Working Papers SIET 2012 - ISSN 1973-3208

An input-output based methodology to estimate the economic role of a port: the case of the port system of the Friuli Venezia Giulia Region, Italy.

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Abstract

The paper illustrates the results of a research project aimed at identifying the main economic and industrial characteristics of the port system of the Friuli Venezia Giulia Region, Italy, and the role it plays within the economy. Combing a top-down and bottom-up approach, based on interviews and detailed data at firm level, a bi-regional input-output table is built with a special disaggregation of the 12 port-related sectors of the Friuli Venezia Giulia region. The input-output table provides the basis for the estimation of a bi-regional input-output model. Drawing from the input-output literature, the paper also implements two methodologies to estimate: a) the level of self-sufficiency of the port system and b) its degree of substitutability, that is, what would happen if the Friuli Venezia Giulia port system closes down, completely or partially.

1 Introduction

Estimating of the economic role of a port is a relevant topic both in the political and in the scientific debate[1].

In the political debate, the estimate of the direct and indirect economic significance of a port is often used to motivate the request for public funds for building new port infrastructure or to justify its social costs, such as land take, pollution, noise, community severance and so on. Such estimate is usually commissioned by a Port Authority or a local government.

In the scientific debate, the evaluation of the economic role of a port is also of interest since it allows to compare among different ports (e.g., gateway ports vs. trans-shipment ports, European vs. North American ports, Northern-range ports vs. Mediterranean ports, specialized vs. unspecialized ports) and to trace the historical evolution of a port, for instance, as it changes from the 18th century "emporion[2]" nature to the 19th and 20th century commercial nature, from handling only conventional cargo to handling mostly containers, and so on.

Nevertheless, the evaluation of the economic role of a port is fraught with difficulties that are discussed at length in the literature and that are not completely solved, yet.

The paper presents in Section 2 an extensive literature review of such difficulties, of the methodologies used to estimate the role of a port, and of their most recent applications. Section 3

[1] "Port impact studies" or the "economic importance of a port" are alternative definitions of studies aimed at estimating what is the economic value a port. We choose to use the wider term of "economic role" since it better conveys the notion that a port interacts geographically, industrially and economically with the other economic and leisuure activities.

[2] An "emporion" denotes in the Mediterranean countries a place which the traders of one nation had reserved to their business interests within the territory of another nation.

summarized the main features of the ports of the Friuli Venezia Giulia Region, Italy, explains the research motivation, the research methodology and illustrates the main results. Section 4 illustrates a methodology, developed within an input-output framework, to estimate the degree of technological self-sufficiency of a port and its economic importance and illustrates the results obtained by applying such a methodology to the Friuli Venezia Giulia port system. Section 5 concludes.

2 Literature review

As pointed out in former reviews (Waters, 1977; Chang, 1978; Davis, 1983; Gripaios and Gripaios; 1995), regional port impact studies are used not only to inform the general public on the importance of port services to the region's economy, but also as a public relations tool. However, "the differences in methodologies adopted to define and measure various types of socio-economic impacts sometimes lead to misconceptions as well as misleading comparisons across ports within and between regions" (Dooms *et al.*, 2011, abstract, p. 1). Hence, it is very important for the researcher to be conscious of which methodologies could be used to estimate the role of a port in an economy and which are their main pros and cons. The following paragraphs summarize the relevant literature on these topics.

According to Bichou (2007, p. 573) the economic impact studies of a port may be considered as "a branch economic geography, extended to the field of urban planning and environmental economics due to the increasing importance of the port—city interface". Port impacts on the economy are measured to assess the economic and social impacts (direct, indirect and induced) of ports on their respective hinterlands or forelands. In this approach, ports are seen as economic catalysts for the regions they serve, where the aggregation of services and activities generates benefits and socio-economic wealth. The performance of a port is depicted in terms of its ability to generate maximum or optimal output and economic wealth.

Bichou (2007) lists three main methodologies which have been used to evaluate the economic impact of a port: input-output (I-O) , computable equilibrium and gravity models. For more recent classifications see Pallis *et al*. (2009) and Coto-Millán *et al*. (2010).

The U.S. MARAD's Port Economic Impact Kit (PortKit), developed by the Maritime Administration of the U.S. Department of Transportation, is considered the most comprehensive and regularly updated input-output port model (Little, 1979; Temple *et al*., 1985)). The Port Kit – released in December 2000 – is a self-contained, PC-based model that has been developed to help U.S. deep-draft ports and other organizations explain the value of the port industry and port facility investments to their communities. It uses a user-friendly, menu-driven format, model to assess the economic impact of maritime-related construction and on-going activities at the national, state, and local level. It comprises a 30-sector I-O analysis – with up-to-date portrayals of key maritime sectors. On-going maritime activities modelled in the PortKit include container, liquid and dry bulk, break bulk, auto transport, cruise, project cargo, and passenger ferry operations. The PortKit considers all activities directly needed to handle each specific movement. Maritime construction and dredging are also included in the model. Hamilton, Ramsussen, and Zeng (2000) developed a similar software versions for the U.S. rural inland waterways.

The National Technical Information Service (2000) even produced a guide for the proper use of economic impact assessment models necessary for analysing the economic outcome of transportation projects, including ports. It argues that these models can range from the relatively inexpensive and fairly simple Regional I-O Modeling System, to the moderately complex Minnesota IMPLAN I-O model, to the most sophisticated and expensive integrated I-O-econometric models of analysis typified by the widely used proprietary Regional Econometric Modeling, Inc. (REMI) software. Their aim is to provide transport managers, operators and planners with a well-researched and simply-presented comparative economic impact assessment guidebook for using each of these tools.

Typically, the I-O model in a port impact study is used to calculate indirect effects (Haralambides, 1996; Hughes, 1997). For instance, EconSearch Pty Ltd (2001) measures the economic impact of port-related activity defined as the activity undertaken by firms and organisations in moving cargo through the Port of Esperance. This is measured in terms of output, value added, household income and employment. Estimates cover the direct effects of the port and the subsequent flow-on effects to other sectors of the regional economy using an I-O table. Similar applications are performed by the Urban Center of the Cleveland State University (1997) and the Bureau of Transport Economics (2000).

I-O port models are also used to assess impacts of existing port facilities (Moloney and Sjostrom, 2000) or to justify future port investments (e.g., Braun, 1990; Le Havre Port, 2000). Braun *et al.* (2002) focuses on the role of the cruise industry in the U.S. economy. They measure the direct spending of the cruise industry, and use a regional I-O model to estimate the total economic impact. The impacts are based on survey data for the following three groups: cruise line spending, cruise passenger spending, and ships' crew spending. Similarly, Moloney (2004) utilizes a survey of cruise liner tourists visiting Ireland through the Port of Cork to assess the scale and variety of spending by these tourists. These expenditures are then applied to an I-O model of the Irish economy to establish the direct, indirect and induced expenditures , as well as the employment effects of this spending.

Coppens *et al.* (2007) made an interesting attempt to estimate the economic relevance for a region or for the national economy at a disaggregate level by identifying, quantifying and locating the mutual relationships between the various port players themselves and between them and other Belgian industries. They perform a sectoral analysis by compiling a regional I-O table using a bottom-up approach and identifying the main customers and suppliers of the port's key players or stakeholders. In so doing, the economic impact of the port is quantified, both functionally and geographically. They find, in the case of the port of Antwerp, important links between freight forwarders and agents. The geographical analysis suggests the existence of major agglomerating effects in and around the port of Antwerp, referred to as a major transhipment location point. Coppens *et al.* (2007) is the primary source of inspiration for the work presented in this paper.

Since the limitations of the I-O model are well-known - that is, production functions with constant technology, lack of scale economies and non-input substitution in the process of production (Francou *et al.*, 2007) - an alternative is to resort to computable equilibrium (CGE) models. These models have a level of disaggregation that allows structural change analysis but also capture the interdependent nature of production, demand, and trade within a general equilibrium framework. They incorporate market mechanisms and price incentives. The first application of this methodology to port analysis is due to Doi *et al.* (2001). They use a CGE model developed for the year 1995 to analyse the system-wide impact of increased efficiency of ports in Japan. They consider three transportation sectors: shipping, port operations and other transportation. All sectors are assumed to be perfectly competitive and operate under constant returns to scale. Production technology is modeled by nested CES functions. It is also assumed that there are three factors of production: labor, capital and sector-specific fixed intermediate inputs. Labor supply is determined by a variable linear expenditure system and labour moves freely between sectors. Hence, there is a single equilibrium wage rate in the economy. Total capital stock is fixed and also capital is free to move among sectors. They find port sector has limited direct intermediate but shipping industry, imports and exports. Through the latters , changes in the port industry affect the economy. Spill-over effects are substantial on shipping transportation and to a lesser extent on the Japanese economy.

Haddad et a. (2010) use a spatial CGE model to elucidate one of the mechanisms that link trade barriers, in the form of port costs, subsequent growth and regional inequality. The spatial CGE model is integrated to a transport network system. The role of ports of entry vs. ports of exit are explicitly considered. Measures of efficiency for different port locations are incorporated in the calibration of the model and used as a benchmark in simulations. Three scenarios are evaluated: an overall increase in port efficiency in Brazil to achieve international standards; efficiency gains associated with decentralization in port management in Brazil; and regionally differentiated increases in port efficiency to reach the boundary of the national efficiency frontier.

A further methodology is to use gravity models. Wilson *et al*. (2003), for instance, analyse the relationship between trade facilitation, trade flows economic development in the Asia-Pacific region for the goods sector. Four indicators of trade facilitation are used: port efficiency (to capture the quality of infrastructure of maritime and air ports), customs environment, regulatory environment, and electronic-business usage. The authors find that enhanced port efficiency has large and positive effects on trade.

In addition to the methodological debate, there is also a debate concerning the definition of what a port is or, more specifically, which industrial activities is part of a port and which geographical boundaries does a port have.

In fact, in a port perimeter many activities are performed. Some of them are typically transport-related, such as ship loading and unloading operations, ship operations and services (agencies, pilotage, towage and bunkering), land transport, logistics activities, cargo services (e.g. freight forwarding and customs broking). Some others such as industrial production of (petro)chemical, iron and steel, automotive, engines, energy, ships and food products and service and government agencies are located within the port perimeter or in the surrounding areas for convenience or for historical reasons. Which of these and how should they be considered in a port impact study?

Yochum and Agarwal (1987, 1988) distinguish between required and induce industries. Required industries are those necessary to the movement of waterborne commerce and are fairly easy to define. They are included in all port impact studies to assess direct impact. Induced industries are much more troublesome, since they are defined as those firms that have been able to expand their markets by using a particular port. The port is as a source of reduced transportation cost and a magnet for their competitiveness. However, they could locate in the region regardless of the availability of port facilities. Hence, it is not clear-cut if and how they should be included. A complete inclusion might lead to a overestimation and insufficient inclusion in an underestimation. Following Davis (1983), Yochum and Agarwal (1987, p. 76) deem essential to investigate the degree of port dependency and they see “no easy way around this problem other than an extensive survey of firms and government institutions to ascertain the proportion of their work force devoted to the movement of cargo through the port”. They provide in Table 1 of their paper a list of the main activities and the percentage of total employment that is transport related in their case study.

The distinction between port and non-port-related industries is taken one step further by Musso *et al.* (2000) who claim that the crucial question is not “if” but “to what extent” an industry is port related. They implement and test a methodology estimating the probability of the relationship, using location quotients and control region techniques.

With regards to uncertainty about what are the geographical boundaries of a port, influential papers by Notteboom and Rodrigue (2005), Notteboom (2008) and Rodrigue and Notteboom (2009) point out that a port is just a node in a global supply chain. The functioning and the competitiveness of a port depends on its relationship with the hinterland. A port is not simply to be considered the set of activities taking place in the port perimeter as many crucial activities (such as storing areas, distribution centre or service activities) take place in the surrounding areas, in the seaport hinterland and or in metropolitan areas. These ideas are also discussed by Bichou and Gray (2005), Mangan *et al*. (2008), Notteboom (2010), and Vitsounis and Pallis (2010). Consequently, drawing a dividing line in an integrated supply chain is inevitably arbitrary. Following these suggestions, Verbeke and Dooms (2008) propose an integrative framework and an operational model to be used for long-term strategic port planning. They come to the conclusion that there exists “in spite of only limited potential for additional direct employment in the port area itself (due to the continued containerisation phenomenon), a large potential for employment creation in the port network existed within the planning horizon, if the relevant public agencies create the conditions to allow such growth (i.e., make available appropriate transport infrastructure and land).” (Verbeke and Dooms, 2008, p. 5). The employment impact outside the port area is estimated as almost twice as large as the one inside the port area itself.

Further discussion exists on the validity of the above methodologies, particularly the one applying the I-O model. DeSalvo (1994, p. 33), for instance, argues that “port economic impacts are mis-estimated because impact studies fail to consider the price changes and the resulting changes in local-area production that would occur in the impact area were the local port unavailable for the handling of imports and exports.”. He purposes to use supply-demand analysis to obtain the conceptually correct impact, and also proposes an operational formula to be used with five direct-impact categories: port industry, exports, noncomparable imports, comparable imports, and inland transportation.

Hall (2004a,b), on the basis of the widely quoted estimate of the cost of the West Coast port 10-day lockout in fall 2002, which he judged vastly overinflated, reviews port impact studies stating that they do not adequately address the possibilities for substitution, even in the short run. The reason being, in his view, “because port impact studies are poorly designed to deal with the changing nature of the relationship between seaport operations and regional economic development” Hall (2004a, p. 355).

Given the recognized structural weaknesses of economic impact studies that rely on the I-O approach lies in its static character, Castillo *et al*. (2007) proposed a way to solve this problem by linking the I-O model to a system dynamics simulation framework supported by econometric estimations of some important variables.

Ferrari *et al.* (2010) review port impact studies[3] and argue that there is a sort of paradox “as ports – and their efficiency – increase their importance for economic development, their role for the economic system of which they are part decreases”. Such a decrease is due, in their view, to the increasing reduction of the cost of land transport in real terms, to the creation of custom unions, to the development of the logistics industry, and to cargo unitization. These changes have made the port production function more capital- and land-intensive, they have produced the progressive overlapping of port hinterlands together with de-maritimisation. In the above mentioned paradox lies the importance recently acquired by surveys conducted on the economic impact of ports. “In other words, the importance of shifting from a microeconomic point of view founded on port efficiency, which is useful for a port’s users, to macroeconomic assessments of labour, investments and income, which are useful for the port’s community” (Ferrari *et al*., 2010, p. 10).

Coto-Millán *et al*. (2010) represent one of the first attempts to estimate the economic impact of the Port of Santander not on a region but on the economy of the city of Santander, Cantabria and its hinterland in 2005.

Dooms *et al*. (2011) present a meta-analysis of 33 socio-economic impact studies conducted for seaports. They conclude that there is “a great diversity in terms of measures of economic impacts, basic assumptions and methodologies used, leading to important differences between communicated impacts of port activity” (Dooms *et al*., 2011, p. 12). With reference to the discussion on the alleged misuse of socio-economic impacts (Hall, 2004a,b; Crompton 1995, 2004, 2006), they stress the proper inclusion of regional impacts in the port hinterland and logistics network. They also point out that very few countries or regions collect or compile these analyses in a systematic way. As an example of best practice they quote Belgium, where the Belgian National Bank produces a publicly available annual report on the socio-economic impacts of ports, accepted

[3] They group the methodologies used to assess port impact differently. They propose the following classification: direct surveys based on interviews and questionnaires or microeconomic data on firms (Coppens *et al*., 2007); I-O models constructed in order to obtain inter-sectoral multipliers (Warf and Cox, 1989 ; Castro and Millan, 1998, Censis, 1998); and models based on productive specialization that use a mix of tools typical of applied economics, such as comparison with a control region (Rietveld, 1994) or analysis of productive specialization (Musso *et al*., 2000).

by all stakeholders and used in most socio-economic analysis of port projects. Further recent port impact studies include Haezendonck *et al*. (2000), Bryan *et al*. (2006), Guerrero (2008), Accario (2008), Acosta (2010).

3 An estimate for the port cluster of the Friuli Venezia Giulia Region, Italy

In this section, we illustrate the results of a port impact study for the Friuli Venezia Giulia Region, located in the North-east of Italy, that - with reference to the criteria set by Dooms *et al*. (2011) - has the following characteristics: it combines both a top-down and bottom-up approach; it builds an I-O table and makes use of the I-O model; it is based on *ad hoc* surveys; it estimates both direct (employment, revenue, value added) and indirect impacts. It does not set specific geographical boundaries; it encompasses several ports, aggregated in a single one; it provides information on the sectoral boundaries. Furthermore, the substitution issue is dealt with within the I-O framework.

3.1 The ports of Friuli Venezia Giulia

The Friuli Venezia Giulia (FVG) Region, an Italian region located on the north east of Italy and bordering with Austria and Slovenia, utilizes three ports for goods shipping: Trieste, Monfalcone and Porto Nogaro. They form what we have called the FVG port system (FVG_PS). They are all situated in the North Adriatic and, geographically and historically, serve the North East of Italy and the so called Mittle-European countries, that is, southern Germany, Austria, Hungary and the Check Republic.

Insert Figure 1 approximately here

Geographically, the port of Trieste is conveniently located. It lies 1.294 marine miles away from Suez (Port Said), equivalent to 2 days and 16 hours navigation at 20 nautical miles, whereas the Northern range ports are 3.527 marine miles away, equivalent to 7 days and 8 hours navigation at 20 nautical miles. The distances from the port of Trieste of some of the main surrounding cities is as follow: Milan 411 km, Munich 480 km, Graz 288 km, Budapest 539 km, Wien 472 km, Prague 865 km, Zagreb 222 km. The port has a considerable draft: 18 meters minimum along the docks. The total available area is 2.3 km^2 (of which 1,8 custom free); the area available for deposit is equal to 925.000 m^2; the docks length is equal to 12 km. The port is divided into five sections, two of which are devoted to industrial activities, including the Trieste-Ingolstadt pipeline.

The throughput in term of tons of the port of Trieste (Table 1) is rather stable between 2002 and 2007, with a large component of liquid fuel. The share of containers is growing but small in absolute terms. Ro-Ro/ferry transport of trucks from Turkey is quite relevant.

Table 1 - Throughput of the port of Trieste (2002-2007)

	2002	*2003*	*2004*	*2005*	*2006*	*2007*
Break bulk (tons)	9 ,135 ,153	8 ,462 ,722	9 ,265 ,688	8 ,913 ,506	8 ,425 ,006	9 ,234 ,636
Dry bulk (minerals, coal, grains) (tons)	2 ,479 ,152	1 ,783 ,138	737 ,522	839 ,415	1 ,977 ,314	2 ,114 ,609
Liquid Bulk (crude oil, mineral oil) (tons)	35 ,559 ,558	35 ,752 ,000	36 ,835 ,811	37 ,965 ,410	37 ,765 ,398	34 ,766 ,830
Annual cargo tonnage	*47 ,173 ,863*	*45 ,997 ,860*	*46 ,905 ,835*	*47 ,718 ,331*	*48 ,167 ,718*	*46 ,116 ,075*
Containers (in TEU)	185 ,301	120 ,438	174 ,729	198 ,319	220 ,310	265 ,863
Containers (full cont. in tons)			1 ,880 ,412	2 ,314 ,304	2 ,397 ,942	2 ,832 ,064
Ro-Ro/ferry (tons)	Not avail.	Not avail.	6 ,221 ,443	5 ,320 ,351	5 ,680 ,786	6 ,053 ,645
N° of trucks on Ro-Ro/ferry	Not avail.	Not avail.	229 ,390	197 ,115	207 ,378	225 ,656
General cargo ships (tons of general cargo)			256 ,561	192 ,178	445 ,774	658 ,372
Passengers (n°)			303 ,490	90 ,523	103 ,408	113 ,702

Source: Port Authority of Trieste

The port di Monfalcone, which lies closer to the hinterland than Trieste, has an area of 0.68 km^2 with a draft varying between 9,5 and 11,7 meters. Various industrial activities are located nearby, including the largest Italian shipyard. The port specializes in general cargo and dry bulk cargo such as kaolin, coal, cellulose, cement, grains, wood, machinery, minerals, stones, steel and iron, iron scraps, vehicles. In 2007 the port throughput was 4.411.900 tons.

The port of Nogaro operates nearby the river Corno. It is rather small (1.2 km docks) and with draft of between 4.5 and 7.5 meters. It benefits of a large hinterland area and it serves the metallurgical and wood industries located nearby. In 2007 its throughput has been 1,455,000 tons.

3.2 Motivations and methodology

The aim of the research is to answer two questions:

1. Which are the main economic and industrial characteristics of the FVG_PS?
2. What is the economic role of the FVG_PS?

With regards to the first question , the research identifies: how many and which firms are part of FVG_PS; which and how many type of activities they perform; how many people they employ, which is their revenue and value added; where are they located and how many location do they have; which is their profitability.

A choice is made of focusing only the good transport activities, disregarding passengers, although some firms are concerned and some infrastructures are used also for passenger transport and cruises.

In order to identify the role that the FVG_PS plays in the economic system, we decided to use an economic accounting scheme known as intersectoral table (also called I-O table), along the lines of the one build by Italian Bureau of Statistics (ISTAT) for the Italian economy. Since the focus is on port-related activities, 12 port-related sectors are identified and estimated, whereas in national I-O table the port activities are included into two aggregate sectors. The result is a bi-regional (FVG-Other Italian Regions), 22 sector I-O table estimated for the year 2007. 12 sectors are related to port activities performed in the FVG_PS, 5 sectors are non-port related activities performed in FVG and 5 sectors refer to activities performed in the Other Italian Regions.

Insert Figure 2 approximately here

The main research questions that can be answered via an I-O table\model are the following:

- Technological interdependence: which interdependencies do exist between the sectors of economic activity, or in what amount each sector buys\sells goods and services from\any other sector?
- Trade interdependence: which these exchanges do take place within the FVG region, between the FVG region and the Other Italian Regions (hereafter, OIRs) and between the region FVG and the Rest of the World (hereafter, RW)?
- Final demand impact: in case of an increase in demand for a good or service produced by a sector of activity, which are the direct impacts, indirect and induced the production, employment and income at the aggregate level for each sector and for each geographical area?

3.3 Economic and industrial features of the Regional Port System

As discussed above, identifying the geographical boundaries of a port is inevitably controversial. In this research we opted for a pragmatic solution. We identify the firms belonging to the FVG_PS as those who are authorized by the port authorities to enter the port perimeter. Such firms include 6 typologies:

1. Firms authorized to carry out port and service operations according to the articles 16, 17 e 18 of the 84/1994 Italian law.
2. Firms authorized to operate within the port perimeter according to the article 68 of the Italian Navigation Code.
3. Inland transport firms not included in the article 68 of the Italian Navigation Code.
4. Freight forwarders and maritime and custom agents.
5. Firms providing general services (D.M. 14.11.94) and port services (pilotage, towing, mooring and hauling services).
6. Public agencies who, in various ways, manage and control the operations of a port and the movements of the goods (Customs, Coastal Guard, Police, Maritime Health authority, Port Authority, Veterinarian, Fire police).

The total number of the authorized firms in 2007 was 480, that can be subdivided into 4 macro-sectors or 16 sectors (Table 2).

Table 2 - Firms per macro-sector in 2007

Macrosettore	*Number*	*Percentage*
Port-related firms	244	50.8%
Inland transport firms	69	14.4%
Maritime transport firms	2	0.4%
Non-transport-related firms	165	34.4%
Total	480	100.0%

Table 2 shows that only 66.6% of the firms that operate in the FVG_PS perform transport-related activities, while 34.4% perform industrial, construction, commercial ore service activities. These data indicate that ports are not only areas where goods are moved, but have a complex and multi-faceted industrial nature. A finer disaggregation is presented in Table 3, with 12 port, maritime and transport activities and 4 non-transport related activities.

Table 3 – Firms per sector in 2007

Sector	*Number*	*Percentage*	*Monfalcone*	*Porto Nogaro*	*Trieste*
Agents	37	7.7%		2	35
Forwarders	75	15.6%	11	5	59
Shipping.companies	2	0.4%			2
Terminal.operators	19	4.0%	3	1	15
Public.agencies	9	1.9%		1	8
Road.transport	66	13.8%	4	2	60
Railways	3	0.6%	1		2
Port.services	4	0.8%	1		3
General.services	62	12.9%	1		61
Services.to.ships	9	1.9%			9
Labour.coops	22	4.6%	2		20
Services.to.goods	7	1.5%	1		6
Manufacturing	68	14.2%	7		61
Construction	32	6.7%	1		31
Commerce	48	10.0%	2	1	45
Services	17	3.5%	1		16
Total	480	100.0%	35	12	433

Firms can be localized mainly or exclusively within the port perimeter or not. On the basis of the information available, we find that only 26.5% of the firms are localized exclusively within the port perimeter, 31,7% are located also within the port perimeter, and 41,9% are located outside the port perimeter. This indicates that one cannot understand what a port is by looking at what happens within the port area only, as pointed out in the literature on port regionalization.

Next, direct employment, revenue and value added are estimated. This is done on the basis of direct interviews and on the information contained in the income and financial statement for the year 2007. The statistical coverage is presented and discussed in Monte (2011).

Direct employment is estimated on the basis of a questioned asked directly, by telephone or in person, to each firm about the number of people directly employed in port activities in the port perimeter. The overall value is between 5,353 and 8,243 people. The former value considers only of the people employed in the activities strictly performed in the port perimeter, the latter value adds the people employed in the activities performed in port-related firms in the FVG Region but outside the port perimeter (e.g., administrative jobs performed in town offices). The 5.353 people employed in the FVG_PS are distributed as follows: maritime and custom agents: 3%; freight forwarders: 10%; shipping companies: 4%; terminal operators (stevedores): 11%; public agencies: 18%; road transport and logistics companies: 8%; railway companies: 3%; port services (pilotage, towing, mooring and hauling services): 3%; general services: 7%; services to the ships including bunkering: 1%; labour services (cooperative ex art. 68, porterage): 9%; services to the goods (general and chemical control): 0,2%; manufacturing: 16%; constructions: 2%; commerce: 3%; services: 1%.

Total (direct +indirect) employment of the FVG_PS is estimated via a methodology applied to the bi-regional I-O model. This is a specific feature of this research that is discussed in detail in Section 4. The figure depends on which assumptions are made. Under the extreme assumption of total port closure and substitution of the demand currently satisfied by the FVG_PS with foreign imports the total loss for the entire national economic system is equal to 11,443 people.

The estimate of the gross revenue for a FVG_PS poses an additional difficulty since many firms are multi-activity and multi-branch, so that revenues are produced jointly by branches located in the FVG_PS and outside the FVG_PS (in the FVG or outside). Since direct information on how to subdivide the firms' gross revenue between activities and branches were rarely available, the estimate required the introduction of some assumptions. We assumed that total revenue of the firm with many branches could be distributed among them proportionally to the number of people employed in each one , corrected by a factor 1.2 to attribute a larger share where the activity takes place than to the headquarters where the administrative and directional activities are performed. Such correction factor is based on informal evidence collected during interviews to the firms' managers. The results for the FVG_PS are presented in Figure 3.

Figure 3 - Total revenue of the firms authorized to work in the FVG_PS in 2007 per type of activity performed and localization

	FVG_PS	FVG	Row Total
Transport-related activities	1,552	387	1,939
Non-transport-related activities	428	2,752	3,180
Column Total	1,980	3,139	5,119

Set to 100 the total revenue of the identified 480 firms that operated in the FVG_PS, the percentage realized in the FVG Region is equal to 23.6% and that realized in the FVG_PS is equal 9.1%. This indicates that the FVG_PS is a very open economic system, in the sense that many firms operating in the FVG_PS realize their revenue to a larger extent outside the FVG_PS.

A similar analysis is performed for the value added (Figure 4).

Figure 4 - Value added of the firms authorized to work in the FVG_PS in 2007 per type of activity performed and localization

	FVG_PS	FVG	Row total
Transport-related activities	238	183	420
Non-transport-related activities	92	796	888
Column total	330	978	1,309

The total value added within the FVG_PS is equal to 330 million euros, of which 72% deriving from transport-related activities and 34% from non-transport-related activities. Hence, within the FVG_PS, 1/3 of the value-added is generated by non-transport-related activities.

More in detail, the value added generated by the transport activities can be subdivided as follows: maritime and custom agents: 3.2%; freight forwarders: 11.8%; shipping companies: 5.6%; terminal operators: 11.2%; public agencies: 22.1%; road transport and logistics companies: 9.6%; railway companies: 5.1%; port services (pilotage, towing, mooring and hauling services): 8.6%; general services: 9.5%; services to the ship including bunkering: 1.5%; labour services (cooperative ex art. 68, porterage): 9.6%; services to the goods (general and chemical control): 0.6%; manufacturing: 0.7%; construction: 0.0%; commerce: 0.7%; services: 0.1%. It deserves special mention the large percentage generated by the public agencies, underlining the crucial public good nature of a port.

The FVG_PS is a very open system. Many firms that operate within it are part of a group that operates in other ports and regions as well (percentagewise they are 46% in terms of number and

88% in terms of revenue). 37% of the firms have more than one branch. 90% of the firm have their registered office in the FVG, but some have their registered office abroad. The openness of the system is confirmed when one looks at where the input suppliers and the clients are located. It turns out that the FVG_PS buys its inputs 50% abroad, 42% in OIRs and only 8% in FVG. It sells its services 29% within the FVG region, 36% in OIRs and 34% abroad.

From the balance sheets it was also been possible to estimate some financial indicators such as: EBITDA/R (earnings before interest, taxes, depreciation, and amortization on revenues), return on sales (ROS), return on asset (ROA), return on investment (ROI), and return on equity (ROE).

Table 4 - Balance sheet indicators (2007)

Sector	*N° of firms*	*EBIDTA/R*	*ROS*	*ROA*	*ROI*	*ROE*
Agents	26	2.09	1.95	5.54	5.59	16.07
Forwarders	50	1.24	3.01	5.41	2.97	4.31
Shipping.companies	2	2.60	1.30	2.70	1.90	1.70
Terminal.operators	13	6.13	4.29	5.00	3.93	3.08
Road.transport	15	2.35	1.26	2.42	-0.69	0.62
Railways	3	5.96	-7.33	-1.54	1.28	-1.10
Port.services	4	15.68	6.59	4.84	4.35	5.76
General.services	23	16.41	9.56	11.36	12.70	15.17
Services.to.ships	8	2.08	1.43	4.32	1.50	8.25
Labour.coops	12	5.07	2.92	5.65	5.58	31.83
Services.to.goods	4	10.07	7.51	14.87	16.62	36.03
Manufacturing	44	5.09	3.84	2.96	1.19	6.85
Construction	20	10.51	6.96	4.96	5.11	-11.01
Commerce	21	1.14	-1.08	1.31	-2.42	-4.07
Services	8	19.29	9.53	11.47	15.22	25.35

In 2007 the EBIDTA/R indicators are positive. The firms that supply port services and general services show the highest values. The ROS indicator, which is net of amortization, presents in general much lower values with also a negative value in the case of rail transport.

The group of indicators that have the returns in the numerator (, ROA, ROI and ROE) presents high values in the case of the firms offering services to the goods and general services. Road transport has a negative ROI, rail transport a negative ROA and ROE, and the construction sector a negative ROE. The firms that supply services to the goods and the labour cooperatives, being characterized by low levels of equity, have high ROE values. Overall, firms belonging to the port sectors have in 2007 an average ROE equal to 11.07, a relatively good profitability value compared with the firms in manufacturing that have a value equal to 6.85.

4 The role of port system in the economy

In order to evaluate how the FVG_PS interacts with the remaining sectors of the economy, a bi-regional I-O model has been built. Since a bi-regional model was not available, a 5 sector bi-regional model for the regions FVG and OIRs has been initially constructed (for the details of the methodology used refer to Danielis, 2011, p. 93). These 5 sectors are: primary and secondary manufacture, transport, commerce, construction and services. Then, the FVG transport sector has been disaggregated into 12 port sectors plus the remaining transport sector. The final result is a bioregional (FVG and OIRs) I-O model with 12+5 FVG sectors and 5 OIRs sectors. Such model can be used for the structural, multiplier and impact analysis (Miller and Blair, 1985). The model allows to coherently compare the FVG_PS with the other sectors, estimate their backward and forward linkages and perform impact analysis, i.e., how a change in the FVG_PS affects the economy and vice versa.

Focusing on the aggregate data of the I-O table, the direct economic importance of the FVG_PS for the FVG region is the following. It represents 3% of total regional production (1,974 million €, hereafter M€), and 1,3% of total regional value added (424 *M€*), and it generates 3,9% (147 *M€*) of the regional net tax revenue. Its contribution to trade is 9,2% of the exports and 8,5% of the imports. As mentioned, the direct employment is equal to 5,353-8,243 jobs, that is 0,9-1,4% of the total regional employment. The total (direct and indirect) economic importance though, estimated as explain in Section 4.2, is equal in terms of revenue to 1,032-3,055 *M€*, and in terms of employment to 11,443 jobs, depending on the assumption made about how the FVG_PS is substituted.

The I-O model allows us to estimate how output, employment and income changes due to a change in final demand (i.e., private or public consumption, investment, export or change in inventory). Impact analysis depends on the type of model used as shown in Miller and Blair (1985). The bi-regional (FVG-OIRs) I-O model, open to foreign trade (so that part of the multiplying effect is produced abroad and is not accounted in the model), but closed with respect to income (so that the income obtained is assumed to be spent according to the current expenditure pattern; the Type 2 income multiplier is used), produces the multipliers reported in Table 5.

Table 5 – Output and income multipliers

Sector	*National output multiplier*	*FVG output multiplier*	*Induced output multiplier*	*Direct + indirect income variation*
Agents	2.71	1.12	1.22	0.98
Forwarders	3.34	1.14	1.52	1.23
Shipping.companies	3.07	1.07	1.54	1.25
Terminal.operators	3.68	1.90	1.58	1.28
Public.agencies	2.94	1.40	1.46	1.18
Road.transport	4.14	1.16	1.92	1.55
Railways	3.05	1.07	1.52	1.23
Port.services	2.30	1.27	0.98	0.79
General.services	2.91	1.50	1.29	1.05
Services.to.ships	3.41	1.21	1.54	1.24
Labour.coops	3.09	1.55	1.51	1.22
Services.to.goods	3.19	1.67	1.42	1.15
Average FVG_PS	3.15	1.34	1.46	1.18

A unit variation in the final demand for the average FVG_PS has a multiplying output effect on the national economy equal to 3.15 (column 1), a reasonably high value, with some variability among sectors (road transport and logistics being the highest and port services the lowest). However, the effect on the FVG economy is limited to an average 1,34 output effect (column 2) (terminal operators having the highest value and shipping companies the lowest). The induced component of the total multiplier (column 3) is equal, on average, to 1.46, that is, almost half of the total effect (3.15). This is due to the income generated, the remaining to the production interdependences. The forth column reports on the income effect of a unit variation in the port service final demand. On average, when the final demand increases by 1, income increases nationally by 1.18.

It has been possible, within the I-O framework, to estimate the employment multiplier: it resulted that a *M€* increase on the final demand for the average FVG_PS will push employment up by 7,13 labour units (for details, Danielis, 2011, p. 114).

4.1 A methodology to estimate technological self-sufficiency of the port system

The I-O table presented in Figure 2 can be written in compact form:

$$\begin{bmatrix} x^P \\ x^R \\ x^I \end{bmatrix} = \begin{bmatrix} X^{PP} & X^{PR} & X^{PI} \\ X^{RP} & X^{RR} & X^{RI} \\ X^{IP} & X^{IR} & X^{II} \end{bmatrix} + \begin{bmatrix} y^P \\ y^R \\ y^I \end{bmatrix} \qquad (1)$$

where x^P is the output vector of the 12 FVG port sectors, x^R is the output vector of the remaining 5 FVG industrial sectors and x^I is the output vector of the 5 sectors located in the OIRs. The final demand vector y and the flow matrices X are similarly defined. For instance, the rectangular matrix X^{IP} contains the inputs bought by the 12 FVG port sectors from the OIRs. The accounting scheme is made operational and transformed in a model via the Leontief assumption $A = X\hat{x}^{-1}$, that allows us to rewrite (1) as:

$$\begin{bmatrix} x^P \\ x^R \\ x^I \end{bmatrix} = \begin{bmatrix} A^{PP} & A^{PR} & A^{PI} \\ A^{RP} & A^{RR} & A^{RI} \\ A^{IP} & A^{IR} & A^{II} \end{bmatrix} \begin{bmatrix} x^P \\ x^R \\ x^I \end{bmatrix} + \begin{bmatrix} y^P \\ y^R \\ y^I \end{bmatrix}. \qquad (2)$$

This can be solved, thanks to the Leontief assumption, as:

$$\begin{bmatrix} x^P \\ x^R \\ x^I \end{bmatrix} = \begin{bmatrix} I - A^{PP} & -A^{PR} & -A^{PI} \\ -A^{RP} & I - A^{RR} & -A^{RI} \\ -A^{IP} & -A^{IR} & I - A^{II} \end{bmatrix}^{-1} \begin{bmatrix} y^P \\ y^R \\ y^I \end{bmatrix} = \begin{bmatrix} B^{PP} & B^{PR} & B^{PI} \\ B^{RP} & B^{RR} & B^{RI} \\ B^{IP} & B^{IR} & B^{II} \end{bmatrix} \begin{bmatrix} y^P \\ y^R \\ y^I \end{bmatrix} \qquad (3)$$

where the identity matrix I has the needed dimension. Matrix B, here partitioned into 9 sub-matrices, contains the multipliers of the port production, of the other FVG industrial sectors and of the OIRs' sectors activated by a change of the final demand.

Since we aim at analysing how and how strongly the port sectors are linked with the remaining industries, it is convenient to decompose the multiplier matrices. In order to simplify the analysis it is useful to consider a bi-partitioned model made up of the port sectors and of the non-port sectors, regardless whether localized in the FVG or in the OIRs. This simple I-O model has a solution equal to:

$$\begin{bmatrix} x^P \\ x^N \end{bmatrix} = \begin{bmatrix} I - A^{PP} & -A^{PN} \\ -A^{NP} & I - A^{NN} \end{bmatrix}^{-1} \begin{bmatrix} y^P \\ y^N \end{bmatrix} = \begin{bmatrix} B^{PP} & B^{PN} \\ B^{NP} & B^{NN} \end{bmatrix} \begin{bmatrix} y^P \\ y^N \end{bmatrix} \qquad (4)$$

where variables have the standard meaning. The inverse can be written via the Aitken block-diagonalization:

$$\begin{bmatrix} I - A^{PP} & -A^{PN} \\ -A^{NP} & I - A^{NN} \end{bmatrix} = \begin{bmatrix} I & 0 \\ -A^{NP}(I - A^{PP})^{-1} & I \end{bmatrix} \begin{bmatrix} I - A^{PP} & 0 \\ 0 & S \end{bmatrix} \begin{bmatrix} I & -(I - A^{PP})^{-1}A^{PN} \\ 0 & I \end{bmatrix} \qquad (5)$$

where $S = I - A^{NN} - A^{NP}(I - A^{PP})^{-1} A^{PN}$. The matrix S is also known as Schur's complement. It can be proved that equation (4) has a solution only if $I - A^{PP}$ and the Schur's complement are not singular and, hence, can be inverted. In such a case, the inverse can be written as:

$$\begin{bmatrix} B^{PP} & B^{PN} \\ B^{NP} & B^{NN} \end{bmatrix} = \begin{bmatrix} [I + (I - A^{PP})^{-1} A^{PN} S^{-1} A^{NP}] (I - A^{PP})^{-1} & (I - A^{PP})^{-1} A^{PN} S^{-1} \\ S^{-1} A^{NP} (I - A^{PP})^{-1} & S^{-1} \end{bmatrix}$$

(6)

The model can be solved with a different ordering of the matrix:

$$\begin{bmatrix} B^{PP} & B^{PN} \\ B^{NP} & B^{NN} \end{bmatrix} = \begin{bmatrix} H & H A^{PN} (I - A^{NN})^{-1} \\ (I - A^{NN})^{-1} A^{NP} H & [I + (I - A^{NN})^{-1} A^{NP} H A^{PN}] (I - A^{NN})^{-1} \end{bmatrix}. \quad (7)$$

Therefore, the multiplier matrix of the port production with respect to the port demand can be expressed as either:

$$H = B^{PP} = [I - A^{PP} - A^{PN} (I - A^{NN})^{-1} A^{NP}]^{-1} \quad (8)$$

or

$$B^{PP} = [I + (I - A^{PP})^{-1} A^{PN} S^{-1} A^{NP}] (I - A^{PP})^{-1}. \quad (9)$$

The interpretation of equation (8) is immediate when we recall that the inverse of a non-singular matrix non can be expressed by the Neumann's series, so that $(I - A)^{-1} = I + A + A^2 + A^3 + \cdots + A^n + \cdots$. Therefore the port output multipliers are due to the direct technical coefficients of the port's sectors (A^{PP}) and by the forward and feedback effects. In fact, an output increase in a port sector stimulates production in the other sectors. Such forward effect is captured in the matrix A^{NP}. We know that a demand increase in non-port goods leads to a increase in their production that, cycle by cycle, is captured by the inverse matrix $(I - A^{NN})^{-1}$. Moreover, the increased production leads to a further increase in the demand of port services determined by the input coefficient matrix A^{PN}. This explains why the propagation effect outside the port is null when the matrices A^{PN} or A^{NP} are made up of zero values. If the A^{PN} matrix is null, an increase in non-port production does not stimulate port production. Conversely, if the A^{NP} matrix is made up of zero elements, the port production is self-sufficient and does not generates effect on the remaining sectors of the economy.

Equation (8) confirms the importance of these links to calculate the forward effect. Actually, the port production activated by its own demand in an "autarchic" regime is given by $(I - A^{PP})^{-1}$, that is the driving force in equation (9). But it causes a spill-over effect on the rest of economy that is greater the larger the matrix A^{NP}. Such increase in production activates, in turn, the remaining sectors as expressed by Schur's matrix, S, whose inverse captures the total variation. The final effect is an increase in port service demand unless the A^{PN} matrix is zero. The demand increase, in turn, increases the port output according to its integration measure captured by $(I - A^{PP})^{-1}$.

In conclusion, the forward and backward effects are lower, the lower the coefficients of the activation matrices A^{PN} and A^{NP} . In the literature various metrics exists with reference to matrices with non-negative elements, such as the spectral norm or the Frobenius norm, but there is no immediate interpretation of their value (Salce, 1993). Since, it is convenient to analyse the importance of these matrices for the port system, a first exercise consists in observing the total multipliers matrix, B^{PP}, that refers only to intra-port activation. One can estimate the share attributable to the inverse matrix $(I - A^{PP})^{-1}$.

The application of this methodology of matrix decomposition to the TIS bi-regional FVG-OIRs 2007, leads to the result illustrated in Table 6.

Table 6 – Share of internal activation on total production in the FVG_PS

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*Aver. row*
1	Agents	100	99	100	99	76	97	58	98	97	72	93	3	82.7
2	Forwarders	99	100	37	100	70	97	95	69	68	99	81	2	76.4
3	Shipping.companies	95	99	100	100	98	59	99	100	100	98	100	29	89.8
4	Terminal.operators	100	100	64	100	6	60	85	3	3	42	21	0	48.7
5	Public.agencies	100	100	100	100	100	93	99	100	100	100	99	100	99.3
6	Road.transport	98	100	94	100	100	100	93	85	86	99	100	70	93.8
7	Railways	77	96	52	99	100	94	100	80	79	59	100	70	83.8
8	Port.services	98	94	32	100	98	13	70	100	99	100	95	41	78.3
9	General.services	100	99	87	100	100	42	71	100	100	91	100	76	88.8
10	Services.to.ships	100	99	95	100	99	47	73	100	100	100	99	58	89.2
11	Labour.coops	99	100	32	100	20	65	86	17	17	91	100	0	60.6
12	Services.to.goods	87	100	5	99	1	18	22	1	1	40	100	100	47.8
	Average	96.1	98.8	66.5	99.8	72.3	65.4	79.3	71.1	70.8	82.6	90.7	45.8	78.3

The *ij* values presented in Table 6 indicate the share of internal activation (i-th row) deriving from an increase in the sectorial final demand (j-th column). For instance, the value 95, third row and first column, shows that an increase in maritime and custom agents final demand induces a change in the production of the shipping companies, 95% of which remains in the FVG_PS whereas the remaining 5% has an effect outside the FVG_PS. The high values of the first column, hence, indicate that final demand by the maritime and custom agents activates production almost exclusively within the FVG_PS (96.1%). However, if we consider the services-to-goods sector the picture is quite different, with a smaller value (45.8). This means that the multiplying process of the final demand for service to goods activates production to an important extent outside the FVG_PS. It can also be noted that some sectors, for instance row 5, public agencies, have an activation effect across sectors outside the FVG_PS close to zero (99.8).

To summarize, the table allows us to conclude the FVG_PS has a quite high level of self-sufficiency, on average equal to 78.3%. That is, the final demand for the port sectors' services activates production ¾ of which take place in the FVG_PS itself. The positive interpretation of this result is that, at least from a technological point of view, the FVG_PS is a "cluster"[4]. The negative aspect is that the FVG_PS has weak relationships with the remaining economic sectors, a result already found by Doi *et al.* (2001) as illustrated in Section 2.

4.2 The economic importance of the port system

In many empirical studies the estimate of indirect employment is presented but it is not clearly explained how it is obtained. Generally, there is a reference to a multiplier, quoted from the literature, which transforms the direct employment estimate into an estimate of the indirect employment. Consequently, such multiplier is somewhat "ad hoc", external to the analytical framework used.

In other applications, the indirect employment is said to be derived from inputs bought by the port sectors from other sectors. Employment\output ratios, derived from the national I-O tables, are then

[4] But since, according to De Langen (2003), the organizational, management and promotional aspects are an essential part of the cluster concept, and they are not considered in this research, we used the more conservative concept of port system.

used to come up with an estimate of the indirect employment. In such a case, the entire backward\forward linkage structure is lost. Coppens (2005) is, to our knowledge, the only paper that tries to define in a sound approach what is meant by "indirect effect". He defines it on the basis of the I-O model, but fails to account for some recent theoretical developments.

In this section we present and apply a methodology that provides, in our view, a coherent and explicit framework to estimate the total output and employment importance of a port.

The analysis presented in Subsection 4.1 is useful since it provides an estimate of the level of integration of the port system within the economy. However, it is only a starting point because it does not consider the absolute levels of final demand. In other terms, the values provided are only potential, because if final demand is small or null, the induced production is small or null too, notwithstanding the propagation channel. Hence, a methodology that captures both the actual value of the final demand and the propagation channels is needed.

A useful approach is due to Paelinck, De Cavael and Degueldre (1965) and Strassert (1968) who developed a methodology that can quantify the output loss if a given sector would not exist. The initial proposal is quite simple. It consisted in deleting a row and a column of the Leontef matrix and the corresponding final demand. Doing so, one assumes that the production is entirely substituted by imports. The more important the sector is, the larger the total output loss. Similarly, one can proceed deleting a group of homogenous sectors.

However, borrowing from the backward and forward linkages literature (Rasmussen, 1956, Chenery e Watanabe, 1958, Augustinovic, 1970, Jones, 1976, Schultz, 1976, Harrigan and McGilvrey, 1988), it resulted that deleting a whole sector makes little sense. It is more useful to cancel out some or all the links of the sector under scrutiny, since it continues to exist and offer its goods and service, but with a different technology that does not make use of some or all intermediate goods or supplies only final demand. In so doing, it is possible to identify the various propagations channel and the different pull e push factors, without using the Ghosh supply approach.

Formally, one should estimate how much production is lost when $A^{PP} = A^{NP} = A^{PN} = 0$ and Leontief inverse matrix reduces to:

$$\bar{B} = \begin{bmatrix} I & 0 \\ 0 & (I - A^{NN})^{-1} \end{bmatrix}$$

so that the difference between the realized and this "theoretically possible" output levels is given by:

$$\begin{bmatrix} \Delta x_1^P \\ \Delta x_1^N \end{bmatrix} = \begin{bmatrix} H - I & H\,A^{PN}(I - A^{NN})^{-1} \\ (I - A^{NN})^{-1}A^{NP}H & (I - A^{NN})^{-1}A^{NP}H\,A^{PN}\,(I - A^{NN})^{-1} \end{bmatrix} \begin{bmatrix} y^P \\ y^N \end{bmatrix} \quad (10)$$

Following Miller and Lahr (2001), it is possible to propose some alternatives. The simplest and most used one, is the "complete specialization" one, in the sense that the port sector keeps on utilizing the intermediate goods, but only those produced within the cluster. This is to assume $A^{NP} = A^{PN} = 0$, so the Leontief inverse matrix becomes:

$$\hat{B} = \begin{bmatrix} (I - A^{PP})^{-1} & 0 \\ 0 & (I - A^{NN})^{-1} \end{bmatrix}.$$

so that, using equation (9) the difference between the realized and this new "theoretically possible" output levels is given by:

$$\begin{bmatrix}\Delta x_2^P \\ \Delta x_2^N\end{bmatrix} = \begin{bmatrix} (I-A^{PP})^{-1}A^{PN}S^{-1}\,A^{NP}\,(I-A^{PP})^{-1} & H\,A^{PN}(I-A^{NN})^{-1} \\ (I-A^{NN})^{-1}A^{NP}H & (I-A^{NN})^{-1}A^{NP}H\,A^{PN}\,(I-A^{NN})^{-1}\end{bmatrix}\begin{bmatrix}y^P \\ y^N\end{bmatrix} \quad (11)$$

Cella (1984) proposed to decompose the total variation into two components, based on the final demand origin. Specifically, he defined as a backward linkage the one that depends from the sector (or industry) whose linkages have been cancelled out, in our case the port sectors. Hence, the total value of the backward linkage is the sum of the decreased output, wherever produced, due to the port final demand:

$$BL^P = i'(I-A^{PP})^{-1}A^{PN}S^{-1}\,A^{NP}\,(I-A^{PP})^{-1}y^P + i'(I-A^{NN})^{-1}A^{NP}Hy^P \quad (12)$$

where i is a unit vector that allows to sum all elements in a conformable vector. One could immediately see that this indicator is equal to zero only if the input matrix of the port sector service from the OIRs is zero and feedback effects do not exist. Similarly, the forward linkage can be defined as:

$$FL^P = i'H\,A^{PN}(I-A^{NN})^{-1}y^N + i'^{(I-A^{NN})^{-1}}A^{NP}H\,A^{PN}\,(I-A^{NN})^{-1}\,y^N \quad (13)$$

that is equal to zero only if the port sectors do not sell their service to the remaining sectors.

Miller and Lahr (2001) propose alternative elimination strategies consisting in deleting one or more sub-matrices described in equation (4). For instance, one can eliminate only one of the two exchange matrices, that is A^{NP} o A^{PN}.

Let us imagine, in our specific case, the closure of the FVG_PS. The direct economic loss in terms of revenue would be 1,975 million euro. This figure indicates the direct economic importance of the FVG_PS. But it does not include the indirect effect due to the forward and backward linkages.

On the substitution of the port service, one can make the following assumption:

a) The port services are imported from abroad (e.g., the port of Koper, Slovenia, located 1 hour south of Trieste).
b) The port services are substituted with other transport services (e.g., road services) produced in the FVG region with the current technology. Obviously, this is a somewhat meaningless assumption since the port services cannot be easily substituted by non-port services.
c) The port services are substituted with port services produced in OIRs with the current technology (e.g., the port of Venice, located 2 hour east of Trieste).

The impact on output and the total loss per the entire national economy (FVG+OIRs) are summarized in Table 7.

Table 7 – Change in production if the FVG_PS is closed down (*M€*)

Settori	*Current output with FVG_PS*	*Estimated output if port service are imported from abroad*	*Estimated output if port service are substituted from other non-port transport services produced in FVG*	*Estimated output if port service are substituted from other port services produced in OIRs*
Transp&Comm FVG	4,286	4,268	5,352	4,268
Manuf FVG	19,888	19,862	19,915	19,863
Constr FVG	5,476	5,471	5,516	5,471
Comm FVG	8,629	8,612	8,688	8,612
Serv FVG	26,059	26,012	26,207	26,014
Transp&Comm OIRs	280,546	280,089	280,117	281,340
Manuf OIRs	955,101	954,922	955,001	955,149
Constr OIRs	277,712	277,672	277,725	277,758
Comm OIRs	401,033	400,937	400,995	401,085
Serv OIRs	1,161,959	1,161,763	1,161,885	1,162,071
Total	3,140,689	3,139,608	3,141,401	3,141,631
FVG_PS	1,975	0	0	0
Global Total	3,142,664	3,139,608	3,141,401	3,141,631
Total loss		3,056	1,263	1,033

Under assumption a), closure of the FVG_PS and substitution with imports from abroad, the output loss would be equal to 3,056 *M€*. FVG and OIRs sectors would experience a decrease in production due to the indirect effects. In particular, the largest output loss would be experience in the OIRs (in the transport and communications sector and in the service sector) because the FVG_PS buy considerable inputs from those sectors.

Assumption b), substitution with other transport services (e.g., road services) produce in the FVG region with the current technology, would entail obviously a large output in the FVG transport and communication sector. Overall, however, a loss of 1,263 *M€* would be experienced because of the technological and forward and backward linkage shift. As mentioned, this assumption is somewhat unrealistic.

It is probably more realistic to assume that the substitution with port services produced in OIRs with the current technology, as in the third assumption. This would also entail a total loss of 1,033 *M€*, even though the OIRs transport and communication sector would experience a production increase.

Consequently, depending on the substitution assumption, the economic importance of the FVG_PS can be estimated between 1,032 and 3,055 *M€*.

Similar estimates can be made with reference to the impact on employment, hence, capturing the direct and indirect employment content of the FVG_PS (Danielis 2011, Table 63). The larger value obtained is 11,443 jobs. Hence, the indirect employment lies between 6,090 (=11,443-5,353) and 3200 (=11,443-8,243), depending on how direct employment is defined.

Furthermore, one can assume, instead of total closure of the FVG_PS, a partial closure such as that:

1. The FVG_PS operates but it imports all goods and service from abroad, without producing them locally, so that only the primary factors (capital and labour) generate income (Assumption 1, only VA);
2. The FVG_PS operates but it imports all goods and service from abroad and it does not sell nor acquire its services neither to the FVG nor to the OIRs (Assumption 2, $A^{NP}=A^{PN}=0$);
3. The FVG_PS operates but it imports all goods and service from abroad and not from the FVG or OIRs, but it sells its services to the FVG nor to the OIRs (Assumption 3, $A^{NP}=0$);

4. The FVG_PS operates, it buy goods and service from the FVG or OIRs but it does not sell its services neither to the FVG nor to the OIRs (Assumption 4, $A^{PN}=0$).

The impact on port production is summarized in Table 8, that presents in the first column the current production and in the last row the total loss for the national economy.

Table 8 – Impact on FVG_PS production under alternative assumptions (*M€*)

	Current	*Assumption 1* *VA only*	*Assumption 2* $A^{NP}=A^{PN}=0$	*Assumption 3* $A^{NP}=0$	*Assumption 4* $A^{PN}=0$
Agents	59	40	42	59	42
Forwarders	289	68	71	289	71
Shipping.companies	692	593	606	692	606
Terminal.operators	211	150	153	211	153
Public.agencies	73	1	47	73	47
Road.transport	188	43	51	188	51
Railways	290	53	55	290	55
Port.services	27	14	18	27	18
General.services	53	4	11	53	11
Services.to.ships	48	8	13	48	13
Labour.coops	40	3	23	40	23
Services.to.goods	4	2	2	4	2
Total	1,975	978	1,091	1,974	1,091
Output loss in FVG_PS		996	883	0,7	883
Total loss for the whole economy		2,077	1,963	1,081	1,426

Under assumption 1) the loss for the FVG_PS is equal to 996 *M€* where the total loss for the national economy would be equal to 2,077 *M€*. Under assumption 2), no trade between the FVG_PS and the non-port sectors, the loss for the FVG_PS is equal to 883 *M€* (lower than the previous case because the port still operates) and the total loss for the national economy is equal to 1,963 *M€*. The loss for the FVG_PS is almost null under assumption 3) because it operates and it imports its inputs from abroad while it sells to the remaining sectors. Yet, the total loss for the national economy would be equal to 1,081 *M€*. Under assumption 4) the loss of the FVG_PS is again equal to 883 *M€* because the FVG_PS does not sell its services to the non-port sectors and the total loss is 1,426 *M€*. Hence, the total losses range between 2,077 and 1,081 *M€*.

It can also be observed that, under assumption 2), 72.6% of the loss is due to the forward linkage and 27.3% to the backward one.

Similar impacts have been estimated for employment (Danielis, 2011, p. 105 and 107).

In summary, the output directly attributable to the FVG_PS is equal to 1,975 M€. If the FVG_PS is hypothetically closed down, the total loss for the national economy would be equal to (Table 7):

1. 3,056 M€ if the port services are imported from abroad;
2. 1,263 M€ if the port service are substituted with other transport services (e.g., road services) produced in the FVG region with the current technology;
3. 1,033 M€ if the port service are substituted with port services produced in OIRs with the current technology.

Note that in cases 2) and 3), the total loss for the national economy is lower than the direct output loss for the FVG region. This happens because the backward and forward linkages of the port-related sectors are weaker than those of the other FVG or OIRs transport sectors.

Under less drastic assumption of partial closure of the FVG_PS, the total loss for the national economy would be equal to (Table 8):

a) 2,077 M€ if the FVG_PS operates but it imports all goods and service from abroad, without producing them locally, so that only the primary factors (capital and labour) generate income;

b) 1,963 M€ if the FVG_PS operates but it imports all goods and service from abroad and it does not sell nor acquire its services neither to the FVG nor to the OIRs;
c) 1,081 M€ if the FVG_PS operates but it imports all goods and service from abroad and not from the FVG or OIRs, but it sells its services to the FVG nor to the OIRs;
d) 1,426 M€ if the FVG_PS operates, it buy goods and service from the FVG or OIRs but it does not sell its services neither to the FVG nor to the OIRs

Hence, to total (direct + indirect) importance of the FVG_PS varies between 1.033 M€ and 3.056 M€, depending on which assumption of its substitution and operability are made. Again, it is worth nothing that in 5 cases out of 7, its total importance is less than its direct importance for the same reasons mentioned above.

5 Conclusions

The paper has summarised the results of a research project aimed at identifying the main economic and industrial characteristics of the FVG port system and at estimating how it is connected with the rest of the economy. Combing a top-down and bottom-up approach, based on interviews and detailed data at firm level, a bi-regional I-O table has been built with a special disaggregation of the port-related sectors of the FVG region. The I-O table provided the basis for the estimation of a bi-regional I-O model. The research project used as an inspiration the studies performed for the Antwerp port (Coppens *et al*., 2007).

Although many of the criticisms directed to the I-O model, some of which are summarised in Section 2, should be acknowledged, a well-known advantage of this approach is that it allows to estimate both the direct and indirect (employment, revenue, value added, income) impacts of a change in the final demand, in a framework that is consistent with the national and regional accounts. Furthermore, such impacts can be sectorally and geographically specified.

With regards to the identification of the industrial characteristics, it is concluded that the FVG_PS

- plays a relevant macroeconomic role in the region;
- is characterised by a high degree of openness from an economic, commercial and industrial point of view;
- it is part of a larger territorial system;
- it has an important public good nature.

In the project report comparisons are also made (not presented in this paper) between the current FVG port system and the port of Trieste in year 1900 (Babudieri, 1965) with regards to the number of people directly and indirectly employed (of course, enormously different), nowadays with the port of Venice and the Belgian ports (Danielis, 2011, p. 125). Another relevant finding is that the value added per square-km is much higher in the FVG_SP than in most Belgian ports.

With regards to the question of how is the FVG port system connected with the rest of the economy, the paper, not only estimated the relevant multipliers with a 12 port-related sector disaggregation level, but also proposed two methodologies to estimate, coherently with the I-O modelling framework: a) the level of self-sufficiency of the port system and b) its degree of substitutability, that is, what would happen if the FVG port system closes, completely or partially, depending on the assumption made on where the port services are alternatively procured. It is found that the FVG port system has a 78.3% self-sufficiently level and an economic importance ranging between 1.033 M€ and 3.056 M€.

Although, both methodologies suffer, of course, from the general limitations of the I-Oapproach , they provide a coherent and explicit method to evaluate what role does a port, or a port system, play within an economic system.

Acknowledgments

The research has been made possible by a grant from the Commissario del Governo, Fondo Trieste of 60.000 euro. It started in June 2009 and ended Octobre 2011. The research group was lead by Romeo Danielis and included Daniele Andreozzi, Giacomo Borruso, Massimo Gardina, Tullio Gregori, Alessandro Kostoris, Jerome Massiani, Adriana Monte, Loredana Panariti, Paolo Rosato, Lucia Rotaris and Vittorio Torbianelli. Luca Buzzulini, Fabio Franceschinel, Palo Frisenna and Alessia Piccolo collected the data via direct or telephone interviews. A special thanks to the Port Authority of Trieste and to Francesco Parisi Spa for the technical support.

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Figure 1 - The Friuli Venezia Giulia port system

Figure 2 – Graphical illustration of the bi-regional (FVG-Other Italian Regions), 22 sector input-output table. The table with the actual data is available in Danielis (2011).

			Friuli Venezia Giulia																	Other Italian Regions								
			Port-related sectors												Non-port-related sectors					Sectors								
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Int. outputs	Final Demand		Total outputs
Friuli Venezia Giulia	Port-related sectors	1																										
		2																										
		3																										
		4																										
		5																										
		6																										
		7																										
		8																										
		9																										
		10																										
		11																										
		12																										
	Non-port-related sectors	13																										
		14																										
		15																										
		16																										
		17																										
Other Italian Regions	Sectors	18																										
		19																										
		20																										
		21																										
		22																										
		Total intermediate costs																										
		Value added																										
		Output																										
		Imports																										
		Total inputs																										