IIOA Conference
Atlantic City, 2017

ECONOMIC IMPACT OF THE NEW MEDITERRANEAN RAIL CORRIDOR IN ANDALUSIA: A DYNAMIC CGE APPROACH.

M. ALEJANDRO CARDENETE* AND ROBERTO LÓPEZ-CABACO**

** Department of Economics, Universidad Loyola de Andalucía, Campus Palmas Altas, 41014 Seville, Spain. ** Higher Technical School of Engineering, Seville University, Camino de los Descubrimientos s/n, 41092, Seville, Spain.*

ABSTRACT. The transport sector is the life blood of the economy that serves as engine that fuels economic growth. From this perspective, the European Union is favouring the improvement of communications all around Europe. The goal is to create a European net of transports (TEN-T), and in this net the port of Algeciras in the strait of Gibraltar is an important node, as a primary rail hub for both the Mediterranean and Atlantic TEN-T rail corridors of the European Core Network. This paper assesses the impact of this new infrastructure in the economy of Andalusia through the use of a Computational General Equilibrium (CGE) model. The CGE will also add a dynamic component to evaluate the effect along several periods of time, based on the growth model of Ramsey with a representative consumer with infinite lifetime. The calibration of the model is done with the Social Accounting Matrix (SAM) of Andalusia of 2010 where the different modes of transport have been previously disaggregated. This work evaluates the long-term impact of the new rail infrastructure in the port of Algeciras, in terms of an increase of the traffic and also a shift from the road transport to the train. This work, however, is not taking into account other effects such as the impact of the construction of the infrastructures, neither the effect of the attractiveness of the area to the installation of new industries. Although impact analysis has been previously applied to assess the impact of transport infrastructures in Spain, these have made use of linear models, which underlay assumptions that are very restrictive. CGE models shifts these limitations, providing more realistic values; therefore, this work fill in this gap by introducing a Dynamic CGE model that overcome some of the limitations of linear models.

Key Words: Computed General Equilibrium, Rail Transport, Andalusia, Mediterranean Corridor.
JEL Classification: H54, O18, O25, R40, L92, C68

1. Introduction

One of the relevant sectors in any economy is the sector of transports, due to their weight in the economy, and how it interacts with the rest of sectors. Manufactured goods and rough materials are moved from one place to another through a transport system. Transport makes also possible the movement of people, what ease the commercial activity of companies beyond the limits of their geographical area of activity. From this perspective, the European Union is favoring the improvement of communications all around Europe. The goal is to create a European net of transports (TEN-T).

In this net, the port of Algeciras is an important node. It is classified as a primary rail hub for both, the Mediterranean and Atlantic TEN-T rail corridors of the European Core Network. It is among Mediterranean and Spanish more important ports. It is also placed in an exceptional geo-strategic location, on the crossroads of the world's main cargo shipping lanes, close to the Strait of Gibraltar in the south of Spain. In 2013, it broke through the 90-million tons' barrier for total cargo throughput for first time in its history.

Once containers arrive to their destiny port, the shipping line has to decide which mean of ground transport will be used to carry the containers to their final destiny. The train is usually the most efficient and less costly ground mean of transport; therefore, the improvement of the access by train to the center of Spain and to the rest of Europe will has an impact in the port´s activity. In addition, this infrastructure can also promote a shift from road to transport by rail. In 2014 roughly 138.000 tons were transported by rail versus 9.500.000 tons by road in the port of Algeciras. The starting of the infrastructure is foreseen for the year 2020. The works started in 2015, and the cost is partially financed by the European Union through FEDER funds.

This paper is organized as follows. Section two reviews the methodology used in this chapter. In the third, the main characteristics of the dynamic model are explained. Fourth section describes the different scenarios as well as how the impact has been modeled. In section five results are shown and analyzed. Finally, section 6 concludes and summarizes.

2. Methodology

This work assesses the effect of this new infrastructure in the Andalusian economy through the use of a Computational General Equilibrium (CGE) model. The CGE will also add a dynamic component to evaluate the effect along several periods of time.

The concept of general equilibrium in the economy was developed at the end of 19^{th} century by Walras (1874), and later completed by Arrow and Debrew (1954), although CGE models finally gathered momentum with the development of the computers at the end of the 20^{th}

century. CGE provides a modelling approach that overcomes some of of the limitations of lineal models, since it takes into account price effects and 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. The evaluation of the parameters that reflect the behavior of the economic agents is done through the data in the Social Accounting Matrix (SAM). A SAM includes data for the transactions between the different agents in the economy, and it represents the equilibrium of reference that the CGE treats to reproduce.

Most of the CGE models developed over the years are static. They are useful to compare the equilibrium ex-ante with the one reached after the simulation of a shock or an economic policy. However, in certain cases it could be useful to have a growth path for the endogenous variables. This is the goal of dynamic CGE models. The most popular approach is the growth model of Ramsey with a representative consumer with infinite lifetime. The model of Ramsey (1928) was later on improved by Cass (1965) and Koopmans (1965). However, there are also models based on overlapping generations. Scarf and Hansen (1973) started the use of dynamic CGE models, although Johansen (1974) was the first one to develop a dynamic CGE to depict the Norwegian economy. Harberger (1962) was another early user of the dynamic CGE models to show the impact of taxation in an economy with two sectors.

Since nineties, dynamic CGE models have become more common in the literature. These models have been used to analyze policy issues in disciplines such as taxation, international trade or climate change. A good review of the literature about dynamic-CGE models, including recent applications, can be found in Cardente and Delgado (2015), which is also the last application of this family of models to the Andalusian economy.

Dynamic-CGE models have been also used in the field of transportation. The Spatial CGE models are widely used in the impact analysis of infrastructures. Instead on including transportation as a production sector, Bröcker et al. (2004) treated it by assuming that goods lose value in transit between regions in proportion to the transport costs, in line with the "iceberg" model of Samuelson (1954). Latter on Bröcker and Korzhenevych (2013) propose a dynamic extension that allows factors to adjust. Rather than iterating a series of static models, Bröcker and Korzhenevych's model is forward looking and formulated in continuous time. Kim et al. (2004) use the concept of spatial accessibility explored in Vickerman et al. (1999) to model the effects of transport. This dynamic model consists of a within-period static CGE model combined with an intertemporal model to update exogenous variables, such as capital stock that is determined by investment, as well as population and government expenditure.

The model is thus recursive, and, unlike Bröcker and Korzhenevych (2013), decisions are only optimized for each static period of time.

3. One Applied General Equilibrium Model

The CGE model in this work is a numerical representation of the Andalusian economy following the basic principles of the Walrasian equilibrium. The fundamentals of these models are well explained in works as those from Dervis et al. (1982), and more recently from Ginsburgh and Keyzer (2002), Kehoe at al. (2005), Hosoe et al. (2010), Burfisher (2011) and Cardenete et al. (2012)

3.1. Static Model

A static general equilibrium model is the basis for the within period equilibrium. This model includes the following actors and markets:

1. Producers

The production technology is given by a nested production function. In the first level the overall input y_i is obtained combining domestic q_i and imported m_i outputs according to the Armington (1969) hypothesis, with a CES aggregator:

$$y_j = \left[\left(\mu_{qj} \cdot q_j \right)^{\alpha_j} + \left(\mu_{mj} \cdot m_j \right)^{\alpha_j} \right]^{\frac{1}{\alpha_j}} \tag{1}$$

In the second level of the nested technology, the domestic output of a sector is obtained by combining, through a Leontief technology, inputs from the rest of sectors and value-added, with fixed coefficients a_{ij} and v_i:

$$q_j = \min\left(\frac{y_{1j}}{a_{1j}}, \frac{y_{2j}}{a_{2j}}, \ldots, \frac{y_{33j}}{a_{33j}}, \frac{VA_j}{v_j} \right) \qquad j = 1,2\ldots,33 \tag{2}$$

Where y_{ij} are que quantities of the good *i* available for the manufacturing of the domestic good *j*; a_{ij} are the technical coefficients that represent the technology of the production process: a_{ij} is the quantity of goods from sector *i* that are required for the manufacturing of one unit of the domestic product *j*. a_{ij} are also the elements in the matrix of technical coefficients denoted as *A* that is obtained from the Social Accounting Matrix (SAM). VA_j is the added value, and v_j is the amount of VA_j that is required for the manufacturing of one unit of domestic good *j*. SAM is an extension of Input-Output (IO) tables (Leontief, 1941, 1951), first developed by Stone (1962), and they give a detailed account of interindustry transactions in an equilibrium setup in which total supply matches the sum of intermediate and final demand.

In the third level, the quantity of value-added for sector *j* is determined by the aggregation of primary factors labor (L_j) and capital (K_j) by a CES technology:

$$VA_j = \left[\left(\gamma_{Lj} \cdot L_j\right)^{\beta_j} + \left(\gamma_{Kj} \cdot K_j\right)^{\beta_j} \right]^{\frac{1}{\beta_j}} \tag{3}$$

Elasticities have been set to 0,5. It represent a low elasticity but within the range of values usually found in the literature.

All agents, consumers and firms, behave rationally as utility and profit maximizers, and as constant returns of scale are assumed for firms, to maximize profits for them is the same than to minimize cost.

2. Consumers

On the demand side, there is one representative consumer *h* that demands final consumption C_j of each good *j*, and saving, S_v. The objective of the consumer is to maximize a Cobb-Douglas utility aggregator subject to a disposable income constraint, $YDISP_h$, and a price vector for goods $\mathbf{p}(p_1,\ldots p_j,\ldots)$ and for primary factors $\mathbf{w}(w, r)$, where *w* and *r* are the prices of labor and capital.

$$\begin{aligned} & Max U_h\left(C_{jh}, S_h\right) = \left(\prod_{j=1}^{n} C_{jh}^{\chi_{jh}} \right) S_h^{\kappa_h} \qquad j = 1,2,\ldots,33 \\ & s.t. YDISP_h = \sum_{j=1}^{n} p_j C_{jh} + pinv S_h \end{aligned} \tag{4}$$

χ and κ are the coefficients of participation in the consumption of goods and saving; therefore, they represent the elasticities of consumption. p_j is the price of the good *j* and *pinv* is the price of the good of investment for consumer *h*.

Total disposable income is financed by the sale of the primary inputs, labor and capital. As a result of the sale of these inputs, the customer pays taxes; *ID* is the tax rate on the consumer´s income and *CO* is the employee´s contribution to the social security. The customer also receives lump transfers from the government and also consumes public goods *TSM*. There are also transferences from the rest of the world *TRM*. Disposable income for consumption is gross income minus taxes,

$$YDISP = wL + rK + ipcTSP + TRM - ID(rK + ipcTSP + TRM + wL) - CO \cdot wL \tag{5}$$

where *w* and *r* are the prices of the primary factors, labor and capital, and *ipc* is the consumer price index.

Rearranging:

$$YDISP = (1 - ID)(rK + ipcTSP + TRM) + (1 - ID - CO)wL \tag{6}$$

In summary, the consumer will maximize the utility of consumer goods and savings, subject to the disposable income restriction.

3. Public Sector

The government is a special agent in the economy that taxes exchanges between the rest of agents in order to get resources. The government will finance its activity with them. On the other hand, it also transfers resources to the private sector through the consumption of goods and services. The difference between income and expenses will determine the deficit. The income from the taxation to the productive activity follows the next expression:

$$RIP = \sum_{j=1}^{n} \frac{\tau_j}{1+\tau_j} \cdot y_j p_j \tag{7}$$

RIP is the collection of indirect taxation to the production, including VAT. τ_j is the tax rate on production of sector *j*,

The government taxes the labor in two different ways. One way is through the employer´s contribution to the social security. The collection of this tax is denoted as *RP* and CP_j is the rate of employer´s contribution to the social security.

$$RP = \sum_{j=1}^{n} CP_j w\, l_j \tag{8}$$

Another way is by the employee´s contribution, whose collection is denoted as *RO*. Taking into account that there is only one representative consumer, *RO* is defined as follows:

$$RO = CO \cdot w \cdot L \tag{9}$$

Tariff for imports has not been considered as most of them come from the rest of Spain and the UE. The government also obtains resources from the direct taxation on consumer´s income.

$$RD = ID\left(w \cdot L + r \cdot K + ipc \cdot TSP + TRM\right) \tag{10}$$

The total collection of taxes by the government is thus:

$$R = RIP + RO + RP + RD \tag{11}$$

In our model the demand of the public sector is kept as steady, and denoted as DC_j. The government deficit D is consequently endogenously determined as follows:

$$D = -R + TSP\ \ ipc + \sum_{j=1}^{n} DC_j\, p_j \tag{12}$$

4. External Sector

The Andalusian economy is negligible compared with the rest of the world. Based on this assumption, the demand of foreign sector is assumed to be exogenously given, not being influenced by domestic variables. On the other hand, imports are considered as imperfect substitutes for domestic production, following the Armington hypothesis, and they are endogenously determined. According to this hypothesis for the external sector, it could be an external deficit F, which is endogenously determined.

$$F = prm \sum_{j=1}^{n} m_j - TRM - prm \sum_{j=1}^{n} EXP_j \qquad j = 1,2,...,33 \tag{12}$$

Where *prm* is the weighed averaged price of the international market, EXP_j is the external demand of goods from sector *j* and m_j the imported goods of sector *j*.

5. Saving and Investment.

This is a saving driven model, for this reason the level of investment is endogenously determined by saving, that is endogenously defined by the preferences of consumers and the deficit of the government and of the external sector. *pinv* is a price index for the investment goods.

$$pinv \sum_{j=1}^{n} INV_j = S\ \ pinv + DP + DPRM \tag{13}$$

The demand of investment is shared between sectors. When the government decreases its demand of goods and services, the government deficit also decreases; therefore, the demand of investment increases. This is important to understand how the general equilibrium works and how it impacts to macroeconomic aggregate magnitudes.

6. Prices

Prices are endogenous in the model and they are made up taking into account the production and prices of goods and primary factors. There is an internal price pi_i of the locally produced good *i* as defined in expression (14) where pva_i denotes the price index for added value used in sector *i*, under the zero-profit condition. There is also a final price p_i that also takes into account the participation of imported goods in the production of final products and indirect taxation τ_i to production, as we can see in (15). In this expression ξ_i and ζ_i represent, respectively, the participation of locally produced and imported good in the final product.

$$pi_i = pva_i \cdot v_i + \sum_{j=1}^{n} p_j \cdot a_{ij} \tag{14}$$

$$p_i = (1+\tau_i)(\xi_i \cdot pi_i + \zeta_i \cdot prm) \tag{15}$$

7. Labor Market

Labor market behavior is imposed assuming that the real wage is sensitive to the unemployment rate. This sensitivity is related to the power of unions, or any other socioeconomic factors inducing frictions and rigidities in the labor market. The idea behind the proposed formulation is that of a wage curve (Blanchflower and Oswald, 1990, 1994) that captures the relationship between the real wage $(w_l/(p \cdot \gamma))$ and the unemployment rate u through a parameter β.

This model follows the implementation of Kehoe et al. (1995), based on the use of the elasticity of the real wage relative to the unemployment rate:

$$\overline{w} = \left(\frac{1-u}{1-\overline{u}}\right)^{\frac{1}{\beta}} \tag{16}$$

where $\overline{w}$ is the real wage rate and $\overline{u}$ is the benchmark unemployment rate. Salaries are rigid when β is large, and salaries are more flexible when β is decreasing.

8. Model Resolution

Due to the law of Walras, one equation is redundant. For this reason, one of the prices has to be chosen as *numéraire* and results are referred to it. In this case, the net price of labor has been chosen as numéraire.

The economic structure of the model is translated to a nonlinear system of equations. The equilibrium is reached when the consumers maximize their utility and firms their benefits. In addition, the government redistributes among the different actors in the economy. All markets also reach their equilibrium; at each market of factors and goods the demand equals the supply.

GAMS software module computes the benchmark equilibrium and uses it as an internal basis for subsequent simulation. This guarantees very fast compilation and execution time, and in practice yields convergence in all studied cases.

9. The Database

The SAM represents the equilibrium in the economy. Once the model is stablished, all parameters in the model need to be calibrated to reproduce such equilibrium. This model is calibrated using as reference the SAM of the Andalusian economy for 2010 assembled by Cardenete et al (2011) with the sectors of transport disaggregated (Cardenete and López, 2014). Table 1 presents the SAM structure of accounts. It includes 33 productive sectors: the 25 original ones where the sector of transport has been split in 8 sectors of transport plus the annexed services to the transport. It also includes two primary factors (labor and capital), a capital account (savings and investment), a private consumption account, a foreign sector, a government account that collects the taxation, one indirect tax to production, a direct taxation to the next income, and taxation to the labor. The matrix structure is such that for each sector the sum by column equals the sum by row.

Table 1.

Structure of SAM of Andalusia (2010)

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	Extractivas	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 (AVE)
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, tratment 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.

3.2. Dynamic Model. The growth model of Ramsey

There are different approaches to develop a Dynamic-CGE. The growth model of Ramsey is the most widely used in the literature. This approach is based on the growth model of Ramsey (1928), later improved by Cass (1965) and Koopmans (1965). The model behaves in a different way depending on whether the economy is in a steady state or not. The steady state is the one where the economic aggregates such as capital, GDP or investment grow at a constant rate. The analysis of the Ramsey´s model starts with the data of the base period of an economy in a steady state. The representative consumer maximizes the present value of their utility along his lifetime.

$$Max \sum_{t=0}^{T} \left(\frac{1}{1+\rho} \right)^{t} U(C_t) \tag{17}$$

t represents the periods of time. The lifetime of the consumer is *T* periods. ρ is the discount factor between periods, *U* is the utility function and C_t is the consumption in the period *t*. Additionally, the representative consumer is facing some constrains. The total production in the economy is dedicated to investment I_t and consumption C_t. There is also a capital depreciation rate denoted as δ. Finally, the investment cannot be negative. These restrictions are written as follows:

$$C_t \leq F(K_t, L_t) - I_t \tag{18}$$

$$K_{t+1} = K_t(1-\delta) + I_t \tag{19}$$

$$I_t \geq 0 \tag{20}$$

K is the capital and F is the function of production. The solution to the maximization problem subject to these restrictions is gathered in the following equations:

$$P_t = \left(\frac{1}{1+\rho} \right)^{t} \frac{\partial U(C_t)}{\partial C_t} \tag{21}$$

$$PK_t = (1-\delta) PK_{t+1} + P_t \frac{\partial F(K_t, L_t)}{\partial K_t} \tag{22}$$

$$P_t = PK_{t+1} \tag{23}$$

P_t, PK_t and PK_{t+1} are the Lagrange multipliers of the maximization problem. These can be interpreted as the price of the product, the price of today's capital and the price of tomorrow's capital.

One of the objectives is to determine the value of the investment in the steady state. To achieve this goal, the capital and the labor have to be established first. We start from the assumption that the growth rate is *g*, the depreciation rate is δ and the interest rate is *r*, and all them are known. The initial labor force L_0 is also known, therefore the labor force at any time *t* is as follows:

$$L_t = (1+g)L_{t-1} \tag{24}$$

$$L_t = (1+g)^t L_0 \tag{25}$$

In a steady state economy, all the quantities of capital, output, labor and consumption grow at the same steady rate *g*. Therefore, the growth path of the capital follows the next rule:

$$K_{t+1} = (1+g)K_t \tag{26}$$

The interest rate *r* is fixed. If the future prices are in present value, then:

$$P_{t+1} = \frac{P_t}{1+r} \tag{27}$$

The capital can be rented or purchased. There are therefore two prices of capital, the purchase price, *PK*, and the rental price, *RK*. If *VK* is the total return of capital, the rental price can be written as follows:

$$VK_t = K_t RK_t \tag{28}$$

The first order conditions from the maximization problem can be used to define the growing path of investment and capital levels in the steady state economy. These conditions can be re-written:

$$PK_t = (1-\delta)PK_{t+1} + RK_t \tag{29}$$

$$PK_{t+1} = P_t \Rightarrow PKt = (1+r)P_t \tag{30}$$

Equation (30) can be used to substitute PK_{t+1} and PK_t in equation (32). It can be thus rewritten as:

$$(1+r)P_t = (1-\delta)P_t + RK_t \tag{31}$$

The renting price of capital is:

$$RK_t = (r+\delta)P_t \tag{32}$$

Investment is obtained from the second restriction of the maximization problem (19) and the growing path of the capital. Investment is consequently given by the following equation:

$$I_t = (\delta + g)K_t \tag{33}$$

This expression is the base for the investment rule in the steady state growth model.

In the Ramsey´s model, investment can be also referred to the initial capital attending to the grow path:

$$I_t = (\delta + g)(1+t)^t K_0 \tag{34}$$

CGE models are calibrated with the information in IO tables or SAM. The data available will be then the total return of capital in the base period, VK_0. The equations (28), (32) and (33) referred to the basic period give us the relation between investment and return of capital in the base period:

$$I_0 = \frac{g+\delta}{\delta + r} VK_0 \tag{35}$$

From equations (26) and (28) the investment rule is:

$$I_t = (\delta + g_{t+1})K_t \tag{36}$$

And the growth rule for the capital stock is the equation (28):

$$K_t = (1 + g_t)K_{t-1} \tag{37}$$

The capital stock in the basis period is obtained from equations (28) and (32):

$$K_0 = \frac{VK_0}{\delta + r_0} \tag{38}$$

Ramsey´s model has been introduced in the dynamic CGE model through the equations (36), (37) and (38)

In the static model, investment (I) is calculated as the sum of household savings (S_h), government (D) and the external (F) deficit, therefore I is well established once S_h, D and F are also defined. All these variables are endogenously determined in the model, so an additional degree of freedom has to be added to the model. Household saving (S_h) is defined through the utility function of the consumers. Government deficit (D) is the difference between government income obtained through taxes, that is endogenously determined in the model, and the government expenditure, that is an exogenous variable. The external deficit (F) is the variation between imports (M), that are endogenously determined in the model, and exports, that are exogenously defined. The government expenditure and imports are the only variables that can be added as new degrees of freedom. The government expenditures are quasi-fix. As a consequence, if a level of investment is required and the household saving and government deficit are not enough, external sector will fulfill the required level of investment through external deficit. As imports are endogenously defined, exports will be also; they are thus endogenously determined in the dynamic CGE model, in contrast to the static CGE.

4. Shaping the shock and Alternative Scenarios.

4.1. Shock in the Model

The shock will be modeled in two ways. First, as an increase of exports in the sector of transport of cargo by train, and hence a decrease in exports of sector of transport of cargo by road. In this case, the shock is neutral from the point of view of the quantity of transported goods. There is only a shift from a transport mean to another. The second way of modeling the shock is through an increase of the transport by train, but without reducing the amount transported by road. The sock assumes an increase on the goods transported by ground.

This effect has been modeled in the equations of production. The expressions that define the total output have then modified to change the amount of the external demand in different periods of time. It has been defined a new parameter that defines the change of the demand of the external sector. For each sector this change has been defined in terms of the total output of the previous period.

$$\Delta Dex_{t+1} = y_t \cdot \delta_t \tag{39}$$

For each sector δ_t is the parameter that defines the increase of external demand in terms of the total output in the previous period of time. This parameter is null except for the sectors of transport of cargo by train and road. The values of these parameters are defined afterwards. This change on the external demand is included in the equation of the total output.

$$Y_j = INV_j + DC_j + \sum_h C_{jh} + \sum_i a_{ij} \cdot q_i + EXP_j + Dex_j \tag{40}$$

4.2. Modeling the Impact of the Rail Infrastructure

In year 2014, the share of load carried by train was negligible, but in Europe the weight of rail transport in the entry/exit of cargo to/from ports is around 20%. Where this weight is not reached, it is due to the relative importance of inner waterway, such as Rotterdam or Antwerp, or the lack of appropriate infrastructure, such as Valencia that is also pushing for a European rail corridor (Enrico Pastori, 2015).

Based on these data three scenarios are chosen. The scenarios will show the final weight of the rail transport in the port of Algeciras. This relative weight will be reached after three periods of times (six years), from the entry into service of the rail infrastructure.

The first simulation has taken into account the shift from one mode of transport, trucks by road, to another, transport by train, but it has not taking into account any additional increase of traffic due to the more efficient connections of the port with its hinterland. In the second simulation, the scenarios are based on a net increase on the transport due the growth of the transport by train.

The realistic scenario is based on a weight of the transport by train of 20%. This weight takes into account the overall transport of cargo. This 20% is in line with the weight of the rest of ports in Europe. Additionally, there is also an optimistic scenario with a weight of the transport by train of 30%, and a pessimistic scenario of 10%.

According to the agreed criteria for the MIOAN-2010[2] transport services rendered by non-residents fall on the imported goods exclusively. In the same way, the transport services linked to the exports are provided by resident transport units. Following this criterion and also in line with the valuation criteria of Eurostat, the transport of goods “in transit” carried out by resident units is considered as export of services.

To define the dynamic model based on Ramsey´s growth model it is necessary to establish the growth path. Table 2 shows this data for basis year 2010, up to year 2014, as well as the sources. Table 3 shows estimations and projections for future years (2015 and onwards).

Table 2.

Economic data for Andalusia (2010-2014)

		Historical data					
Parameter	**Source**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
GDP deflactor	BdE	0,3%	0,2%	0,1%	0,2%	0,7%	-0,5%
Real GDP	IGEA	-3,5%	-1,0%	-1,3%	-3,0%	-1,6%	1,4%
Rate of capital depreciation	Literature*	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%
10 year bond´s yield	INE	3,8%	5,4%	5,5%	5,3%	4,1%	1,8%
rate of real interest.	Estimated	3,5%	5,2%	5,4%	5,1%	3,4%	2,3%

Bde: Banco de España (Bank of Spain)

IGEA: Instituto de Estadíatica y Cartografía de Andalucía (Statistical and Cartography office of Andalusia)

INE: Instituto Nacional de Estadística (Spanish Statistical Institute)

*Denia, Gallego and Mauleón. 1996

[2] Andalusian Institute of Statistics (IGEA), *Metodología Marco Input-Output 2010*

Table 3.

Economic data for Andalusia. Estimations 2015-2020

		Forecast					
Parameter	Source	2015	2016	2017	2018	2019	2020
Real GDP	various**	3,2%	2,7%	2,4%	2,4%	2,4%	2,4%
Rate of capital depreciation	Literature*	5%	5%	5%	5%	5%	5%
rate of real interest.	Various***	1,3%	1,4%	1,1%	1,1%	1,1%	1,1%

Various**: BdE (Feb 2016) and UE (http://ec.europa.eu/economy_finance/eu/countries/spain_es.htm)

Various***: BdE. Stability Plan 2015-2018

*Denia, Gallego and Mauleón. 1996

Finally, table 4 summarizes the parameters that will be used in the model to simulate the grow path in the six two-year periods of time.

Table 4.

Parameters defining the growing path of Ramsey´s model.

Parameter	Period 1 2011-2012	Period 2 2013-2014	Period 3 2015-2016	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022
Real GDP	-4,3%	-0,2%	6,0%	4,9%	4,9%	4,9%
Rate of capital depreciation	10,3%	10,3%	10,3%	10,3%	10,3%	10,3%
Real interest rate	10,8%	5,8%	2,7%	2,2%	2,2%	2,2%

Source: Own Elaboration.

4.3. Simulation Without Traffic Increase.

Based on the figures of year 2014[3] the realistic scenario of 20% means 1.908.562 tons transported by train. Roughly half of this quantity is entry and the other half is exit. The hypothesis is that the cargo in transit is considered as export if it exits from the region; therefore, exports of the sector of transport by train increase in 954.281 tons. In terms of tons, it represents about a 106% increase of the final demand of the transport of cargo by train, that is accounted as exports. The cargo shifts from the transport by truck to the transport by train, consequently, the demand of the transport by truck decreases. The decrease is calculated in terms of kilometer-tons. The increase of the demand of transport by train is about a 2,34% decrease of the demand of transport by truck. Table 5 summarizes the values that will be introduced in the model for each scenario.

[3] Port of Algeciras Bay (2015), *Annual report 2014*

Table 5.

Modal split forecast in the port of Algeciras.

Scenario	Share of transported loads by train over the total			Increase over the total transported loads by train (As exports)			Decrease over the total transported loads by road (As exports)		
	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022
Pesimistic	3,2%	6,6%	10,0%	15,2%	32,8%	53,0%	-0,39%	-0,78%	-1,17%
Realistic	6%	13%	20%	27,2%	61,9%	106,0%	-0,79%	-1,57%	-2,34%
Optimistic	9,1%	19,1%	30,0%	37,3%	88,6%	159,0%	-1,18%	-2,35%	-3,51%

Source: Own Elaboration.

4.4. Simulation with Traffic Increase.

Due to the high amount of transshipment in the port of Algeciras, there is room for increasing the transport by train, not only as a shift from the transport by road, but as a net increase. This increase can be originated not only by a shift from transshipment but also by an increase on the overall traffic in the port.

From this point of view, the first simulation is not taking into account this effect, so a second simulation has been modelled. In this case, the share is reached without any reduction on the amount of cargo transported by road. A share of 20%, keeping the amount transported by road, which means a 116% increase in the overall transported goods by train[4]. This increase will be managed as exports. Table 6 shows the parameters that define the shock for each of the simulations and each of the three scenarios.

Table 6.

Decrease on traffic by road. Andalusia.

Scenario	Share of transported loads by train over the total			Increase over the total transported loads by train (As exports)			Decrease over the total transported loads by road (As exports)		
	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022
Pesimistic	3,2%	6,6%	10,0%	16,5%	35,7%	58,0%	0,00%	0,00%	0,00%
Realistic	6%	13%	20%	29,3%	67,1%	116,0%	0,00%	0,00%	0,00%
Optimistic	9,1%	19,1%	30,0%	39,9%	95,8%	174,0%	0,00%	0,00%	0,00%

Source: Own Elaboration.

---

[4] Spanish Ministry of Transportation, *Statistics of Rail Transport, 2014*.

Observatorio del Transporte y la Logística en España (OTLE), *Annual Report 2015*.

IGEA, *Anuario Estadístico de Andalucia 2014.*

INE, *Statistics of Rail Transport, 2014*

5. Simulations and Main Results

The model has been used to drawn up the different magnitudes previous to the shock. The results with and without the sock will be used to compare the effect of the port of Algeciras´s rail infrastructure.

5.1. Impact of The Rail Infrastructure Without Traffic Increase

The impact is going to be measure in terms of GDP and employment. The results are shown here after for the three scenarios. The shock is designed as neutral on the quantity of transported goods, measured in ton-kilometer. The impact of the new infrastructure in the port of Algeciras is shown hereafter in table 7 in terms of Andalusia´s GDP.

Table 7.

Impact of rail infrastructure on the GDP (million €) of Andalusia.

	Impact on GDP-Best Scenario			Impact on GDP-Medium Scenario			Impact on GDP-Worst Scenario		
	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022
Baseline Scenario GDP	151360	157071	163010	151360	157071	163010	151360	157071	163010
Related Secenario GDP	151360	157073	163015	151360	157073	163014	151360	157072	163012
GDP Variation from Baseline to Related Scenario	0,5	2,1	5,4	0,5	1,6	3,6	0,4	0,9	1,8
GDP Variation from Baseline to Related Scenario	0,0003%	0,0014%	0,0033%	0,0003%	0,0010%	0,0022%	0,0002%	0,0006%	0,0011%

Source: Own Elaboration.

The shift of the transport of loads from the road to the train has a positive impact in the economy. This impact has been valued in up to 5,5 million euro in the best scenario. This impact on GDP will be higher if the traffic increases, as it is confirmed in the second simulation, due to increases in the whole traffic or a reduction of transshipment. All prices are relatives to the labor price, which is the numeraire price, so the results in terms of GDP are also relatives to salaries. The same calculations have been done in terms of quantities, but the changes are very close to these ones in terms of change of GDP in percentage. The shock does not change prices between the base scenario and the ones simulating the shock. The impact on employment has been also calculated and it is shown here after for the all three different scenarios.

Table 8.

Impact of rail infrastructure on unemployment rate of Andalusia.

	Impact on GDP-Best Scenario			Impact on GDP-Medium Scenario			Impact on GDP-Worst Scenario		
	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022
Labor Variation from Baseline to Related Scenario	-0,00447	-0,00611	-0,00374	-0,00255	-0,00353	-0,00249	-0,00090	-0,00134	-0,00124
Labor variation from Baseline to Related Scenario	-0,0010%	-0,0013%	-0,0007%	-0,0006%	-0,0007%	-0,0005%	-0,0002%	-0,0003%	-0,0002%
Variation on Transport of Goods by Train	0,04493	0,11299	0,21448	0,03276	0,07894	0,14301	0,01831	0,04183	0,07151
Variation in Transport of Goods by Road	-0,10803	-0,22787	-0,36033	-0,07237	-0,15229	-0,24022	-0,03576	-0,07570	-0,12011

Source: Own Elaboration.

The magnitudes are in terms of labor quantities, but the units have not any direct relation to worked hours or direct employment.

The impact on employment is slightly negative. The transport by road is more labor intensive than the transport by train. The decrease of labor demand in the sector of transport by road cannot be compensated by the increase on the labor demand in the sector of transport by train. The increase on transport by train only covers the 60% of the decrease in transport by road.

Anyway, there is a positive indirect and induced effect that minimizes the negative impact of the reduction of labor demand. The 40% of the decrease on the labor demand in the sector of transport by road that is not compensated by the increase of the train is reduced to a 1%. In the best scenario, this amount of employment is negligible.

5.2. Impact of The Rail Infrastructure with Traffic Increase

Here after Table 9 shows the results when the growth of transport by train is reached through an increase on the traffic transported by train.

Table 9.

Impact of rail infrastructure on GDP (million €) of Andalusia.

	Impact on GDP-Best Scenario			Impact on GDP-Medium Scenario			Impact on GDP-Worst Scenario		
	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022
Baseline Scenario GDP	151360	157071	163010	151360	157071	163010	151360	157071	163010
Related Secenario GDP	151363	157078	163022	151362	157076	163018	151361	157073	163014
GDP Variation from Baseline to Related Scenario	2,7	6,7	12,5	2,0	4,7	8,4	1,1	2,5	4,2
GDP Variation from Baseline to Related Scenario	0,0018%	0,0043%	0,0077%	0,0013%	0,0030%	0,0051%	0,0007%	0,0016%	0,0026%

Source: Own Elaboration.

The impact in GDP can reach 13 million euro in the best scenario, and 4 million euro in the worst one. As in the previous simulation, all prices are relatives to the labor price, which is the numeraire price, so the results in terms of GDP are also relatives to the salaries. In this case, the difference in terms of quantities between base scenario and the shock are bigger than in terms of monetary value, due to the lower prices relatives to salaries when there is an increase in the transport of cargo by train. The result is around a 70% higher (in best scenario the change in terms of GDP is 0,0130% instead of 0,0077%).

In terms of employment, as the increase in the demand of transport by train is not compensated by a decrease in the transport by road, the impact is much better than in previous simulation.

Table 10.

Impact of rail infrastructure on the unemployment rate of Andalusia.

	Impact on GDP-Best Scenario			Impact on GDP-Medium Scenario			Impact on GDP-Worst Scenario		
	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022	Period 4 2017-2018	Period 5 2019-2020	Period 6 2021-2022
Labor Variation from Baseline to Related Scenario	0,00796	0,01938	0,03567	0,00585	0,01358	0,02378	0,00329	0,00722	0,01189
Labor variation from Baseline to Related Scenario	0,0017%	0,0040%	0,0072%	0,0013%	0,0028%	0,0048%	0,0007%	0,0015%	0,0024%
Variation on Transport of Goods by Train	0,04807	0,12220	0,23479	0,03530	0,08559	0,15654	0,01988	0,04554	0,07827
Variation in Transport of Goods by Road	-0,00078	-0,00199	-0,00385	-0,00057	-0,00140	-0,00257	-0,00032	-0,00074	-0,00128

Source: Own Elaboration.

In the best scenario, the employment can reach an increase of 0,0072% what accounts for roughly 200 new positions. There is a slightly reduction of employment in the sector of transport by road. At the end of the period, the total employment is lower than direct employment, as a consequence of the reduction on employment in other sectors. This is originated by the limitation on resources, what implies that the ones demanded by the sector of transport by train have to be taken out from others. In these sectors, where the resources have been taken from, there is a negative impact that is reflected on the employment reduction. Anyway, the whole effect is positive.

6. CONCLUSIONS

This paper assesses the quantitative effect in Andalusia of the new rail infrastructure in the Port of Algeciras, in terms of GDP and employment, through a dynamic-CGE.

The effect that has been evaluated does not take into account the impact of the construction of the infrastructure (short term impact), but the operation of the new infrastructure (long term effects). It is important also to highlight that the use of the transport by rail has some other advantages that have not been taken into account either, such as the fact that the rail transport is much more environmental friendly than the transport by road.

The impact of the new rail infrastructure is positive in any possible scenario. In the case of having only a shift from road to train, the impact could reach 5.5 million euro in the best scenario. This scenario has been chosen in comparison with the situation in other European ports. The effect in the employment can be classified as neutral. The loss of employment due to the fall of transport by road is compensated by the direct, indirect and induced effect originated by the increase of the transport by train.

A second simulation evaluates the effects of an additional increase on the traffic. In this case, the whole effect on employment is positive, but with a negative contribution of the indirect and induced effects that reduces the direct impact. In this simulation, the effect on GDP in the best scenario can reach nearly 13 million euro per year at the end of the period, although the impact in terms of quantities instead of monetary terms can reach almost double the effect.

7. REFERENCES

Arrow, K. and Debreu, G. (1954), "Existence of an Equilibrium for a Competitive Economy" *Econometrica*, 12:3, 265–290.

Bande, R., M. Fernández and V. Montuenga (2012), "Wage flexibility and local labor markets: a test on the homogeneity of the wage curve in Spain" *Investigaciones Regionales,* 24, 175 -198.

Blanchflower, D.G. and A.J. Oswald (1990), "The wage Curve*" Scandinavian Journal of Economics,* 92, 214-235.

Blanchflower, D.G. and A.J. Oswald (1994), *The wage Curve* Cambridge, MA, MIT Press.

Bröcker, J., and Korzhenevych, A. (2013): "Forward looking dynamics in spatial CGE modelling". *Economic Modelling*, 31, 389-400.

Bröcker, J., Meyer, R., Schneekloth, N., Schürmann, C., Spiekermann, K., and Wegener, M. (2004): "Modelling the Socio-economic and Spatial Impacts of EU Transport Policy". *IASON (Integrated Appraisal of Spatial economic and Network effects of transport investments and policies)*. Kiel/Dortmund. Christian-Albrechts-Universität Kiel/Institut für Raumplanung, Universität Dortmund.

Burfisher, M.E. (2011), *Introduction to Computable General Equilibrium Models* Cambridge, Cambridge University Press.

Cardenete, M.A., and M.C. Delgado (2015), "A simulation of impact of withdrawal European funds on Andalusian economy using a dynamic CGE model: 2014-20" *Economic Modelling*, 45, 83-92.

Cardenete, M.A., A.I. Guerra and F. Sancho (2012), "*Applied General Equilibrium: an Introduction*" Berlin Heidelberg, Springer-Verlag.

Cardenete, M. A., Fuentes, P., Mainar, A., and 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

Cardenete, M.A. and López, R. (2014), “Analysis of the Economic Impact of Different Modes of Transport in Andalusia. An Input-Output Approach”, *XL Reunión de Estudios Regionales-AECR International Conference on Regional Science*, Zaragoza.

Cass, D. (1965): “Optimum growth in an aggregative model of capital accumulation”, *Review of Economic Studies*, 32, 233-240.

Dervis, K., J. De Melo and S. Robinson (1982), *General Equilibrium Models for Development Policy*. Cambridge, Cambridge University Press.

Enrico. P. (2015), *Modal Share of Freight Transport to and From EU Ports*. Brussels. Policy Department B: Structural and Cohesion Policies. European Parliament.

Ginsburgh, V. and M. Keyzer (2002), *The Structure of Applied General Equilibrium Models*. Cambridge, MA, MIT Press.

Harberger, A.C. (1962), “The incidence of the corporation income tax”, *The journal of political economy*, 70:3, 215-240.

Hosoe, N., K. Gasawa and H. Hashimoto (2010) *Textbook of Computable General Equilibrium Modeling: Programing and Simulation*. London, Palgrave MacMillan

Johansen, L. (1974), *A multi-sectorial study of economic growth*. Amsterdam. North-Holland Publishing Company.

Kehoe, T.N., C. Polo and F. Sancho (1995) “An Evaluation of the of the Performance of an Applied General Equilibrium Model of the Spanish Economy” *Economic Theory,* 6, 115-141.

Kehoe, T.J., T.N. Srinivisan and J. Whalley (2005), *Frontiers in Applied General Equilibrium Modeling*. New York, Cambridge University Press.

Kim, E., Hewings, G., and Hong, C. (2004): “An Application of an Integrated Transport Network–Multiregional CGE model: a Framework for the Economic Analysis of Highway Projects”. *Economic Systems Research*, 16:3, 235-258.

Koopmans, T.C. (1965), “On the concept of optimal economic growth”, in *The Economic Approach to Development Planning*. Amsterdam, North Holland.

Leontief, W. (1941). *The structure of American economy, 1919-1924: an empirical application of equilibrium analysis.* Cambridge, MA, Harvard University Press.

Leontief, W. (1951). *Input-Output Economics.* New York, Oxford University Press.

Ramsey, F. (1928), “A mathematical theory of savings”, *The economic journal*, 38:152, 543-559.

Samuelson, P. A. (1954), “The transfer problem and transport cost, II: analysis of effects of trade impediments”. *Economic Journal*, 64:254, 264-289.

Scarf, H.E. and T. Hansen (1973), *Computation of Economic Equilibria*. Yale University Press.

Stone, R. (1962), *A Social Accounting Matrix for 1960 in a Programme for Growth*. London, Chapman and HallLtd.

Vickerman, R., Spiekermann, K., and Wegener, M. (1999), “Accessibility and Economic Development in Europe”. *Regional Studies*, 33:1, 1-15.

Walras, L. (1874), *Elementos de Economía Política Pura.* Madrid, Alianza Editorial (1987)