Strategic Planning for Special Economic Zones to Ports of the Future: System of Models and Test Case

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Abstract. The issue of Special Economic Zones (SEZs) has become increasingly important for underdeveloped European regions. On a world level, the SEZs have allowed the significant development of the territories concerned. The main experiences of SEZs are in the areas of ports. The SEZs became the future of the ports in the underdeveloped regions. It is possible to model some main developments that the SEZ can achieve on the basis of international results. A SEZ has a core node in the area relating to an intercontinental port and can have other nodes located in national ports. A reconstruction of the supply model is then carried out considering all the modalities that allow to connect the different internal nodes to the region and the external macro-nodes. A system of models is proposed to estimate the main impacts of a SEZ. A test case is proposed referring to the TEN-T core node of Gioia Tauro and to the proposed SEZ in the connected areas. It is then modeled the maximum potential increase in employment due to the establishment of the Calabria SEZ, subject to land constraints.

Keywords: Sustainable ports · Special Economic Zone · Port of the future

1 Introduction

The Special Economic Zone (SEZ) has developed in China since the 1980s, with the aim of attracting foreign investment through measures such as incentives, tax breaks and regulatory derogations to favor the development of existing companies and encourage the settlement of new ones, especially foreign ones. The initial SEZ model evolved along different lines in various countries. In the world there are about 4000 SEZs, those in China in Dubai are the best-known examples. In Europe there are about 90, 14 of which are established in Poland, which represent some of the most virtuous examples; there are also examples of SEZs in which significant results have not been achieved. A fundamental element in the most important SEZs worldwide, is the connection with

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ports of an intercontinental level, in this sense the SEZs constitute the natural evolution for the future of third generation ports [1–3]. The first two generations, following the UNCTAD schematization [1], relate to ports connected to cities and to ports connected to large oil plants. The third generation of ports develops from the second half of the twentieth century and reaches maturity in the first 20 years of the twenty-first, and is generated by the container revolution [4–7].

The main challenge of container ports is to be generators of values and not just costs. In fact, while maximizing efficiency for a generic port *a*, a port *b* that offers lower costs may be present in the same market [8, 9].

$$cost\ (generalized\ from\ transport)\ b < cost\ (generalized\ from\ transport)\ a$$

If in port *a*, operating on goods in transit, the value is increased significantly, the following is obtained:

$$cost\ a < benefits\ (value\ added)\ a$$

The expression formalizes the main intervention with which the increase in added value can be introduced in the ports. In this sense, the SEZ is the fundamental element of the ports and allows their future development, on the other hand the ports supplying goods to the SEZs constitute the decisive element for the development of the SEZs. In view of the remarkable results obtained in many contexts by SEZs, the scientific literature is modest regarding the presence of models that allow to evaluate the main impacts of the SEZ such as economic and social outputs, employment of private investments in relation to the main inputs such as available areas and public investments.

The objective of this note is to propose a system of models that allows to estimate ex ante, starting from input variables, the potentially reliable results with the establishment of the SEZ, focusing on the specific models don't present in the literature. After the introduction, in Sect. 2, the set of main objectives that a SEZ should pursue within the goals defined by Agenda 2030 in relation to the development of connected ports is recalled. Section 3 presents the overall system of models that can be implemented to estimate the results obtainable from a SEZ and specifies in particular the models related to the Land Constraints on the available surfaces and to the Economic-functional links between nearby, but not contiguous, areas belonging to a SEZ. A case study is proposed in Sect. 4. The area considered in the study is that of Calabria (IT) and the SEZ is the one that refers to the intercontinental TEN-T [10, 11] port of Gioia Tauro and the other national ports concerned. The port of Gioia has been studied in relation to the transformation into a third-generation port [12–16].

The work can be of particular interest to the technicians of the territorial public administrations and to the technicians of the Port Authorities, to verify the possibilities of development related to the activation of a SEZ.

2 Sustainable Goals and Impact of SEZ

The impacts resulting from the establishment of SEZs can be assessed against the three declinations of sustainability in relation to the 2030 Agenda: economic, social and environmental.

The impacts in terms of economic sustainability of the SEZ mainly concern: export growth; growth in employment levels; growth in foreign capital investments; industrial upgrading and technology transfer; earnings in foreign currency; impacts on the company counts. Compared to the increase in exports, the SEZ can intervene both to accelerate its growth and to diversify the export sectors [17–19]. Tunisia's share of manufacturing exports has more than doubled since 1990. In the Philippines, the share of domestic goods exports increases from 22% in 1995 to 76% in 2003. With regard to the growth in employment levels, the SEZ can be a highly effective tool for job creation. With regard to industrial upgrading and technology transfer, the SEZ can contribute decisively to the improvement of enterprises. Regarding foreign currency earnings, their increase is one of the main expected benefits of the development of the SEZ. With regard to the impacts on the counts, the SEZ transfers to companies the tax policies provided for by the legislation specifically adopted.

Social sustainability should be understood as safety, security and participation. It is necessary to strengthen both the prevention of accidents related to the mobility of citizens and goods (safety) with the consequent reduction of the related social costs, and the protection from criminal acts (security). In line with the indications of the European Union, a qualified target for safety is to eliminate deaths by 2050 with the different intermediate objectives. Participation is declined both as accessibility and reliability of services for all citizens, and passenger rights, and as participation in decisions relating to mobility systems.

Environmental sustainability is divided into different specific objectives related to anthropized and non-anthropized areas. Some issues concern the increase of energy efficiency and environmentally friendly propulsion, the reduction of environmental pollution with particular reference to air quality, the reduction of visual intrusions and noise pollution in urban and non-urban areas.

The environmental sustainability impacts of the SEZ mainly concern: the environmental standards achievable by providing companies with infrastructures and services specifically designed, with the awareness that an effective management of the environment it is a key point for the optimization of the resources committed by investors. It is possible in the SEZ field to develop a prototype area that in Italy is defined by the model of the Ecologically Equipped Production Areas (APEA), L. D. 112/98, art.26.

3 The Proposed System of Models

3.1 The General Framework

This section shows the methodology for estimating the expected impacts of the establishment of a SEZ. The estimation is conducted through an approach based on several models whose scheme is shown in Fig. 1: Aggregated impact (M1); Land Capacity Constraint (M2); Economic - functional link (M3); Factory (M4); Cost (M5); Indirect impact (M6). Figure 1 shows the relationships between the various models, which are framed in a general system, which, through a trial and error procedure, will have as its final output the SEZ Model of the territory considered.

The proposed model structure allows, on the basis of literature data, an estimate aggregate of the impacts deriving from the establishment of the SEZ through the Aggregated Impact Model. The impacts must be verified in relation to the constraints deriving from the surface availability and the socio-economic characteristics of the areas analyzed in the Land Capacity Constraint Model, with a disaggregated approach. The Land model is important because it allows to connect the hypotheses of economic development of companies with the real availability of surface. The economic-functional link between the areas is estimated through Economic Functions Link Model, a gravitational model that includes service level attributes expressed in terms of distances and travel times. The feasibility of the hypotheses with respect to possible settlements and upgrades of companies, based on the available surfaces, and the need for resources is verified with the Factory and Cost models. While the Indirect Impact model allows to estimate the impacts in terms of direct employment and related industries. It is interesting to analyze in detail the Land Constraint (M2) and Economic-functional (M3) models, because there are no models of this type in the literature. The other models studied in the overall system presented have already been developed in the literature. Precisely for the characteristics of innovation, the attention in this note focuses on the M2 and M3 models.

The economic impacts of the SEZ have been quantified through two significant output characteristic variables:

- export of goods and services, produced by companies established in the SEZ operating in the industrial sector that leave the Italian economic territory to be destined for the rest of the world;
- employees in companies established in the SEZ operating in the industrial sector with foreign capital (total or partial) and domestic capital.

3.2 Land Capacity Constraint Model

The Land capacity constraint model estimates the expected impact of the establishment of the SEZ in terms of workforce growth, compared to the capacity constraints resulting from the availability of free areas in industrial agglomerations falling within SEZs.

The impacts of the SEZ must be estimated by considering a reference decade from year 1 to year 10, considering the characteristic variables measured in the base year of activation of the SEZ indicated with year 0:

- d_i density of employees in the industrial agglomerations i of the SEZ;
- $\Delta S_{Ai_1,10}$ change in the area A_i occupied by new holdings in SEZ areas from the free area in the base year.

The model makes it possible to obtain an estimate according to a bottom-up method and to evaluate the variation generated in the individual industrial agglomerations considered fully integrated between them.

It has the following formulation:

$$\Delta Add_{SEZ_Total-1-10} = \Sigma_i \Delta Add_{Ai-1,10} = \Sigma_i d_i \cdot \Delta S_{Ai_1,10} \quad (1)$$

with

- $\Delta Add_{SEZ_Calabria\text{-}1,10}$ total change in the number of employees;
- $\Delta Add_{Ai\text{-}1,10}$ change in the number of employees in the single agglomeration A_i in the decade considered;
- $\Delta S_{Ai_1,10}$ change in the area occupied by holdings in the individual agglomeration A_i in the decade considered;
- d_i density of employees in the single agglomeration A_i, estimated on the basis of the current values recorded in the areas considered in the SEZ.

Compared to the change in the area occupied by holdings in the individual agglomeration A_i, model estimates must be made knowing the SEZs surfaces that are free and therefore potentially available for the establishment of new companies. On the basis of the free surfaces, the possible trend scenarios can be constructed; the simplest are:

- low, an increase in the occupied area of 50% of the free area is expected compared to the value of year 0;
- high, it is expected an increase in the occupied area equal to 100% of the free area compared to the value of the year zero.

By combining the assumptions about the density of employees and the variation of occupied area, the overall scenarios are obtained. Equation 1 outputs the reference information. It is necessary to consider two additional elements in the inputs:

1) areas occupied by disused or abandoned warehouses and areas not yet expropriated in industrial areas.
2) strengthening of companies, with an increase in employment capacity and therefore of employees, which does not entail an increase in the areas currently occupied.

The result of the model must be compared with the result of the aggregate impact model. The surface already occupied and affected by regeneration is indicated by $\Delta^r S_{Ai_0}$.

The increase in use with the inclusion of new employees in companies already operating can be considered in the model expressed by Eq. 1, increasing the d by the factor:

$$\Delta D_d = d_{rif} - d_{act}$$

with
d_{rif} reference density in the scenario considered.
d_{rif}*:* current density of operating enterprises increasing production and labor requirements.

3.3 Economic - Functional Link

Model 3 “Economic - functional link” must make it possible to estimate the effects deriving from the establishment of the SEZ in the macro-node of the main port of reference and in the economically and functionally integrated area connected to it. A i/o

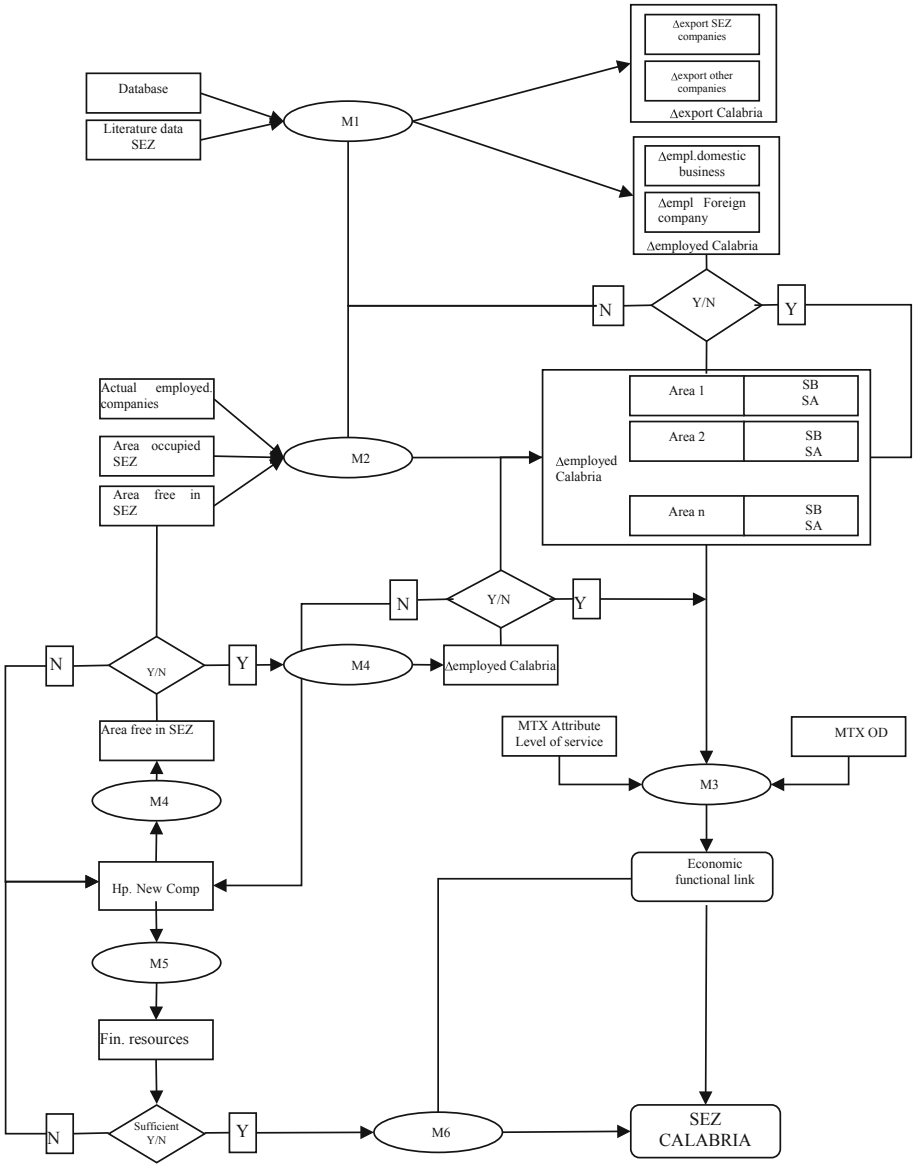

Fig. 1. System of models

model can be considered [20–23], but discontinuity between the areas make difficult the use. An aggregate model is proposed. The hypothesis is that among the areas it is possible to identify hierarchical functional relationships, focused on the core port, starting from the matrix of origin/destination O/D displacements.

It is therefore necessary to first estimate an indicator that allows to evaluate the relationships that exist between the different areas considered in the SEZ under current conditions. It is therefore necessary to estimate a different indicator that allows to evaluate the links between the areas after the first 10 years of activation of the SEZ.

The current indicator is estimated from the flows of vehicles between the areas considered.

Consider:

$d_{od} > 0$	the flow of demand for the users of the pair *od*.
d	the demand vector whose components are the d_{od} demand values for the individual OD pairs
d^*	the demand vector to be estimated.
$\widehat{d}$	the initial demand vector.
f	the flow vector on the network.
$\widehat{f}$	the vector of the measured flows.
x	the unknown demand vector
$f(x)$	the flow vector obtained by assigning x to the network

The estimation problem can be written as [24, 25]:

$$d^* = argmin_{x \geq 0}\left[z_1(x, \widehat{d}) + z_2(v(x), \widehat{f})\right] \tag{2}$$

where z_1 is a measure of the distance between the unknown demand x or the a priori question and z_2 is the measure of the distance between the counted flows and those derived from the assignment of x, $\widehat{d}$.

Once the vector d^* including the demand between the areas linked, has been obtained, the indicator of the current economic and functional links between the level I and II areas can be evaluated starting from the percentage of distribution conditioned at the main port h

$$L_{i/h} = (d_{h,i} + d_{i,h}) / \sum_i (d_{h,i} + di, h) \tag{3}$$

with

$L_{i/h}$ percentage of distribution relative to industrial area i, relative to the hub of the SEZ;

$(d_{h,i} + d_{i,h})$ sum of the request for displacement related to the relationships (hub h, generic industrial area i), (generic industrial area i, hub h);

with the summation extended to all level II industrial areas.

The numerical value expressed by Eq. 3 can be further specified by weighing it with the value of the employed.

The establishment of SEZ profoundly changes the economic and functional relations between the areas concerned, with a strong push for integration, for several reasons:

- Sharing administrative simplifications
- Centralization of housekeeper functions in the hub
- Integration of the offer of combined transport services both sea (road + ship) and rail (road + train).

Due to these elements it is possible to evaluate an indicator in the field (0,1).

$$R_{i,j} = k_1\left(A_i + A_j\right)/k2\, D_{ij} \tag{4}$$

Note that the indicator varies in the field (0,1).
A_i attractiveness factor of area i, measured with respect to employees;
A_j attractiveness factor of area j, measured in relation to employees;
D_{ij} disutility between areas i and j, measured in terms of spatial and/or temporal distances;
k_1 and k_2 constant.

Note the matrix of relations, R_{ij} it can be estimating the economic-functional relations, as a percentage of gravitation expressed by:

$$E_{ij/i} = R_{ij}/\Sigma_i R_{ij}$$

with:
E_{ih} percentage of gravitation between area *i* and area *j*.
R_{ij} generic element of the matrix of functional links joining the area *i* and the area *j*, if search for the link with the hub, it can insert *h* instead of *j*.

4 The Study Case of SEZ in Gioia Tauro Port

4.1 Land Capacity Model

The area considered in the study is that of Calabria Region where the first Italian SEZ have been proposed [26–28]. The SEZ is the one that refers to the intercontinental TEN-T [10, 11] port of Gioia Tauro and the other national ports and airport located in the region. To implement the model specific characteristics of Calabria region have been considered [29–33]. The Aggregated Impact model made possible to evaluate the increase in employment in the case studies on the basis of parameters estimated on an international scale.

The Land capacity model makes it possible to verify whether the increase in employment can be constrained by the availability of areas, or if the areas are in excess of potential development. In this phase, it is assumed from the model that the density is homogeneous for all areas and that, in the reference decade, it can assume two possible scenario values, derived from the analysis of the current state:

- $d1 = 10$ add/ha, on the establishment of medium-sized enterprises;
- $d2 = 20$ add/ha, on the establishment of large enterprises.

The change in the area occupied by holdings in the individual agglomeration has been estimated compared to the base year 2018.

Two possible trend developments were considered:

- low, increase of occupied area equal to 50% of the free area compared to the 2018 value, i.e.

$$\Delta S_{Ai_19,28} = 0,50 \cdot (S_i SA_{i_18_AIL})(SCENARIO\ B);$$

- high, increase in the occupied area equal to 100% of the free area compared to the 2018 value, i.e.

$$\Delta S_{Ai_19,28} = 1,00 \cdot (S_i SA_{i_18_AIL})(SCENARIO\ A).$$

Combining the assumptions on the density of employees and the variation of occupied area, 4 possible scenarios were built:

1. *Scenario B_d*1, with 50% occupation of free surfaces and a density of employees equal to 10 add/ha;
2. *Scenario B_d*2, with 50% occupation of free surfaces and a density of employees equal to 20 add/ha;
3. *Scenario A_d*1, with 100% occupation of free surfaces and employee density of 10 add/ha;
4. *Scenario A_d*2, with 100% free surface occupation and employee density of 20 add/ha.

In conclusion, it is estimated that the territorial capacity of the areas destined for the SEZ can generate a variation in employees, in the hypothesis of full employment of the areas and full activation of the SEZ tools, equal to about 5,680 employees. For sparsely dense areas, based on literature data, it is estimated that this value is around 25% of the output generated by the occupation of the available areas. In the hypothesis of scenario *A_d*2 this value is around 1420 employees. The result of scenario *A_d*2 is consistent with the aggregate output from Model 1. From the model data, however, it emerges that the total value of 2,476 hectares could prove to be a limit for the plan compared to the potential offered by the SEZ.

4.2 Economic - Functional Link Model

The Economic - functional link model estimates the effects of the SEZ in the port area of Gioia Tauro and in the integrated areas.

The territorial levels in the case study are: at Level I the Gioia Tauro Macronode; at Level II the Integrated Areas relating to other ports and airports.

The OD matrix was derived from the correction model expressed by (2), considering:

- for equivalent vehicles, Istat data [34, 35];
- for heavy-duty vehicles, the daily matrix of equivalent vehicles of the PRT, with the flows of heavy-duty vehicles detected in some type sections.

The relationships between the areas, evaluated with respect to the current OD matrix, with this indicator are not adequately represented, nor can they be considered to be particularly significant, considering the critical issues both infrastructural and functional inherited from decades of absence of regional policies outlined according to an organic approach and consistent with national and community planning and programming.

On the basis of the calculated matrix, the values of the indicator taken from (3) were calculated. The indicator expressed by (4) for all the main modes was then calculated.

The results show, in different measures, how the establishment of the SEZ determines a multiplier effect that translates into a strengthening of the economic-functional link between the level 2 areas and the Gioia Tauro area and between all the areas.

The model applied to the current scenario denotes a framework of different relationships compared to what is obtained from the analysis of the OD matrices, highlighting significant interrelationships between the areas of: Gioia Tauro, Vibo Valentia and Lamezia Terme; Crotone and Corigliano. If it is considered the scenario A_d2 and the area of Gioia Tauro, it is evident that all the areas have an interdependence that stands at least around 10%, with the maximum value of 20% for Lamezia, and with the exception of Corigliano Calabro, which is characterized by an interdependence of around 18% with Lamezia and 15% with Crotone.

5 Conclusions

From the proposed model system and its application to the test case results in various elements that can be summarized. From the Aggregated Impact Model: the total employment in Calabria for companies located in SEZ areas, considering all industrial agglomerations, is estimated at 17,351 units of which 4,095 units in foreign capital companies; 13,256 units in domestic capital companies. The Land Capacity Model shows that the increase in employment in the industrial agglomerations included in the SEZ, based on the estimated current value of employees and available areas, current and potential, is equal to about 7,100 employees, which, added to the current employees, provide a result completely consistent with the Aggregated Impact Model. From the Economic Link Model, it is clear that the increase in employment estimated by the Land Model allows to strengthen the functional economic link with respect to the main pole of GioiaTauro and to favor the development of functional economic relations also between the II level SEZ areas.

Considering the whole system of models, it appears overall that the employment deriving from the SEZ is about 16,000 employees between direct, indirect and induced. The results obtained in the test case allow to respond positively to the objective of the paper, namely on the feasibility of a system of models that in an aggregate way allows to analyze results that in terms of employment an SEZ can produce. The overall result is valid because it manages to identify a line of research in the available scientific literature.

From the summary of the results obtained and the comparison with the results known for the real implementations of the SEZs, it can be concluded clearly, highlighting the importance of immediately introducing the SEZs in the European areas underdeveloped in order to accelerate social and economic development, in full respect of the environment.

The results also show the importance of the work presented for the technicians who were working to support the strategic direction of the companies that manage the SEZs because they can prepare quantitative analyzes for the development of the different areas, which are part of the single SEZ.

The possibilities for the development of the work go in two directions: on the one hand the development of research, with the study of models in other European realities that have the same delays in development, on the other hand the need to verify the results obtained from the model with those that can soon be obtained in the reality of the SEZ studied. These developments effectively constitute an agenda for future research.

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