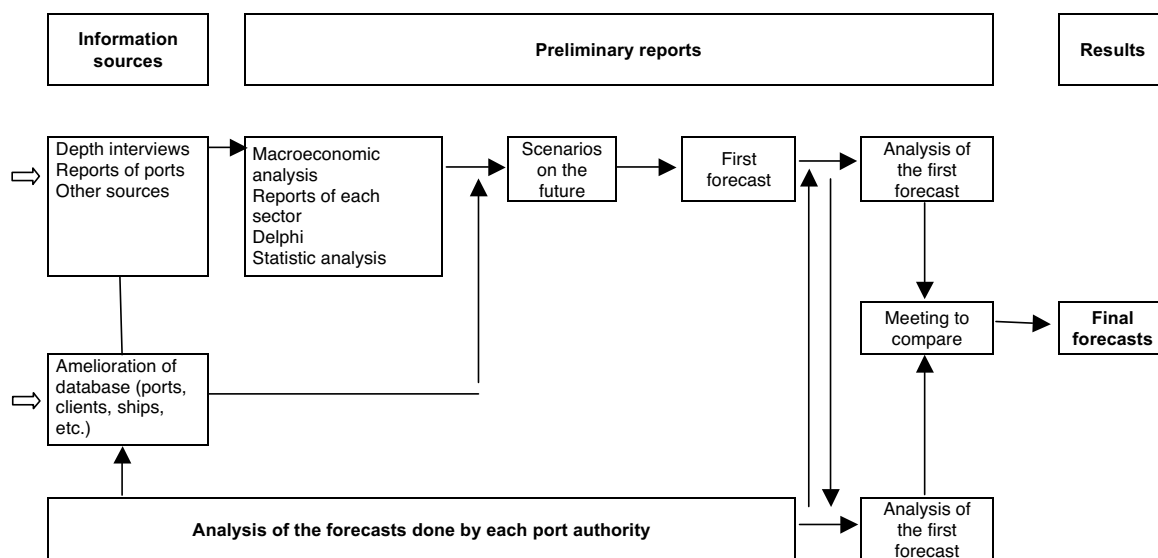
The method is applied by submitting several series of questionnaires to an expert group. After each set, an anonymous synthesis of answers with the arguments that have lead to those

answers is made and returned back to experts (Underhill, 2004). Those experts are invited to revise their responses in light of this synthesized new information. It is generally observed that following this process (which can be carried out many times), the divergences fade away and that the responses converge toward a best answer.

The Delphi survey is an iterative method for analyzing problems and consensus (Armstrong, 2006); it requires that a panel of experts is informed about the survey advancement. The method has showed its worldwide importance in resolving some questions raised by human sciences. It is a major facilitating technique that is based on the idea that group intelligence is superior to the sum of individual intelligences (Rowe & Wright, 1999).

The Delphi technique has been applied mostly to business applications (Green and al., 2007). These included forecasts for determining a power sector, identifying broadband connections, increasing dry bulk shipping, identifying leisure pursuits in Singapore, understanding rubber processing, determining oil prices, and so on.

Figure 5
The process of forecasting traffic in Spanish ports



Source: Poncela (2003)

The Delphi approach was used to forecast the traffic handled by Moroccan ports. It was also used to forecast traffic in Spanish ports (Poncela, 2003) and was employed in several stages:

- Interviews and exploitation
- Macro-economic analysis
- Reports by sector
- Use of Delphi surveys
- Trend analysis
- Development of the final forecast

Schematically, the forecasting process is presented in Figure 5.

The proposed process to use in defining traffic forecasts in Moroccan ports is iterative and hierarchical. The following hierarchy is recommended:

- Operational level: The forecast is done by the port operators who handle the stevedoring and port operations in general. This helps produce information that is more real and reliable. Therefore, it is interesting to limit the scope of this forecast to five years. In fact most of the ports operators prepare their capex in this time horizon.

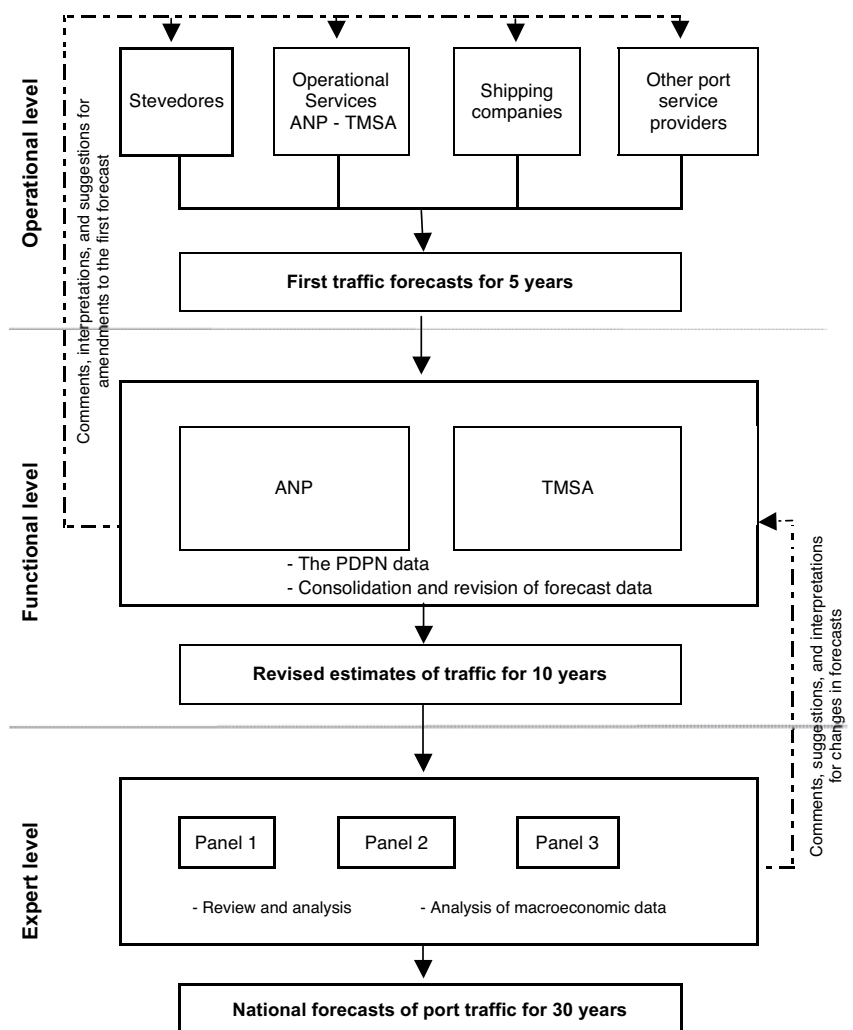
- Functional level or control level: The analysis encompasses consolidation, interpretation, and correction of data received from operations and use of data compiled by the port authorities (ANP and TMSA).

Those regulation operators frequently use port statistics, including the billing of concession fees. Their support is essential to produce accurate traffic forecasts. They use the data provided by the operational level to produce forecasts on a time horizon of ten years.

- Level of experts: The data generated at the functional level are then interpreted and analyzed by a panel of experts engaged by the ports management (the Ministry of Infrastructure and Transport).

At this stage, it would be interesting to use the services of experts in maritime and port traffic. They could then use the data produced by the regulators and make forecasts over a thirty-year period. They would consider micro data, macro economics, and social, political, and commercial factors.

Figure 6
Proposal of traffic forecasting process in Moroccan ports



This way of ensuring forecasts promotes the exchange of data and the capitalization of experiences by all actors in the chain of port traffic and clarifies levels of responsibility.

Figure 6 illustrates the recommended implementation for this approach.

Conclusion

The strategic importance of the port sector has motivated the Moroccan government to make several regulatory reforms. These reforms should be completed by measures to increase the operational efficiency of all actors. A study to determine the measurement of future traffic can

be considered to accomplish this end.

As its main objective, the new mode of governance in Moroccan ports aims to improve the effectiveness and efficiency of the maritime supply chain. However, this improvement cannot be made without a clear vision of the future demand (traffic forecast). By a comparing the modes of governance in Moroccan ports before and after 2006, we conclude that the change in governance mode (from the service port mode to the landlord mode) has affected all aspects of management and administration except the traffic forecasting process. We have studies this problem to propose a

new approach to traffic forecasting to fit with the new governance mode of a landlord port.

The operational aspects of this strategic approach to traffic forecasting were developed as part of our article and will lead to a global vision of the future demand of port traffic. In addition, we tested if the simple linear regression model can be used to define a good estimator of container traffic.

The approach proposed in the context of our article is based on the Delphi method, which helped to improve the forecasting mechanism by making it more clear and methodical. However, this is a milestone in a continuing process of improvement of the operational aspects of port management in Morocco.

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