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MODELING A PLAN FOR SEAPORT INVESTMENTS THROUGH A SYSTEM DYNAMICS APPROACH

The smashing growth of the containers' traffic within the Mediterranean seaports has forced most of the local governments to rethink the development policies of infrastructures, so to better match the new market requests. The idea that the efficiency of seaports may also lead to an economical development of the involved area, with beneficial social effects, like a growing number of employment opportunities, as both a direct and a side effect, is amongst the main reasons. Nevertheless, the economical impact, in terms of cost, for such developments, can't be easily estimated, because it involves a huge number of different subjects and economical effects spread amongst the system.

This paper is focusing on a dynamical approach for analyzing a small sized seaport. Its main advantage is the ability to linearly depict the several relationships occurring amongst the different subjects involved, with increased advantages as opposite to more traditional approaches, like the "Costs-Benefits" model, or the "Multi-criteria" techniques. Herein, we don't limit our approach to simply show how to apply the "System Dynamics" to a seaport, but we also show its application for the analysis which can be conducted to policy the supporting activities of maritime transportation.

Key words: *Seaport Investments, System Dynamics, Public Goods Evaluation*

1. INTRODUCTION

Until the first half of the nineties, in scientific literature not many depths can be found about the aspects involved in the efficiency of the shipping terminals infrastructure [Tongzon J. L., 1995]. Actually, few surveys consider covering separately the production role, in order to isolate and quantify the contribution of each element to the overall efficiency of the activities developed within the seaports.

Still many delays have characterized the development of a detailed analysis in this way and, until the early nineties; the reasons can be ascribed to the prevalence of the geographical factor over the other elements from which it can be considered why the choice of a seaport depends on the users (e.g. shippers, forwarders and ship-owners). The improved accessibility achieved by most of the shipping terminals, itself increasing the potential gravitational area of the individual seaports, has reduced the importance of the location factor in respect of other characteristics that, in some circumstances, may be critical when going to be selected among the available alternatives.

Furthermore, it should be underlined that any change occurring in the transport sector has revolutionized the functional and organizational structure of the major seaports' terminals, now turning into real hubs belonging to the logistic chain. Of course, these issues affect the analysis of efficiency and productivity when the question is to evaluate dynamic and complex entities [Bichou K., R. Gray, 2005], in which several kind of actors work, and where they are engaged in many different economic activities. The today's reality is made up of a terminal casuistry that the physical, organizational, institutional and management characteristics can significantly differ.

Think about the roles carried out in large-scale seaports, ranging from the trade in direction of the industry to financial activities, with major economic, environmental and external social impacts.

This aspect of seaports makes it difficult to individually compare the terminals, because each of them is characterized by specific production roles, whose returns may depend by the production scale unit (say "economies of scale") or by the activities' diversification (say "scope economies")[1].

Moreover, it should not be forgotten that running a seaport infrastructure involves the interaction of a large number of variables and actors, both public and private, and which operate at local, national and international levels. To improve the assessment quality, it would be appropriate to use some conceptual systemic models for better understanding the long term effects. This complexity means that it is critical to understand the dynamics which come out from an articulated decision system.

This paper aims at illustrating the execution of the System Dynamics technique in its "systemic" version, with reference to a simulation in a regional seaport perspective, identifying both the implications in terms of decision making and economic impact, and the information system proposed by the model.

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[1] The development of the maritime sector, and the consequences generated in terms of complexity of the carried out activities within terminals, have raised questions about the validity of the traditional terminology adopted in this sector [Bichou K., R. Gray, 2005].

2. HOW TO ANALYZE THE IMPACT OF A SEAPORT OVER THE LOCAL SOCIO-ECONOMICAL ENVIRONMENT

Assessing the economic impact of the seaports infrastructures is a complex and controversial topic, both for the seaports' hybrid placement between the public service and the private business activities, and for the complexity to identify the spatial reference system, since seaport's benefits tend to be distributed in a wider geographic context, and in comparison with costs spatially concentrated in the seaport regions.

The studies carried out so far are mainly based on the relationship between the seaport activities and the socio-economic environment in which they develop.

The term "economic impact" includes all the changes as regards employment, the demand for goods and services, and the contribution to tax revenues that can be attributed directly or indirectly to the transport infrastructure's presence.

Port activities add strategic importance to the planning of the area surrounding the seaport, and also affect the economy in other ways.

The first one, typical of any infrastructure, derives from the ability to generate an amount of external economies that will benefit all people and firms in the seaport area; indeed, the infrastructure's operation ensures the availability of a wide range of goods and services brought to the whole surrounding system, raising its competitiveness. Besides, the demand for goods and services, required for running the infrastructure, produces a positive repercussion on the whole production system. Any seaport activity involves a firm system much larger than the traditional induced concept which generally deals with those production process phases that, for various reasons, are decentralized outside the unity production. Each new pulse production is spread over the whole system, involving other sectors and other areas; to such indirect effects we can also add the ones deriving from the process incomes which will be partly used for consumption, putting into action an additional demand for goods and services.

The activities of a seaport infrastructure generate an economic impact at macro level, a positive fallout for the territory, caused by the seaport activity, and which can be identified through the economic variables that contribute to the production of incomes, employment and value added services. Furthermore, the seaport activities also rise a net economic impact, defined as the balance achieved between the economic benefits and the costs of the seaport activity on the territory, and a financial impact, which comes from the profitability of the seaport investments, draw up as an income flow generated for the investor subject, per monetary unit invested in the seaport infrastructure and in the seaport services.

3. DYNAMIC MODELS FOR THE ASSESSMENT OF PUBLIC INVESTMENTS IN INFRASTRUCTURES

The application of the System Dynamics has a long and rich history of experiences exploring their possible applications in the project management arena, as recently Lyneis and Ford have summarized (2007). Since the Roberts' fundamental work (1974), the analysis of System Dynamics models has undergone numerous insights on feedback processes, as resulting from "Canonical" interactions (Cooper, 1980) among the actors of a system.

System Dynamics models are adapted to analyze a large number of economic processes and industries. These models are currently widely used in the management of enterprises, so target applications have a corporate character. Recently, however, this technique is also spreading in the economic analysis field related to investments in transport infrastructures (Ford et al., 2004; Kim Hin et al 2008).

System Dynamics is a technique oriented to complex systems analysis or, namely, systems characterized by dynamic interaction between many elements, whose configuration doesn't appear much foreseeable in the course of time. The main peculiarity of the complex systems is that the cause-effect relationship is not linear, but shows feedback typical mechanisms (Forrester 1969).

System Dynamics analysis has, as its primary aim, the design of scenarios, which are meant as a tool to support learning, and the effective formulation of decisions, especially when operating in hasty changing conditions, in which the environmental discontinuities are useless or illusive estimates just based on the extrapolation of historical data. It is the ideal tool to support decision making processes in a programming and planning activity, because:

- the variable "time" is intrinsic into the system, rather than having to reason about time intervals;
- it can deal with all the relevant qualitative variables involved into the decision-making success, as well as the quantitative ones;
- it offers high flexibility, at detail level in the model to be examined.

It is important to have predefined the level of the detail analysis that you want to obtain, to the better understanding of both the real issues and the context.

The advantage of the system dynamics model is that it represents a "gentle" laboratory in which performing experiments to better understand the system's behaviour. These experiments are crucial for anticipating the possible system responses and to develop new interventions to best governing the use of complex realities. Such simulation allows operating in a protected environment, reducing both times and costs of intervention.

In quantitative models, differently from qualitative models, the limited number of variables improves their weight; whilst advantages of these models are associated with the rigor and objectivity of the data used in processing. Drawbacks of this approach are its rigidity and, consequently, its limited validity in the event of any change within the context, because they would require the introduction of new variables and the whole model recalibration.

System Dynamics also differs from traditional quantitative-mathematical methods because, as being first of all knowledge-oriented, it allows to make, with relative ease, changes to the representative models of the investigated systems.

These changes are indeed functional to the use of the methodology in question, because it implies that the control strategy is achieved through a continuous review of the "pro-tempore" hypotheses, taken by the dynamics of the system, and by virtue of the comparison carried out between the model and the actually observed real world.

Models adopted by system dynamics are descriptive models. They, while not giving rise to the identification of "excellent" solutions, in absolute sense, are rather aimed to highlight the key variables trend in function of the adopted policies. So, they allow the decision maker to seize the essence, namely the structure, of the problems being investigated. By adopting this "qualitative-quantitative" analysis, the decision maker may face the reality of an organization levering on the root causes that determine the symptoms of a dysfunction or of a latent crisis, rather than directly on the variables, which constitute instead effects or, indeed, only apparent dysfunctions.

4. A DESCRIPTION OF THE MODEL

As early mentioned, a model simulation structure starts with representing a system's causal diagram, continues with devising a flow chart and then moves to the shaping of an equations model. That model will subsequently be used to implement the informatics system for simulations.

At the present, some special software has specifically been designed for the simulation of dynamic systems. Using such software allows the consumer to describe the system in a simpler way, and it also greatly reduces the amount of time and the number of stages for the construction of equations model. In this paper we are going to use a software package called POWERSIM which, compared to others, is much easier to use, and requires no special skills or mathematical abilities for issuing the proper description of a model.

Powersim, like all other existing softwares for dynamic simulation, makes use of those equations which are coming from the concepts that are central to the systems structure we are now going to examine. These equations can be level equations, flow equations or auxiliary equations. The different kind of equations correspond to the different kind of variables used in the model, while taking the same name.

The equations used to describe a system usually do not remain unchanged over the time, but they often change, or are further added, as needed. At this point, the software allows the calculation of ~~the~~ results from a system dynamic behaviour over different periods of time. This occurs because this software has a standardized algorithm which uses the data input provided through the operator in agreement with a suitable terminology to define the calculation procedure. In addition, each data input (or variable) must point out the given moment to which it relates.

There are typically three time periods considered (scheme 1): **K**, when the calculations is being performed, **J**, is preceding the done calculation, and **L**, following the execution of the calculation. Furthermore, we indicate with DT the length of time between two consecutive computations. All calculations are therefore limited to the time J, to the range JK between J and K, to the time K and to the range KL between K and L.

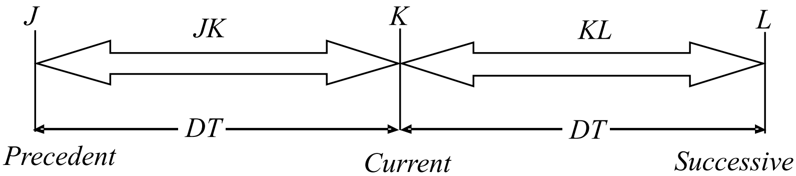

Figure 1.

4.1. Level equations

Level equations represent the accumulation of net differences between increasing flows and decreasing flows on DT lapse of time. *Level equations* will take the following functional form:

$$\mathrm{Liv}_{\mathrm{K}} = \mathrm{Liv}_{\mathrm{J}} + (\mathrm{DT}) \cdot (\mathrm{Fin}_{\mathrm{JK}} - \mathrm{Fout}_{\mathrm{JK}})$$

This functional form indicates that a given variable value at time (K) is equal to its value calculated in the previous time (J) plus the net difference of the flows recorded in (JK). This flow net difference must be multiplied by the length of time between J and K (DT).

In the previous equation it can be noted that the level of the variables is independent from each other. Moreover, to a level equation an indefinite number of flow variables can be added or subtracted.

In brief, according to what we just have said, a *level variable* is only the accumulation of net differences between flow variables in entry and rates in exit. So, it is possible to rewrite the equation under the form of a differential equation of the first degree:

$$Liv(t) = Liv(0) + \int_0^t (Fin - Fout)dt$$

4.2. Flow equations

Flow equations show how the flows change within a system. The *flow equations* input are "the levels, the constants and the auxiliary variables of the system", while the outputs are "the variations between and among the levels of a flow". *Flow equations* are based on the constant and the information values which come from the levels and from the auxiliary variables at the time K, and give the flows value for the next time interval KL. We can symbolize a flow function as the following:

$$F_{KL} = f(Liv_K, Cost, Aus_K)$$

The simplest *flow equation* consists of the constant flow rate, for example: FKL= 30. A second possibility is represented by an equation that shows a flow as a function of the product of a level and of a constant representing a growth factor Δ, for example: FKL=LivK*Δ. A third flow functional form could be that of a level variable divided by the average life time **ν**, namely: FKL=LivK/ν.

Clearly, the complexity of flow equations depends on the phenomenon that will be represented, for that reason it is impossible to make an exhaustive list of such functional forms.

4.3. Auxiliary equations

By constructing model equations it is often possible to increase their clarity and decompose them in other equations. Even in the case of flow equations, it is possible to follow the same approach. In the case of sub-equations, where the result comes from the main equation decomposition, we call them auxiliary equations. Likewise, differently than in levels, auxiliary variables can receive information from other auxiliary variables as well as levels and constant.

4.4. Positive and negative feedback circuits

Feedback circuits are feedback systems that influence circuit variables on a past behaviour basis. They have a closed circuit structure that recovers past actions results and uses them to guide future actions. Feedback circuits can be positive or negative. They are negative when a given variable affects negatively the variables to which it is connected. Counter wisely, a feedback loop is positive when the positive feedback generates growth processes, where the action produces a result that leads, in turn, an action even greater. Indeed, the integration process above described by positive and negative feedback loops generates a huge growth in the first grade loops (with one variable level).

The following equation describes a positive feedback loop:

$$F_{JK} = \frac{Liv_K - Liv_J}{DT} \qquad\qquad Cost = \Delta$$

When considering the limit of the incremental ratio for DT (which tends to zero) we shall have:

$$F(t) = \frac{dLiv(t)}{dt}$$

And by knowing that F(t)=Cost*Liv(t), we can write:

$$Cost \cdot Liv(t) = \frac{dLiv(t)}{dt}$$

Finally, by integrating both members we obtain:

$$\frac{Liv(t)}{Liv(0)} \int \frac{dLiv(t)}{dLiv(0)} \S = \int_0^t Cost \cdot \delta \quad ,$$

where **δ** is a variable and can take the value 0 or 1. And it leads to:

$$\ln \frac{Liv(t)}{Liv(0)} = Cost \cdot t \text{ or } Liv(t) = Liv(0) \cdot e^{COST \cdot t} \qquad [1]$$

In it, *Liv(t)* is the level value at time *t* where *Liv*(0) represents the initial level value; *t* is the considered time duration and *e* is the natural logarithms base.

The equation [1] makes it possible to conclude the value of the level variable through a single computation for any considered point of time. By having an exponential movement, such equation, tells us that unitary time changes, and it will lead to more than a proportional alteration in the level variable.

A *negative feedback loop* is characterized by its behaviour toward the attainment of specific objectives. It happens that words such as homeostasis, or self regulation or self balance, involve the presence of a target, which in turn defines negative feedback systems.

Assume that negative feedback function should take the same functional form of a positive feedback under the condition that is achieved by a given objective (Ob) in K moment. At this point, we can write the negative feedback equation as:

$F_{JK} = \frac{Liv_K \cdot Liv_J}{DT}$ under a given constraint, OBK will make the flow

F(t) = Cost · (Liv-Ob(t)).

Considering once again the limit of Fjk for DT (which tends) to zero we will have

$$\frac{dLiv(t)}{dt} = Cost \cdot (OB \cdot Liv(t))$$

Integrating both members we will have:

$\int_{Liv(0)}^{Liv(t)} \frac{dLiv(\delta)}{Ob - Liv(\delta)} = \int_0^t Cost \cdot d\delta$, where δ is a variable which can embody a value of 0 or 1.

From that

$$\ln \frac{Ob - Liv(t)}{Ob - Liv(0)} = -Cost \cdot t \quad \text{or} \quad \frac{Ob - Liv(t)}{Ob - Liv(0)} = -e^{-COST \cdot t} \qquad [2]$$

Once again it is proved that a negative feedback loop of the first degree has a huge growth and its trend is to reach a lower limit, represented by the imposed constraint.

5. DESCRIBING OUR APPLICATION TO A REGIONAL SEAPORT

A model was created to understand which are the variables affecting a seaport containers handling activity and which is the economic impact for the surrounding area.

Stages, where the model construction was articulated, were as follow:

- collecting the data to build a first qualitative model (causal model), in which to start to identify the significant variables and the causal relations among them;
- collecting the data on a qualitative basis to detail all the causal links and any further model development;

- creating the graphs, where a dynamic simulation software (Powersim) can be of help, together with calibrating parameters and functions on the basis of historical data collections;

We will continue analyzing the interaction among the different variables that are subject to the model execution. They were selected on the basis of the roles that each will carry out in the development of a seaport activity.

The variables considered for a model construction are:

- the number of containers that a seaport can handle;
- the number of firms that operate near the seaport;
- the added value produced by the firms;
- the income of the residential population;
- the demand for goods and services;
- the costs of the seaport;
- the revenues of the seaport;
- the profits of the seaport.

All the above listed variables can be grouped in variables that have an impact on the macroeconomic level and variables that have a financial impact. Regarding the economic impact at the macro level, the number of seaport containers can be considered as a gauge of its level of development: its increasing growth affects the number of firms running in the territory. This is because transport costs represent a substantial share of total costs incurred by firms, which have the convenience to locate themselves in the immediate seaport The increase in the number of firms that operate near the seaport tends to rise the level of employment and, consequently, the income of the residential population increases; this as well leads to an increase in the demand of goods and services that generates a further increase in the number of firms that work within the common territory. And an increasing number of firms working in the seaport area produce a larger number of containers.

Regarding the financial impact, the increase in the containers traffic generates higher revenues, but at the same time, there is also an increase in costs; these two variables affect the level of profits achieved by the seaport. It is possible to represent the interaction between the different variables through a feedback loop which immediately gives an idea how the considered variables interact with each other and how their walking along the circuit may generate indirect effects on the self.

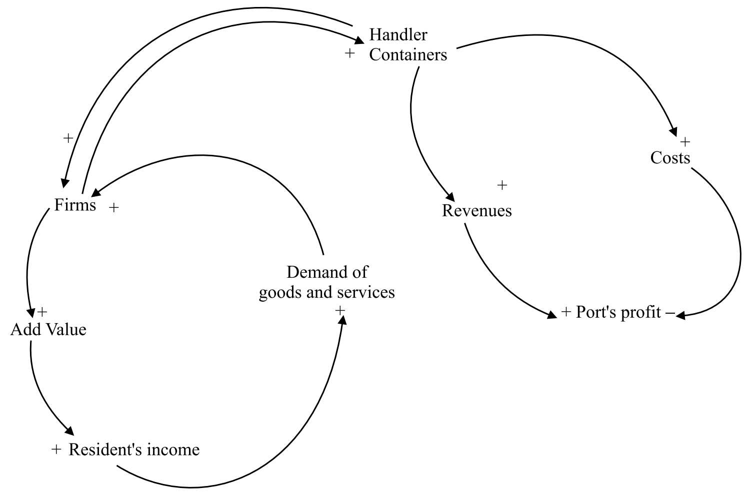

Figure 2.

The feedback loop highlights the significant impact of variables to the problem definition and the connections that exist between them, represented by arrows showing a positive or a negative sign; a positive sign in the arc that connects two variables means that there is a direct proportionality between them, a negative sign indicates that the connection is inversely proportional.

To estimate the values assigned to variables we had to split them up into sub-variables, whose interaction is represented by the following graph:

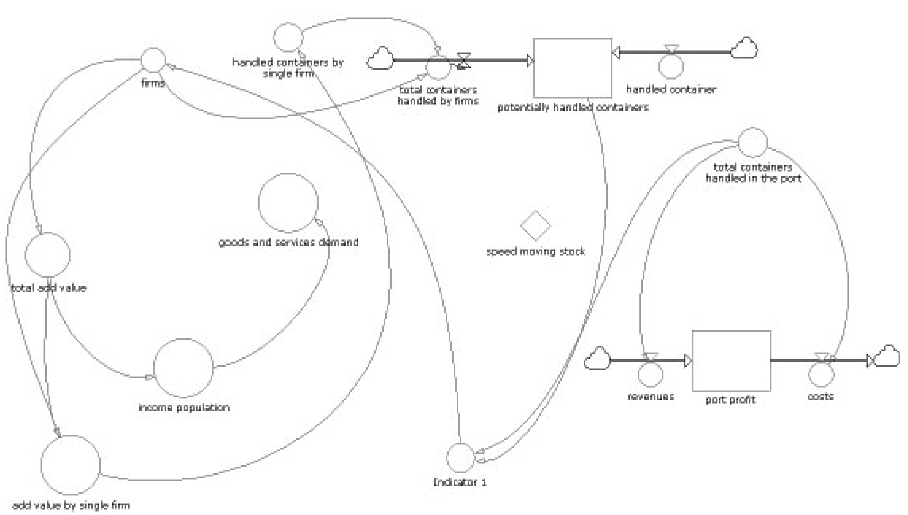

Figure 3.

Let's now proceed to analyze the efficiency of the Palermo regional seaport in Italy, in terms of economic variables and technology variables, constructing two different scenarios based on different investment policies adopted by the Port Authority: The first one represents the results achieved by the Palermo Port in handling containers in the 2008, and makes projections which consider a span of four years. The second scenario takes up the realization of investments that will enable the seaport to achieve more efficient results.

The first scenario shows the handling containers activity in the Palermo seaport that, in 2008, is measured by the level of the handled containers reaching the 31,767 units. We can also assume that the seaport uses three mooring points, each able to handle an average of 60 containers per day, so it becomes impossible to handle more than 65,700 containers per year. Furthermore, according to surveys carried out by Istat[2], and assuming that each firm may handle, on average, one container for every 10,000.00 euro of the added value produced by the seaport, it will revenues incomes for 110.00 euro and bears costs for 80.00 euro per each container, where such costs increase to 105.00 euro once exceeding the threshold of 50,000 handled units. These values are on average, calculated on the basis of different fares charged by the Port Authority, and varying from each other due to the different trade categories and to the services offered by the seaport. In this scenario, the considered variables can be represented as follow:

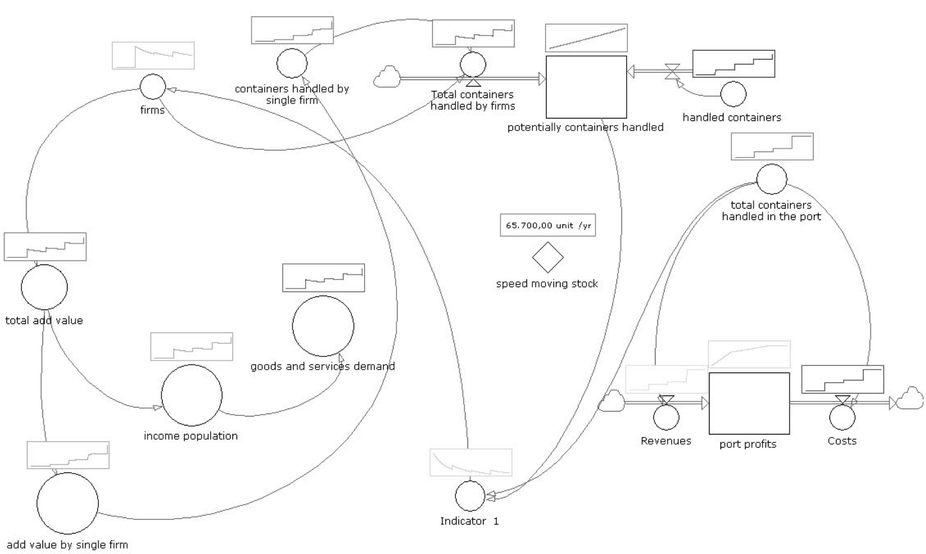

Figure 4.

[2] National Institute of Statistics.

The following record shows the general trend in the profits of the seaport.

Table 1.

Time	total containers handled in the port (unit /yr)	port profits
2008	31.767	108.400,00
2009	41.401	1.061.410,00
2010	46.324	1.268.415,00
2011	65.700	1.500.035,00
2012	65.700	1.500.035,00

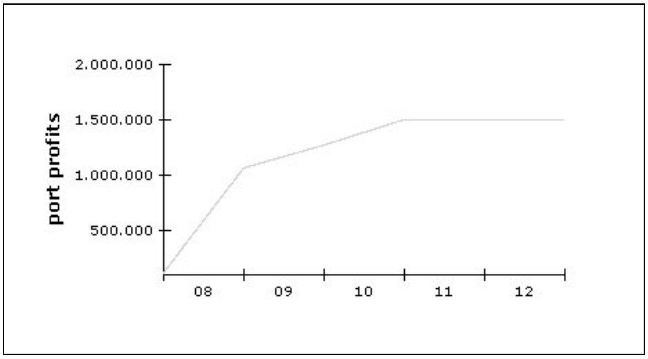

Figure 5.

In this first scenario a brake about the seaport development comes up from its structural limitation: the seaport cannot handle more than 65,700 containers per year; and not only this limits the seaport from the fully exploit of the potential offered by the territorial economic development, but it also slows down its development, because firms will be forced to route toward other transport modes, higher for sure, and thus to overall sustainable higher costs.

The following graph represents the gap between the actual number of containers handled in the seaport and the number of containers which would be handled thanks to the higher number of firms running in that area:

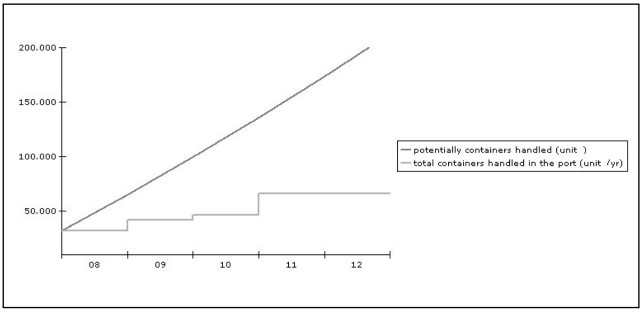

Figure 6.

The ratio of these two numbers allows us to deduce a gauge of the level of development reached by the seaport, whose evolution is shown on the graph below:

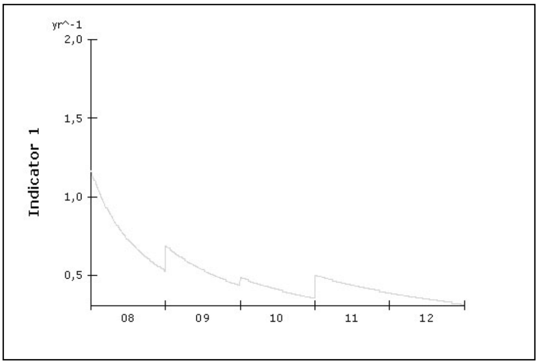

Figure 7.

In the second scenario, making projections in a period of five years, we assume that the Port Authority decides to invest annually the 20% of the revenues, in order to increase the number of handled containers within the seaport. These investments consist in increasing the mooring points from three to five and in purchasing more efficient cranes. Given these assumptions, the feedback loop that can be drawn is as follow:

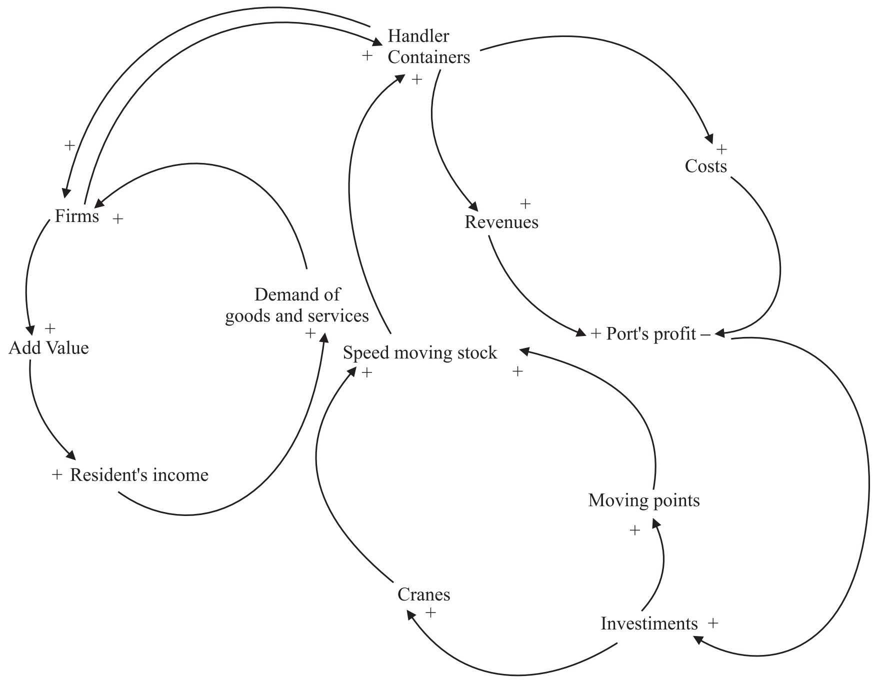

Figure 8.

Through the investments made, over 164,000 containers can be handled, thus the gap between the number of containers which can potentially be handled and the effective number of handled containers in the seaport is withdrawn. And for those years where projections are made, the seaport records an excess in the ability of handling containers.

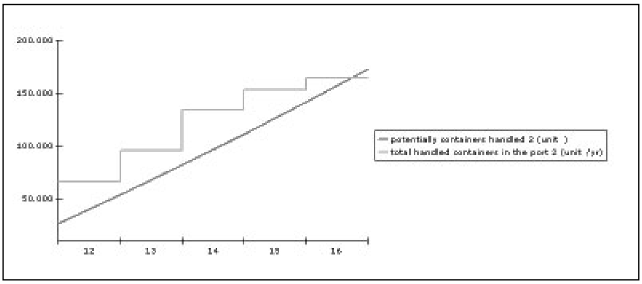

Figure 9.

In the second scenario, the development indicator shows an upward trend:

Table 2.

Time	total handled containers in the port 2 (unit /yr)	port profits 2
2012	65.700	675.860,00
2013	95.568	978.080,00
2014	133.725	1.417.692,80
2015	153.025	2.032.827,80
2016	164.250	1.206.492,80

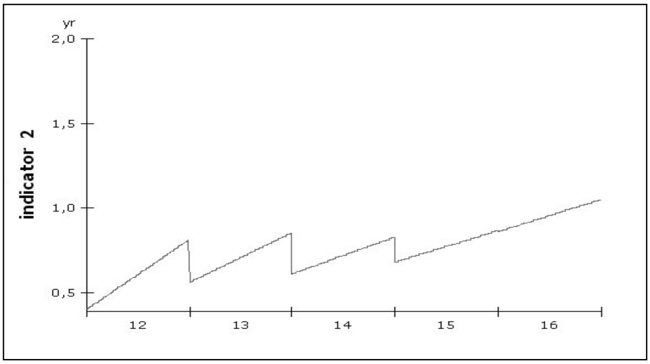

Figure 10.

And returns can be represented by the following graph:

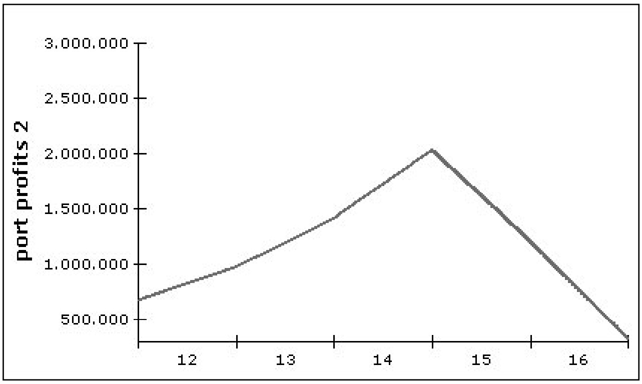

Figure 11.

It is possible to compare the profits performance, achieved from the seaport in the different considered scenarios

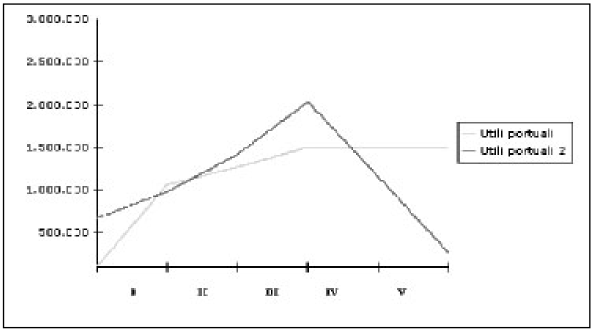

Figure 12.

As we can see in the first scenario, considering the first three years of activity, profits are slightly higher than those in the second premise, but they show a growth rate considerably higher; also because during the second year the situation changed thanks to the investments that were decided to perform in the second assumptions, and which made the seaport able to take the advantage from the scale-economies created as a result of the higher number of containers handled. However, it should be underlined that in the second scenario the number of the handled containers is much higher, and it determines a growth rate substantially higher for the entire district.

The graph clearly shows that, starting from some point, profits which characterize the second scenario will begin to fall rapidly, and they will even be lower than those ones coming from the first scenario. This is caused by the "congestion" from the high number of handled containers, and it causes a more than proportional increase in the bearing costs from the side of the seaport. If you want to avoid it, you must develop new solutions and make new types of investments to reduce costs, or at least, not to make them grow exponentially.

6. CONCLUSIONS

Maritime transport has played, and it continues to play, a key role in the global integration process of economies.

Retracing the major stages in the shipping evolution, it is easy to notice that in Europe, in the second half of 1800, steam shipping development, allowing a substantial reduction of time and hauling costs, led to a radical change in the people's habits, with clear positive effects in terms of the improved life quality. Particularly, the progress gained from the shipping industry made it possible, and economically advantageous, to start moving huge quantities of finished and semi-finished products, raw materials and agricultural products over thousands of kilometres distances (Petriccione S., F. Carlucci, 2006).

Therefore, the presence of seaport infrastructures, in addition to the effects on incomes and their distribution, generates an attractive effect on all economic activities.

Indeed, the presence of a seaport which carries out its activities efficiently is a main element in the choice of locations for establishing a firm, because it generates a quick and efficient mechanism for distributing goods and services, by reducing trade costs, opening new market opportunities and increasing the efficiency of the economic system.

Changes in the seaport organization have significant consequences in terms of space, giving importance to the strategic planning of the surrounding area of the seaport, and affecting the economy in other ways as well. The first of whose, typical for each infrastructure, depends from the ability to generate a mass-amount of external economies from which all stakeholders in the seaport area will take benefit; indeed, the running of a seaport infrastructure ensures the availability of a wide range of goods and services, which allow to raise its competitiveness to the entire system surrounding a seaport and the demand for the goods and services required for running the infrastructure positively kicks on the production system.

Each new production pulse is spread all over the system, involving other areas; and to the side effects we can also add those deriving from the partly consumptions generated from the incomes that this process raises, enabling a further demand for goods and services. Therefore, seaports can be regarded as a strategic asset for the region in which they are located.

We must also remember that the new transportation system is focused on integrated logistics, on intermodality and containerization. And the rail and road connection with the hinterlands have a chief importance. It is a strategic element that allows to extend as much as possible the seaport attractiveness even on remote areas. Delays in adjusting terrestrial infrastructures mean serious disturbances in the future.

Fundamentally, in literature, the analysis of the seaports competitiveness is based on targeting the elements affecting the process of choice by users, with a focus that such factors may differ considerably, between different geographical areas in which terminals are intended to work (G. Yeo, M. Roe, J. Dinwoodie, 2008).

Considering what was said so far, a System Dynamics approach allows us to obtain absolutely different results from what a normal Costs-Benefits analysis would provide. Indeed, the system analysis allows us to consider many of the interactions which occur between the several players involved in the seaports activity.

Additionally, the model dynamization helps to see how the interactions among the circuit develop. In other words, these models retain the special characteristics of the traditional Cost-Benefit analysis, but, at the same time, help to understand the execution model of the system, what are the interactions among the actors involved, and how they evolve over the time. Clearly, this model has limitations too: interactions between the actors must necessarily be represented by a closed circuit, so it is impossible to define in the model unidentified actions if we do not know their effects on former actors.

Finally, we believe that this model has the advantage of being relatively transparent and to make clear to the reader how to visualize the whole system and its interactions. This analysis, joint with some multicriterial analysis, could allow a future development in order to obtain more and more reliable dynamic models of seaports performances.

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Sažetak

OBLIKOVANJE PLANA ULAGANJA U MORSKE LUKE KROZ SUSTAV SISTEMSKE DINAMIKE

Veliki porast prometa kontejnerima u lukama Mediterana prisilila je većinu lokalnih vlasti da ponovo razmotre politiku razvoja infrastrukture kako bi se što bolje udovoljilo novim zahtjevima tržišta. Jedan od glavnih razloga tomu je i pomisao da učinkovitost morskih luka može dovesti i do ekonomskog razvoja onih područja koja su u to uključena, uz koristan učinak i na društvo u cjelini kao što je porast mogućnosti direktnog ili indirektnog zaposlenja. Ipak, nije lako procijeniti koliki je ekonomski udio, u smislu troškova, unutar takvog razvoja, budući da je u to uključen ogroman broj različitih subjekata, a ekonomski se učinci protežu kroz čitav sustav.

Rad je usmjeren na dinamičan pristup pri analizi luke malih kapaciteta. Prednost takve luke je mogućnost linearnog prikaza različitih odnosa koji se pojavljuju unutar različitih subjekata koji su u to uključeni, pri tome ističući više prednosti koje su u porastu, što je u suprotnosti s više tradicionalnim pristupima kao što su modeli troškova i koristi ili višekriterijalna tehnika. Autori u radu ne ograničavaju pristup samo na prikaz primjene sistemske dinamike na razvoj luke, već prikazuju i primjenu sistemske dinamike za analizu koja može biti provedena na politiku pratećih djelatnosti pomorskog prijevoza.

Ključne riječi: *ulaganja u morske luke, sistemska dinamika, vrednovanje javnih dobara*

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