Transport Policy 66 (2018) 9–16

Contents lists available at ScienceDirect

Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

How modes of transport perform differently in the economy of Andalusia

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ARTICLE INFO

JEL classification:
O14
R40
L90
C67

Keywords:
Social accounting matrix
Input–output analysis
Transport

ABSTRACT

This paper analyses the impact of the different modes of transport in the economy of Andalusia. This assessment makes use of multipliers analysis based on a Social Accounting Matrix (SAM). It has been performed a breakdown of output multipliers as a sum of direct, indirect and induced effects, and the salary and employment multipliers have also been calculated. The starting point is the creation of a SAM from the existing one of year 2010, but disaggregating the sector of transport into their different modes. Thanks to this, we establish the different impact in the economy of each mode of transport, highlighting their different performance. Regarding freight transport, train offers better effects in terms of output multipliers than transport by road. In transport of passengers, the impact of high speed train is more important than air transport, two modes that compete in some routes. The results in this paper are the kind that is of highest interest to policy makers, moreover when large investments are required.

1. Introduction

The motivation for this work is the need to know about long-term impact of each mode of transport in the economy. Our main interest lies in highlighting the differences between modes of transport. In short, the focus of this work is to calculate the output, salaries and employment multipliers for each mode of transport, identifying the main differences between them. Andalusia, the most populous region in Spain, is taken as the economic framework of reference.

This information helps to policy makers to improve their decision making. They should be aware about the effects of promoting one mode instead of others or evaluate the impact of investing in infrastructures of transport or other policies to increase its demand. This information is important due to the cost of investing in transport infrastructures. However, there is not literature including a comprehensive comparation of economic impact between modes of transport, only assessments about economic impact of a certain infrastructure or a single mode of transport.

This study confirms the different impact of modes of transport in the economy of Andalusia, based on their effects in term of multipliers. It is interesting the comparison between modes of transport that enters into competition in some routes. As an example, this is the kind of results that give information about the effects of future investment in rail infrastructure in Andalusia (The Mediterranean Corridor) or policies subsidizing air transport or Hight Speed Train (HST).

Regarding freight transport, this work shows how transport by train has better performance than road transport, except in term of employment multipliers, because transport by road is more labor intensive. However, it has poorer performance in term of number of jobs induced by direct employment.

In transport of passengers, one interesting case is the competition between HST and air transport. In the case of Andalusia, HST has better impact in the economy in terms of total output (multiplier is 25% higher), in the creation of employment (multiplier is also 25% higher) and in the generation of indirect and induced jobs per direct employment (32% more than air transport).

Analysis of economic impact can be calculated using standard Input-Output (IO) model (Leontief, 1966). Similar calculations can be done with Social Accounting Matrix (SAM) models, which extend the inter-industry Leontief model to take into account the income generation and expending. Therefore, SAM models allow also to gather induced effects, which sometimes are an important part of the economic impact. The use of SAMs was first introduced by Stone (1962) who published a SAM for

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https://doi.org/10.1016/j.tranpol.2018.02.015
Received 5 March 2017; Received in revised form 28 January 2018; Accepted 20 February 2018

the United Kingdom, as a useful tool to organize national accounts. Later on, Pyatt and Round (1979) further developed this methodology and its applications, in particular the use of multiplier analysis.

The study is structured as follows. First of all, there is a short literature review about the application of IO methodology to modes of transport, followed by a description of the basis of the SAM model as an extension of the Leontief model. Later on, we explain shortly how SAM has been built up, because it will be used for obtaining the results in following sections. In next section the multiplier theory is applied to the SAM model, using the one of Andalusia of year 2010 with modes of transport disaggregated. Finally, we stated the conclusions and discuss constrains and possible extension of the model.

2. Brief literature review

Economic Impact Analysis (EIA) is used to either predict the impact in the economic indicators as a result of the implementation of future investment or policies, or to evaluate the impact of past or present policies.

EIA methodology is mainly based on the use of mathematical models. Analysis based on IO models is a key component in most impact analysis. It quantifies the multiple economic effects resulting from a change in the final demand of a specific product or service. Similar calculations can be done with SAMs, which are an extension of IO tables to take into account income generation and expending.

The methodology based on IO models was first put into practice in the 60's and it was applied first to seaports in the United States, and later on in Europe. Since then, the impact analysis of seaports has had predominance over other transport infrastructures. Pérez and García (2004) provide a detailed review of the literature about this methodology applied to seaports. However, this methodology has also been used to assess the impact of infrastructures linked to other sectors through the use of multipliers, as the one for the Highway Widening Projects in Texas (Buffington and Wildenthal, 1998). Today the economic impact analysis of seaports has shifted to airports, and its amount has increased recently. We can cite the ones of the airport of Dublin (Vistas Consulting Ltd, 2015) and the commercial airports in the U.S. (Smith, 2014).

In the early times of IO methodology already appeared some critics (Christ, 1955). They focused on the lack of dynamism or their inability to adequately reflect the replacement of local production by imports, as a consequence of changes in prices (R. C. Waters, 1977). Nevertheless, there were also defenders (Chang, 1978) by showing them as very useful tools, despite their limitations. However, the methodology is not exempt from inaccuracies in the results or difficulties of interpretation.

The debate about the limitations of the methodologies based on IO tables has not been completely closed. Verbeke and Debisschop (1996) listed the limits on the use of economic impact studies in transport infrastructures, concluding that they can perform a major role as complement to other decision criteria, such as the cost-benefit analysis. Today the limitations of IO models are well known (Kockelman et al., 2013), as the existence of fixed prices, fixed coefficient technology or constant returns of scale. More recently Cardenete and Sancho (2012) showed the limitations to the use of multipliers based on IO models when there are supply constraints.

Computable General Equilibrium (CGE) provides a modelling approach that overcomes these limitations, since it takes into account the price effects, elasticities of demand and substitution of products and factors. CGE can furthermore make use of different production functions for each sector and different utility function for utility-maximizing consumers. There is also literature addressing issues on transport topics with CGE models, which have been improved with multiregional and dynamic CGEs. Chen et al. (2016) made use of a dynamic CGE to assess the economic and environmental impact of high speed train in China on the 2002–2013 period, concluding that rail investment has had an important effect on economic growth and a substantial positive impact in terms of CO_2 emissions. Bröcker et al. (2010) made use of a multi-regional CGE model to analyze the economic impact of the Trans European Network (TEN) and found that welfare impact was modest.

But CGE models also have some limitations and critics, such as the need of a big amount of statistical data, whose updating or quality is variable. Additionally, the accuracy of their results relay on how the equations reproduce the real behavior of the economy in a certain point of the time. For this reason, methodologies based on IO and SAM tables are the most widely used due to their simplicity, that they are easily implementable and that they are empirically operational.

Methodologies based in IO tables or SAM have evolved since they started to be used. One of the last improvements is the use of multiregional IO tables, which allow the analysis of impact beyond the area where the transport infrastructure is located. In this line, Merk et al. (2013) not only analyze the interregional impact of four seaports in North-West of Europe but also quantify spillover effects. Previously Coto-Millán et al. (2010) already assessed the impact of the port of Santander in the city of Santander, in the region of Cantabria and in its hinterland.

The literature about impact analysis of modes of transport in Spain is slightly more modern. The first references are from the early nineties, such as the one from Villaverde and Coto-Millán (1998) for the port of Santander. The production of academic literature about impact analysis of modes of transport has continued, with a predominance of those related to port infrastructures; Acosta et al. (2011) not only provide an economic impact of the port of Algeciras, but also a forecast of its future expansion. Nevertheless, there are also examples about others means of transport in Spain, as those for the airport of Santander (Carrera-Gómez et al., 2004) or the logistic platform of Zaragoza (Sainz et al., 2013).

As in other countries, in Spain these methodologies have been also widely employed in works prepared by consultancies or institutions, as part of their economic impact analysis. In some cases, they are issued with the objective of social justification. These have been carried out not only for ports, such as the one for the port of Tarifa (Universidad de Cádiz, 2009), but also for rail (PWC, 2010) or airports (Analistas Económicos de Andalucía, 2007).

However, this paper is more in line with the studies that stablish the economic impact of a mode of transport in a region instead of the impact linked to a certain infrastructure, as the one carried out for the air transport in Canada (Snc-Lavalin, 2013) or for the port's sector in South Africa (Chang et al., 2014). In this line, we are analyzing the long-term effects of each mode of transport in the region of Andalusia.

After the literature review, there has not been detected any impact analysis comparing the relative importance of modes of transport in the Spanish economy or in any of its autonomous regions. Therefore, this paper fills the gap in the academic literature by providing such comparison among modes of transport, in particular in the autonomous region of Andalusia. In addition, this work is making use of a SAM model instead of IO tables, where the different modes of transport are disaggregated. This methodology has been already applied to analyze the impact of other sectors in the Andalusian economy (Cardenete and López, 2015).

3. Social Accounting Matrix and the model

3.1. Social Accounting Matrix

IO tables give a detailed account of inter-industry transactions in an equilibrium setup in which total supply matches the sum of intermediate and final demand. This methodology analyses the structural composition of the economy and the productive system. SAMs improve IO tables by introducing balanced accounts for factors, institutions, and other auxiliary accounts, to close the process of income distribution and income spending. As Stone (1962) pointed out, a SAM is an efficient and transparent device that presents the circular income flow of an economy over a period of time by means of a square flow matrix. Each row and corresponding column in the matrix contains information about the resources and uses of an account; they represent industries, factors income (labor and capital), institutions, tax instruments, and so forth. Because total resources (income) equal total uses (expenditures) for each account, the information in a SAM can be interpreted through zero benefit conditions, budget constraints, and markets clearing condition.

SAMs can be split in four, each of them with its own meaning:

Intermediate Consumption Matrix: It gathers the links among all the productive sectors in the economy. Columns represent the purchases of one sector to the others, and rows the sales of one sector to the others.

Primary Factors Matrix: It gathers the consumption that productive sectors require from the accounts of labor, capital, social contribution and imports.

End Use Matrix: It gathers by column the expenditures of households, government, savings, investment and exports.

Closing Matrix: It makes the difference with IO tables. This matrix gathers the links between the added value and the final demand, closing the circular flow of the economy. For households and the government, total consumption and investment expenditure is shown by row. Each column shows final consumption, taxes and savings.

Fig. 1 presents the structure of the SAM employed in this study, with 33 productive sectors, including 9 for the different modes of transport: freight by road, train and sea, and passengers by road, train, HST, air and sea, plus an additional sector covering all the annexed services. Table 1 list the accounts of the SAM used in this work.

The information in a SAM can be used to develop a SAM model in the same way that IO tables are employed to develop IO models.

SAM consist in a *nxn* matrix denoted as $Y = (Y_{ij})$ of income flows among the *n* accounts in the economy. Some are productive sectors, others are economic actors, such as consumers or institutions, and others are the accounts of capital, labor and taxes, in such a way that the account equality of the economy is satisfied: total income equals total expenditure.

Each column and the corresponding row provides the payments and sales of an account to the others. Each component Yij of the matrix shows the bilateral flow between the account *i (row)* and the account *j (column)*.

3.2. - SAM linear model

The average income flow from account *j* directed to account *i* is $aij = Yij/Yj$, $i, j = 1,.., n$. The total income of account *i* can be written as the product of average income flows directed to account *i* multiplied by the corresponding income levels:

$$Y_i = \sum_{j=1}^{n} \left(\frac{Y_{ij}}{Y_j}\right) Y_j = \sum_{j=1}^{m} \alpha_{ij} Y_j + \sum_{j=m+1}^{m+k} \alpha_{ij} Y; \quad m + k = n \tag{1}$$

Table 1
Account structure of SAM of Andalusia in 2010 with modes of transport disaggregated.

1	Agriculture	22	Transport of passenger by road
2	Cattle	23	Transport of cargo by road
3	Fishery	24	Transport of cargo by train
4	Extractives	25	Treansport of passenger by train (excluding high speed)
5	Oil refining and treatment of nuclear waste	26	Transport of passenger by high speed train (HST)
6	Electrical generation and distribution	27	Transport of passenger by air
7	Generation and distribution of gas, steam and hot water.	28	Transport of passenger by sea
8	Water capture, treatment and distribution	29	Transport of cargo by sea
9	Food	30	Activities Annexed to transport, mail and telegraph
10	Fabric and leather	31	Other Services
11	Wood made goods	32	Sale Services
12	Chemistry	33	No Sale Services
13	Mining and foundry	34	Labor
14	Metallic made goods	35	Capital
15	Maquinaria	36	Households and private institutions
16	Vehicles	37	Savings/Investment
17	Building Materials	38	Indirect Tax
18	Transport	39	Direct Tax
19	Other goods	40	Government
20	Building	41	Foreign Sector
21	Commerce		

Source: Own elaboration

Indexes *m* and *k* represent the split between exogenous and endogenous accounts. The average income flow matrix, *A*, can be therefore divided in four: *Amm*, *Amk*, *Akm*, and *Akk*. and the identity referred to the endogenous accounts can thus be expressed as

$$Ym = Amm\ Ym + Amk\ Yk, \tag{2}$$

and the income vector of the endogenous accounts follows the expression:

$$Ym = (I\text{-}Amm)^{-1}(Amk\ Yk) = M \cdot Z. \tag{3}$$

where $Z = Amk\ Yk$ is the vector of exogenous income directed to the endogenous accounts and $M = (I\text{-}\ Amm)^{-1}$ is the square generalized multiplier matrix. Each element in matrix *M* can be interpreted as the income accruing to account *i* when the vector of exogenous income directed to account *j* increases by just one unit. It has a similar meaning than the Leontief inverse, although it has the particularity that when it is

	Productive Sectors (1…25)	Productive Factors: - (26) Labour - (27) Capital	Institutions: - (28) Household and institutions - (30) Direct tax - (31) Indirect tax - (32) PPAA (Public Administrations)	(29) Savings/Investment	(33) Foreign Sector
Productive Sectors (1…25)	INTERMEDIATE CONSUMPTION MATRIX (1)	FINAL USE MATRIX (3)			
Productive Factors: - (26) Labour - (27) Capital Institutions: - (28) Household and institutions - (30) Direct tax - (31) Indirect tax - (32) PPAA (Public Administrations) (29) Savings/Investment (33) Foreign Sector	PRIMARY FACTORS MATRIX (2)	CLOSING MATRIX (4)			

Fig. 1. Brief structure of SAMAND2010.
Source: Own Elaboration

extended to SAM models links between production, factors income, income distribution and final demand are also taken into account. Submatrix A_{mk} shows how income flowing from exogenous accounts are shared between endogenous accounts.

Which accounts are selected to be endogenous and exogenous depends on which ones are explained (endogenous) by changes in others (exogenous). The solution is determined by the partition chosen: the larger the subset of endogenous accounts, the greater the income directed to all accounts when there is a one-unit increase in exogenous income.

Once the SAM linear model has been established, the same methodology used in Leontief models is also applied in this analysis.

3.3. Linear SAM model-based output multiplier decomposition

This methodology is developed from the work of Defourny and Thorbecke (1984) and Pyatt and Round (1985), and from the works of Polo et al. (1991) for the Spanish economy. IO tables gather the direct and indirect effects through the links among sectors. But SAMs also gathers the induced effects through the links between the rents of primary factors and final demand.

Find here after the different effects in which the output multipliers are split off, where *I* is the identity matrix, *A* is the matrix of technical coefficients (a_{ij}), *M* is the square generalized multiplier matrix and *Ml* denotes the Leontief inverse matrix:

- Direct or own effect effects = (I + A), It weights up the effect on the output of a sector to meet the changes in the final demand.
- Indirect or derived effects = (Ml-I-A), It weights the effect on the output of the rest of the sectors to meet the changes in the final demand of a certain sector.
- Induced effects = (M – Ml), It weights up the effect on the output due to changes in final demand as a consequence of an increase of rents.
- Total effects = Direct Effects + Derived Effects + Induced Effects. It is the total effect of a shock of one monetary unit in the sector *j*, and can be written in the following way:

$$\sum_{i=1}^{n} Ma_{ij} = Ma_{1j} + Ma_{2j} + \ldots + Ma_{nj} \tag{4}$$

where Ma_{ij} are the components of the square generalized multiplier matrix, denoted as *M*.

This procedure for breaking down the economy multipliers in the additive sum of three effects, each of one representing one effect in the economy, was stablished by Pyatt and Round (1979). It has been already used in sectorial studies in the Andalusian economy, as the one for the petrochemical sector (Cardenete and Sancho, 2006) and the aeronautical sector in Andalusia (Cardenete and López, 2015). The advantage of using SAMs instead of IO tables is the possibility to have a measure of induced effects, gathering the feedback effects from the accounts receiving income to the rest of accounts. This is an improvement in the process of obtaining a detailed picture of the economy with regards to IO linear models.

3.4. Employment and salary multipliers

These multipliers measure the effect on the employment and salaries when there is a shock in demand.

The employment multiplier for each sector is determined by:

$$E_j = \sum_{i=1}^{n} w_{n+1} b_{ij} \tag{5}$$

where $w_{n+1} = Y^{ei}/X_i$, Y^{ei} is the employment per sector, *Xi* is the total output of sector *i*, and b_{ij}, is the element in position *ij* in the matrix of multipliers *M*.

The notion of salary multipliers is the same than for the employment multipliers, although in this case the multiplier shows the effect of a shock in the final demand in terms of salaries.

The salary multiplier for each sector is determined by:

$$S_j = \sum_{i=1}^{n} s_{n+1} b_{ij} \tag{6}$$

where $S_{n+1} = W^{ei}/X_i$, W^{ei} is the salary per sector, *Xi* is total output of sector *i*, and b_{ij}, is the element in position *ij* in the matrix of multipliers M.

Employment and salary multipliers can also be disaggregated in direct, indirect and induced effects, as it has been done with output multipliers.

Both, employment and salary multipliers, provide additional information about the impact of sectors in the economy. Employment multipliers adds information about the total employment that an increase in the demand of one sector can create in the economy, and not only in one sector. The salary multiplier gives information about the generation of rents in the economy, that in the circular flow of the economy will generate induced effects; salary multipliers could then explain induced effects in some sectors.

Employment and salary effects have also been already introduced in sectorial studies in Andalusia (Cardenete et al., 2011).

4. Modelling the impact of modes of transport in the economy of Andalusia

The starting point has been the SAM already drawn up for the Andalusian economy for year 2010 (Cardenete et al., 2011), which is an update of the one for year 2005 (Cardenete and Fuentes, 2009). In the SAM of 2010 the sector of transport gathers all the different modes of transport. To have the different performance of each one, the accounts in the SAM are enlarged to disaggregate the sector of transport into their different modes. As a result, the sector of transport in the SAM of 2010 is replaced by eight new sectors, one per mode of transport, plus the sector of annexed services to transport. The SAM of year 2010 is an update of the one of year 2005, so the split has been done using sharing rules based on data from year 2005 and values from year 2010 when available.

The split of the primary consumption by columns has been done with data from the satellite sector of tourism in Andalusia (Department of Tourism and Commerce of Andalusia, 2005) and from the Andalusian and Spanish IO tables of year 2005, elaborated by the Andalusian Statistical Institute (IEA) and the National Institute of Statistics of Spain (INE). Finally, data has been updated to year 2010 with data from the yearly survey of services in Andalusia for year 2010 elaborated by IEA. To split the intermediate consumption of modes of transport by columns we have used data of year 2005 from IO tables of Spain and Andalusia, and transport companies as proxy (Vueling; Renfe).

In a SAM, the sum of rows equals the sum of columns. Therefore, we split the demand into the different modes of transport, keeping the sum by rows equals to the sum by columns, which has been done previously. The demand is split into their components by modes of transport, following a sharing rule based on data from the satellite sector of tourism of Andalusia and the IO tables of Spain and Andalusia of year 2005. We have also used IO tables of Spain and Andalusia of year 2005 to split the demand from productive sectors by rows.

Finally, the values in the closing matrix also need to be adjusted to comply with the equality of the sum by rows and columns, but it is solved with a system of equations that sets the values in the matrix that fulfils this requirement.

As a result of this process, we have a SAM of year 2010 for Andalusia, with new sectors, one per mode of transport plus the annexed services to transport. The disaggregation of sector of transport into their different modes will allow us to highlight the different performance of each mode of transport in the economy of Andalusia.

5. The different performance of modes of transport in Andalusia

The objective of this work is to gather the long-term effects in the economy of Andalusia of each mode of transport, once the infrastructures (airports, roads, ports, stations …) are in place, due to the operation of the transports (trains, buses, planes, ships or trucks). Additionally, there are also short-term effects linked to the construction of transport infrastructures, whose impacts are widely explored in the literature, as it has been shown in the literature review's paragraph.

With these data, we will assess the performance of each of mode of transport and we will compare them.

Labor, capital and consumption accounts have been considered as endogenous accounts to take into account the circular income inflow of the economy, gathering the feedback effects from the accounts receiving incomes to the rest of sectors.

5.1. Behavior of modes of transport in Andalusia

Table 2 shows how output multipliers differ appreciably from one mode of transport to each other, in absolute value and in their direct, indirect and induced effects. Different output multipliers indicate a different economic impact.

The results highlight the high values of (25) *Transport of passenger by train (excluded the high-speed train),* making it the mode with the highest value, although it is explained by the large amount of subsidies received. Most of its demand is due to final demand (households), and subsidies increases the relative weight of intermediate consumption of the column (25) as they minimize the cell gathering government taxation. As a consequence, when there is an increase on demand equivalent to monetary unit, as sum by rows equals sum by columns, intermediate consumption of column (25) reacts suppling more than in absence of subsidies. This is the key effect in the transmission of an increase in the demand of sector 25 to the total output in the economy, although there are also effects in the rest of sectors contributing to the total output. From the point of view of the model, a decrease in taxation results in greater technical coefficients.

On the other hand, the mode of transport with lower values is (27) *Transport of passengers by air*, due to its low indirect effect. It is an isolated sector, and one of the sectors with lower output multipliers in the economy.

5.2. Employment multipliers

Employment multipliers are going to be analyzed from two different points of view, in terms of absolute values and in terms of the capability of each mode to create indirect and induced employment per direct job. This approach is sometimes used to evaluate the quality of the employment generated by one activity.

For each sector, its employment multiplier means the rise in employment in Andalusia when the demand increases in 1.000 € in that sector.

Table 3 shows how (25) *Transport of passengers by train* is the one with the highest value, but it is a consequence of its high output multiplier due to subsidies. Excluding this mode of transport, the ones with highest multipliers are both transports by road (with highest values for (22) *Transport of passenger by road* than for (23) *Transport of loads by road*) and (24) *Transport of loads by train*. (28) *Transport of passengers by sea* is in an intermediate position. (26) *HST*, (27) *Air transport* and (29) *Transport of goods by sea* are in lower positions with low values. These sectors have values which are around one half of the road transport's ones. This means that the demand required to create employment is higher for (26) *HST* or *(27) Air transport* than for road transport. It is a consequence of the higher labor intensity of transport by road than transport by air, sea, or HST.

Table 4 shows how the performance of the modes of transport is different in terms of relative effects than in terms on absolute effects.

The highest positions in the table are occupied by (26) *HST,* (28) *Transport of loads by sea* and (27) *Air transport*, while the modes of transport by road are in lower positions. This situation is just the opposite one to the classification in terms of their absolute values (see Table 3). (27) *Air transport* and (29) *Transport of goods by sea* creates one additional job per direct employee, and (26) *HST* more than one, due to induced effects. This approach is used sometimes as a measure of the quality of the employment generated.

5.3. Salary multipliers

Table 5 shows salary multipliers. For each sector the salary multiplier points out the increase of total wage bill in the economy when the demand for that sector increases in one euro.

All modes of transport are relevant in terms of salary multipliers. All of them are among the most important sectors in the economy generating salary income. Excluding (25) *Transport of passenger by train (excluding high speed),* the sectors with higher values are (24) *Transport of goods by train* and (22) *Transport of passenger by road*. The sectors (26) *HST* and (27) *Transport of passenger by air* have lower values, but with better figures for the air transport.

5.4. Performance of each mode of transport in the economy of Andalusia. Differences between them and implications for economic policy

Once that we have calculated the multipliers for each mode of transport, we can compare them. Table 6 puts together all the multipliers for each mode of transport of cargo, showing their different impact in the economy of Andalusia.

The comparison between (24) *Transport of cargo by train* and (23) *by road* is interesting, because they are two modes of transport that very often enter into competition. (24) *Transport by train* has better performance than (23) *Transport by road*, in terms of output and salaries multipliers. An increase in its demand contribute to augment salaries more than (23) *Transport by road*, and this effect contributes to the induced effects in the total output. (23) *Transport by road* has only better behavior in terms of employment, because it is a more labor-intensive sector, although it has poorer performance in terms of employment induced by direct jobs. However, the larger number of employments created by an

Table 2
Output multipliers break down in Andalusia.

Output **Multipliers** and **Position** among all sectors in the economy (33)									
Sectors		Direct Effect	%	Indirect Effect	%	Induced Effect	%	Total Effect	Position
25	Treansport of passenger by train (excluding high speed)	1.97	38%	0.83	16%	2.40	46%	5.20	1
28	Transport of passenger by sea	1.61	52%	0.50	16%	0.99	32%	3.10	6
26	Transport of passenger by high speed train (HST)	1.56	52%	0.42	14%	0.99	33%	2.97	13
22	Transport of passenger by road	1.30	44%	0.23	8%	1.40	48%	2.93	15
24	Transport of goods by train	1.37	47%	0.32	11%	1.23	42%	2.91	16
29	Transport of goods by sea	1.49	55%	0.30	11%	0.91	34%	2.70	20
23	Transport of goods by road	1.31	50%	0.21	8%	1.11	42%	2.63	22
27	Transport of passenger by air	1.33	56%	0.16	7%	0.88	37%	2.37	29

Source: Authors' calculations, based on SAM linear model for year 2010 with modes of transport disaggregated by authors.

Table 3
Additive break down of employment multipliers in Andalusia, ordered by total effect.

Number of employment created by a sock in demand of 1 000€ and **Position** among all sector in the economy (33)									
Sectors		Direct Effect	% of Total Effect	Indirect Effect	% of Total Effect	Induced Effect	% of Total Effect	Total Effect	Position
25	Treansport of passenger by train (excluding high speed)	0.0358	61%	0.0067	11%	0.0166	28%	0.0591	1
22	Transport of passenger by road	0.0226	66%	0.0017	5%	0.0097	29%	0.0340	3
23	Transport of goods by road	0.0194	68%	0.0016	6%	0.0077	27%	0.0287	8
24	Transport of goods by train	0.0157	59%	0.0026	10%	0.0085	32%	0.0268	10
28	Transport of passenger by sea	0.0135	57%	0.0035	15%	0.0069	29%	0.0238	18
26	Transport of passenger by high speed train (HST)	0.0082	44%	0.0037	20%	0.0069	36%	0.0188	25
29	Transport of goods by sea	0.0083	49%	0.0025	15%	0.0063	37%	0.0171	27
27	Transport of passenger by air	0.0077	51%	0.0014	9%	0.0061	40%	0.0151	30

Source: Authors' calculations, based on SAM linear model for year 2010 with modes of transport disaggregated by authors.

Table 4
Additive break down of employment multipliers in the Andalusia, ordered by relative effect.

Employment created relative to direct employment and **Position** among all sector in the economy (33)					
Sectors		Indirect Effect	Induced Effect	Total Effect	Position
26	Transport of passenger by high speed train (AVE)	0.45	0.83	2.29	3
29	Transport of goods by sea	0.31	0.75	2.06	6
27	Transport of passenger by air	0.18	0.79	1.98	7
28	Transport of passenger by sea	0.26	0.51	1.77	12
24	Transport of goods by train	0.16	0.54	1.71	14
25	Treansport of passenger by train (excluding high speed)	0.19	0.46	1.65	16
22	Transport of passenger by road	0.07	0.43	1.50	24
23	Transport of goods by road	0.08	0.39	1.48	28

Source: Authors' calculations, based on SAM linear model for year 2010 with modes of transport disaggregated by authors.

Table 5
Salary multipliers in Andalusia, ordered by total effect.

Increase of total salary income by a shock in demand of one € and **Position** among all sector in the economy (33)			
Sectors		Total Effect	Position
25	Treansport of passenger by train (excluding high speed)	1.51	1
24	Transport of goods by train	0.69	3
22	Transport of passenger by road	0.67	4
23	Transport of goods by road	0.53	6
28	Transport of passenger by sea	0.49	9
27	Transport of passenger by air	0.48	10
29	Transport of cargo by sea	0.42	14
26	Transport of passenger by high speed train (HST)	0.41	15

Source: Authors' calculations, based on SAM linear model for year 2010 with modes of transport disaggregated by authors.

increase in the demand of (23) *Transport by road* do not produce more salaries in the economy than the same increase in (24) *Transport by train.* (29) *Transport of cargo by sea* cannot always compete with train and road. Anyway, it has the best performance in terms of induced employment and the worst in terms of salaries and labor multipliers.

For policy makers this is an important result, as it shed light about the effect of substituting road transport by rail transport, that is a highly topical question. It will lead to a rise in total output, as well as in total wages in the economy. On the other hand, it will have a negative impact in terms of employment, although it is of better quality as it induced more indirect and induced employment per direct job.

When we focus on transport of passengers, Table 7 shows that the modes of transport that can better favor an increase of the total output are (28) *Transport of passenger by sea*, (26) *HST* or (22) *road*, and the one with the worst performance is (27) *Transport by air*.

In terms of employment, the one that offers the best results is (22) *Transport by road,* and the one with the poorest performance is again (27) *Transport by air*. However, it has also to be taken into account that the capability to generate indirect and induced employment of (27) *Transport by air,* once that a job has been created in that sector, is higher than (22) *Transport by road*, but still lower than (26) *HST*. Finally, an increase in the demand of (22) *Transport by road* produces the best results in terms of increase of salaries. In this case the largest rise in the number of jobs also gives the best salary multiplier among all modes of transport of passengers.

In the transport of passengers, we also have to take into account that sometimes two modes of transport are not substitutive, and as a consequence we cannot favor one mode in detriment of another: transport of passenger by road cannot be compared with HST or air transport due to the duration of the trip. Sea transport cannot compete with road transport as not all destines have a seaport. But sometimes the modes of transport enter into competition, it is when they also compete for investment on infrastructures that favors an increase in demand. These are the one of the highest interest for policy makers. One typical case is the competition between *HST* and *air transport.* In the case of Andalusia, (26) *HST* has better impact in the economy in terms of the total output of the economy (multiplier is 25% higher), in the creation of employment (multiplier is also 25% higher) and in the creation of indirect and induced employment per direct job (0.31 additional jobs, what means 32% more than air transport). (27) *Transport by air* only offers a better performance in creating labor income (air transport salary multiplier is 17% higher than HST). With this information, policy makers can anticipate that by favoring substitution of air transport by HST there will be a rise in total output and total employment in the economy, although total wages will shrink.

All these results are based on the use of SAM linear model under the premises of linearity, constant prices and no restriction of factors.

6. Conclusions

This work highlights how the performance of the different modes of transport in the economy of Andalusia differs between them. It is thus very interesting to have data with the modes of transport disaggregated, Policy makers should be aware about the different effects of promoting one mode instead of the others. If there is no alternative, they have to evaluate the impact in the economy in order to have more data about the

Table 6
Summary of multipliers of modes of freight transport in Andalusia.

Sectors of freight transport		Multipliers			
		*Total Output**	*Total Employment***	*Total Jobs Relative to Direct Employment ****	*Salary*****
23	Transport of cargo by road	2,63	0,0287	1,48	0,53
24	Transport of cargo by train	2,91	0,0268	1,71	0,69
29	Transport of cargo by sea	2,7	0,0171	2,06	0,42

Maximum Value
Minimum Value

* As increase in total output in the economomy when the demand of the sector increases one monetary unit
** As increase in number of employments when the demand increases in 1000 €
*** As total job created relative to the generation of direct employment
**** As increae in total salary income when the demand increases in one €

Source: Authors' calculations, based on SAM linear model for year 2010 with modes of transport disaggregated by authors.

Table 7
Summary of multipliers of modes of transport of passengers in Andalusia.

Sectors of transport of passengers		Multipliers			
		*Total Output**	*Total Employment***	*Total Jobs Relative to Direct Employment ****	*Salary*****
22	Transport of passenger by road	2,93	0,034	1,5	0,67
25	Treansport of passenger by train (excluding high spe	5,2	0,0591	1,65	1,51
26	Transport of passenger by high speed train (HST)	2,97	0,0188	2,29	0,41
27	Transport of passenger by air	2,37	0,0151	1,98	0,48
28	Transport of passenger by sea	3,1	0,0238	1,77	0,49

Maximum Value
Minimum Value

* As increase in total output in the economomy when the demand of the sector increases one monetary unit
** As increase in number of employments when the demand increases in 1000 €
*** As total job created relative to the generation of direct employment
**** As increae in total salary income when the demand increases in one €

(25) Transport of passenger by train (excluding high speed) not considered.
Source: Authors' calculations, based on SAM linear model for year 2010 with modes of transport disaggregated by authors.

results of investing in infrastructures of transport or other policies to increase their demand. By using a SAM, we have also enriched the results with the induced effects of the circular flow of the economy, which gathers the income generation and spending. This effect is sometimes very important, and it establishes differences in the multipliers.

The results of this exercise are useful to have more information about the impact of favoring the demand of different modes of transport, mainly when they are competing for investment.

According to the model that has been used, (24) *transport of loads by train* has better performance than (23) *transport of loads by road* in terms of output and salary multipliers, due to stronger links with the rest of the sectors in the economy. (23) *transport of loads by road* only offers better performance in terms of employment due to its labor intensity, but with lower ratio of indirect and induced employment created per direct job. Therefore, the policies favoring freight transport by rail instead of by road will lead to a rise in total output and total wages in the economy, but will have a negative impact in terms of employment.

In transport of passengers in Andalusia in 2010, in routes where (27) *Transport of passengers by air* and (26) *by HST* are competing, the impact of (26) *HST* in the economy is better that the one of (27) *Transport by air*. (26) *HST* has better performance in the economy in terms of the total output of the economy, in the creation of employment and in the generation of indirect and induced employment per direct job This data adds information about the effect of favoring HST over air transport: increase of total output, and more and better-quality jobs. Among all modes of transport of passengers, (28) T*ransport by sea* has the better performance in terms of output multiplier. (22) T*ransport by road* is the most intensive in labor, and as consequence the one that generates more labor income in the economy, although it has the poorest results in terms of the number of jobs created per direct employment.

In this respect, an interesting extension of this research could be to make an approach by using other models such as Computer General Equilibrium (CGE), which are much more elaborated and could provide with more accurate information and overcome some of the limitations of linear models.

References

Acosta, M., Coronado, D., Cerbán, Ma M., 2011. The economic impact of the port of Tarifa (Spain) in 2007 and the forecast for 2015. Int. J. Transp. Econ. 38 (3), 243–263.
Analistas Económicos de Andalucía, 2007. El Aeropuerto de Málaga, Motor de Desarrollo Económico. Fundación CIEDES, Málaga.

Bröcker, J., Korzhenevych, A., Schürmann, C., 2010. Assessing spatial equity and efficiency impacts of transport infrastructure projects. Transport. Res. Part B: Methodologycal 44 (7), 795–811.

Buffington, J.L., Wildenthal, M.T., 1998. Estimated Economic Impact of Selected Highway Widening Projects in Texas. Texas Transportation Institute, Texas A&M University. Available at: http://ntl.bts.gov/lib/20000/20800/20823/PB98153315.pdf.

Cardenete, M.A., Fuentes, P., 2009. Una estimación de la matriz de contabilidad social de Andalucía de 2005 a precios de adquisición. In: 3rd Spanish Conference on Input-output Analysis. Albacete, 30th Sept-2nd Oct 2009.

Cardenete, M.A., López, R., 2015. Análisis del sector Aeroespacial en Andalucía. Econ. Ind. 398, 155–166.

Cardenete, M.A., Sancho, F., 2006. Análisis de impacto económico de sectores industriales a partir de Matrices de Contabilidad Social. Econ. Ind. 359, 211–222.

Cardenete, M.A., Sancho, F., 2012. The role of supply constrains in Multiplier Analysis. Econ. Syst. Res. 24 (1), 21–34.

Cardenete, M.A., Mainar, A., Fuentes, P., Delgado, M.C., 2011. Análisis del mercado laboral en la provincia de Sevilla para detectar sectores estratégicos y claves. Unión Provincial de CCOO de Sevilla, Sevilla.

Carrera-Gómez, G., Coto-Millán, P., Sainz-González, R., Inglada-López DE Sabando, V., 2004. Economic impact of santander airport. In: Coto-Millan, P. (Ed.), Essays on Microeconomics and Industrial Organization. Physica-Verlag Heidelberg, pp. 317–332.

Chang, S., 1978. In defence of ports economic impact studies. Transport. J. 17, 79–85.

Chang, Y.T., Shin, S.H., Lee, P.T.W., 2014. Economic impact of port sectors on South African economy: an input–output analysis. Transport Pol. 35, 333–340.

Chen, Z., Xue, J., Rose, A.Z., Haynes, K.E., 2016. The impact of high-speed rail investment on economic and environmental change in China: a Dynamic CGE analysis. Transport. Res. Pol. Pract. 92, 232–245.

Christ, C.G., 1955. A review of input-output analysis. In: Christ, C.G. (Ed.), Input-output Analysis: an Appraisal. Princeton University Press, Princeton, NJ.

Coto-Millán, P., Mateo-Mantecón, I., Villaverde-Castro, J., 2010. The economic impact of ports: its importance for the region and also the hinterland. In: Coto-Millan, P., Pesquera, M.A., Castanedo, J. (Eds.), Essays on Ports Economics. Springer-Verlag Berlin Heidelberg, pp. 167–200.

Defourny, J., Thorbecke, E., 1984. Structural path analysis and multiplier decomposition within a Social Accounting Matrix framework. Econ. J. 94 (373), 11–136.

Department of Tourism and Commerce of Andalusia. CSTA2005 Tables. Available at: http://www.juntadeandalucia.es/turismocomercioydeporte/publicaciones/143372506_tablas05.pdf.

IEA, 2005. Input-output Framework of Andalusia. Regional Government of Andalusia, Seville. Available at: http://www.juntadeandalucia.es/institutodeestadisticaycartografia/institutodeestadisticaycartografia/mioan/mioan2005/index.htm.

IEA (Instituto de Estadística de Andalucía) [Andalusia Statistics Institute]. Annual Accounts of Andalusia. Seville, Regional Government of Andalusia. Available at: http://www.juntadeandalucia.es/institutodeestadisticaycartografia/anuario/anuario12/anuario12c04.htm (Accessed June 2015).

INE (Instituto Nacional de Estadística) [National Institute of Statistics], 2005 Input-Output Framework. Madrid, Ministerio de Economía. Available at: http://www.ine.es/daco/daco42/cne00/cneio2000.htm.

Kockelman, K., Chen, D., Larsen, K., Nichols, B., 2013. The Economics of Transportation Systems: a Reference for Practitioners. University of Texas at Austin. Available at: http://www.utexas.edu/research/ctr/pdf_reports/0_6628_P1.pdf.

Leontief, W., 1966. Input-output Economics. Oxford University Press, New York.

Merk, O.M., Manshanden, W.J.J., Droes, M.I., 2013. Inter-regional spillovers of seaports: the case of North-West Europe. Int. J. Transp. Econ. 40 (3), 401–417.

Pérez, J., García, G., 2004. Ports economic impact: literature review and alternative proposal. J. Marit. Res. 1 (3), 85–104.

Polo, C., Roland-Holst, D., Sancho, F., 1991. Descomposición de multiplicadores en un modelo multisectorial: una aplicación al caso español. Invest. Econ. 15 (1), 53–69.

Pricewaterhousecoopers, PWC, 2010. Impacto socioeconómico de la llegada del AVE a Valencia. Generalitat Valenciana.

Pyatt, G., Round, J.I., 1979. Accounting and fixed price multipliers in a Social Accounting Matrix framework. Econ. J. 89 (356), 850–873.

Pyatt, G., Round, J.I. (Eds.), 1985. Social Accounting Matrices: a Basis for Planning. The World Bank, Washington, DC.

Renfe. Economic Report 2007. Available at: http://www.renfe.com/docs/2007_memoria_economica.pdf.

Sainz, R., Baños, J., Val, S., Kattour, S.J., 2013. The economic impact of logistics infrastructure: the case of PLAZA - the Zaragoza Logistics Platform. Transport. Plann. Technol. 36 (4), 299–238.

Smith, C.D.M., 2014. The Economic Impact of Commercial Airports in 2013. Airports Council International, North America. Available at: http://www.aci-na.org/sites/default/files/economic_impact_of_commercial_aviation_2013.pdf.

Snc-Lavalin, 2013. The Economic Impact of the Air Transportation Industry in Canada. Canadian Airports Council (CAC), Ottawa, ON.

Stone, R., 1962. A social accounting matrix for 1960. In: A Programme for Growth. Chapman and Hall Ltd., London.

Universidad de Cádiz, 2009. Evaluación del Impacto Económico del Puerto de Tarifa. Departamento de Economía General. Universidad de Cádiz. Available at: http://webserver.apba.es/portal/page?_pageid=394172031&_dad=portal&_schema=PORTAL.

Verbeke, A., Debisschop, K., 1996. A note on the use of port economic impact studies for the evaluation of large scale port projects. Int. J. Transp. Econ. 23 (3), 246–266.

Villaverde, J., Coto-Millán, P., 1998. Port economic impact: methodologies and application to the port of Santander. Int. J. Transp. Econ. 25 (2), 159–179.

Vistas Consulting Ltd, 2015. Dublin Airport Economic Impact Study. DAA Dublin Airport. Available at: http://dublinairport.com/Libraries/sustainability/Dublin_Airport_Economic_Impact_Study_April_2015.sflb.ashx.

Vueling. Economic Report 2005. Available at: http://www.cnmv.es/AUDITA/2006/10052.pdf.

Waters, R., 1977. Port Economic impact studies: practice and assessment. Transport. J. 16, 14–18.