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Article

Effects of Rail Freight Corridors in Low Population Regions

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Abstract: Impact analysis of the construction and commissioning of a rail freight infrastructure must contemplate the regional economic system in its entirety, since that impact extends beyond the direct contribution to the increase in production, and the consequent generation of income from capital and remuneration of labor incorporated in such activity. The objective of this research is to know the effects that a rail freight infrastructure produces in a region with a low population, such as Extremadura (Spain). For this purpose, the calculation of the total impact produced by the rail freight corridor on the regional economy of Extremadura has been made, which will correspond to the sum of the direct, indirect and induced impacts. For its determination, a simulation tool has been created from Input-Output tables that allow you to compare different impact levels depending on the intensity of the investments made, or the activity developed following the launch of the new rail corridor. The research concludes with the profitability of the action because for a planned investment of 160 M€ for 3 years in the freight rail corridor from Extremadura, every euro invested returns in more than 2 euros to the Extremadura's productive system, creating more than 4100 jobs.

Keywords: freight transport; railway; socio-economic impact; input-output tables; investments

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1. Introduction

Transportation is one of the key elements for the economic development of any society. The white paper of the European Commission [1] establishes a road map to achieve transport models that increase their freight volumes using more efficient and sustainable systems. Among its list of initiatives is to make investments to expand or improve the capacity of the rail network, since railway is the land transport system that achieves better performance and lower CO_2 emissions into the atmosphere [2].

1.1. State of Art

In 2006, Givoni [3] conducted a study on the impact that different elements of the high-speed train have on the design and provision of the service. In 2016, Armstrong et al. [4] sets out a proposed framework for classifying the railway network by socio-economic importance and vulnerability to climate change. Subsequently, other authors have conducted studies that analyze the effects of high-speed rail on mobility [5,6] and urban structure [7,8].

However, this type of infrastructure requires high investments, so additional socio-economic impact studies that justify the profitability of its execution are necessary. In 2010, Monzon et al. [9] evaluate the territorial and economic impacts of the Transport Infrastructure Plan of Spain (2005–2020). Before, the Spanish Administrations had also carried out some impact studies for investments in their road network [10,11]. In 2008, De Rus [12] set the guidelines for the economic effects of investments in high-speed lines, having made a preliminary study [13] of the Madrid-Barcelona high-speed line. In 2014, Sánchez et al. [14] conducted a similar study for high-speed rail in Andalusia (Spain) and later in 2016, Hoyos and Bel [15] conducted an economic evaluation of the Spanish Basque rail infrastructure. Regarding freight research, Andreoli et al. [16] and Outwater et al. [17] study vehicle freight in Washington and Chicago. Samimi et al. [18] develope a Freight Activity Microsimulation Estimator (FAME), Kontelj y Jakomin [19] develope a model to know how investments in the railway infrastructure influence the whole railway system and finally, Camisón et al. [20,21] directs an economic impact study of the investments necessary for the construction of the Mediterranean rail corridor (passengers and freight) belonging to the Trans-European Transport Network.

Despite having these references, it must be taken into account that Extremadura is composed of the two largest provinces in Spain, and yet has a little over one million inhabitants. The unemployment rate is 29.23% [22] and the Gross Domestic Product (GDP) per capita is €16,166 [23]. If we compare the existence of the almost 5 million inhabitants of the Valencian community, together with an unemployment rate below 20% and a GDP per capita of more than € 20,000, the results of this community and others with high population, are difficult to translate to the reality of the Extremaduran community.

Therefore, there is a research gap to know the effects that the construction and subsequent exploitation of a rail freight corridor will have on regions with a low population, such as Extremadura.

1.2. Case Study: Manchegan-Extremaduran Rail Freight Corridor (Cofemanex)

The Trans-European Transport Network (TEN-T) is formed by a compound of priority lines of transport which make the communication of people and freight easier throughout Europe. The 16th axis was a high-capacity rail freight corridor since 2003. It came from the ports of Sines and Algeciras, it went through the Iberian Peninsula and crossed the center of the Pyrenees through a low elevation tunnel to reach Paris. In December 2013 the European Parliament [24] establishes a radical change in the priority core ideas of the TEN-T reducing the 30 initial main axis to 9 in the 2014–2020 period. A part of the 16th axis, more specifically the Manchegan-Extremaduran rail freight corridor (Cofemanex), disappears as main idea of the Core Network, to become part of the Comprehensive Network, whose construction is not expected until 2050. Cofemanex is part of the Madrid-Ciudad Real-Badajoz railway line, it has 304 km of length and runs in a crosswise way (from east to west) by the communities of Castilla La Mancha (91 Km) and Extremadura (213 Km). Cofemanex starts in Puertollano (Castilla La Mancha) and finishes in Badajoz (Extremadura) at the Portuguese border (Figure 1).

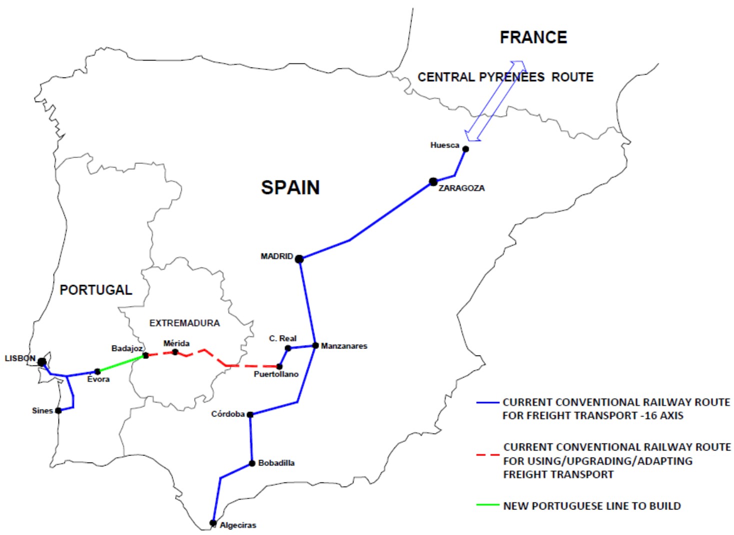

Figure 1. Location of Cofemanex.

Inauguration on 26 June 2016 of the expansion works of the Panama Canal has increased the traffic of large merchant ships coming from the main Asian ports, so the ports of Sines and Algeciras that serve as entry-exit to the Iberian Peninsula, are gaining lots of freight. The port of Sines has increased in 2016 its volume of TEUS by 13.58% having managed in 2016 a total of 1,513,083 TEU [25]. In order to guarantee the correct transport of the products from the port of Sines to Europe, it will be necessary that Extremadura has a high-performance rail freight infrastructure.

1.3. Scope and Objectives of the Research

The objective of the research will be, firstly, to evaluate the contribution of the high-performance rail freight corridor in its construction phase to the production and employment of Extremadura and, subsequently, the effects produced by the commissioning of this new infrastructure in the productivity and employment of Extremadura. The research will also include the study of the effects produced during the first 5 years by the operation of the new railway line in Extremadura.

2. Methodology

The analysis of the impact of the construction and commissioning of a rail freight infrastructure must consider the regional economic system in its entirety, since this impact extends beyond the direct contribution to the increase of production, and the consequent generation of income from capital and remuneration for work incorporated in that activity. It is necessary to quantify the indirect effects that are generated with the purchases of goods and services, as well as the income generated, from both direct and indirect suppliers; that is, the drag effect of the investments made and the operation of the infrastructure [26]. The structure of intersectoral relations reflected in the Input-Output tables provides an adequate tool to determine the drag on the rest of the economic system [27]. The effects generated on the employed population and the wage incomes associated with these levels of employment (induced effects) can be quantified by the relationships between production levels and employment needs [28].

The input-output analysis has been a valuable tool for the study of productive systems, since it considers that the effects of demand in the productive system are not exhausted in its simple direct satisfaction but are spread and multiplied through the framework of the dominant intermediate relationships in the economic system [29]. These analyzes require the creation of a symmetric Input-Output table (TIO) that is able to represent the economic system as a whole, on which an accurate measurement of all its interrelationships and main variables will be established within the production and exploitation accounts of a certain economy. This matrix simulates all the intersectoral relations of a given economy, which allows implementing an input-output demand model, which quantifies the impacts on the vectors of production, added value and employment, associated with a certain volume of investment/billing in a temporary reference period. It is therefore the best method to quantify the socio-economic effects of the investments required in the adaptation of Cofemanex and its subsequent exploitation as a high-performance rail freight corridor, on the whole of the economic system of Extremadura.

In 1995, Macorra and Prudencio published the regional Input-Output tables (TIO-R) for Extremadura for the year 1990 [30]. De Miguel et al. published a social accounting matrix and accounting multipliers for Extremadura [31] and subsequently an Input-Output model of prices applied to Extremadura's economy [32]. However, this information should not be used as a reference because it is a reflection of society at the end of the 20th century that has nothing to do with the situation in Extremadura in the 21st century. It has therefore been necessary to look for an autonomous community that has updated TIO-R tables and that has a productive structure similar to Extremadura as its starting point. Finally, among the 12 Spanish autonomous communities that do have TIO_s, the 2008 Autonomous Community of Castilla la Mancha has been selected [33], which is the latest updated and has the structure of the closest Gross Value Added (GVA) to Extremadura. It is important to note that the impact model derived from the TIO tables operates on the basis of technical coefficients of production, GVA and employment in relative terms. That is why the use of these ratios can be transferred to the case of Extremadura. When absolute values are used, the impact model always work with updated statistical information of Extremadura.

The approach is based on the quantification of the performance indicators on which the I_t^e impact vectors are built, for each of the stages considered "e" (construction and exploitation), and each of the years contemplated in the time horizon of the analysis "t". Being A the inverse matrix of the input-output matrix, the calculation of the total production necessary to supply this initial demand P_t^e is made through Equation (1) [34].

$$P_t^e = [I - A]^{-1} \times I_t^e \tag{1}$$

Tarancón [35] describes the way to obtain the total income generated (GVA_e^t), the employment necessary to carry out this production and the fiscal returns from the calculated production and the coefficients of added value and employment of the TIO-R tables.

The socio-economic impact indicators finally generated are:

(a) Total value of regional production, total income (added value) and tax collection generated by the main tax figures (direct and indirect), differentiating between the construction and exploitation phases.
(b) Total employment generated (direct, indirect and induced), differentiating the construction and exploitation phases.

To carry out this methodology it will be necessary:

(a) Identify the flows of acquisition of goods and services during the stages of construction and operation of the high-performance railway network.
(b) Calculate the corresponding macroeconomic effects direct, indirect and induced, in terms of production, added value and employment.

For the construction and commissioning phase, the flows to be considered will be formed by all those investments made for the adaptation of the rail freight corridor. For the exploitation stage, it will be necessary to identify the total amounts of billing generated by the different agents linked to the rail corridor, which must include, not only the strict activities of freight transport, but all those services generated around the infrastructure of reference (maintenance of infrastructure, hotel business, etc.). Additionally, other investments that help to boost the transport activity in the rail corridor (electrification, logistics platforms, execution of accesses to logistic nodes, etc.) must be included. The calculation of the direct effect will be determined by the added value and employment used in each of these activities, while the indirect effect will be calculated from the purchases of goods and services made to other suppliers. In addition to the calculation of direct and indirect effects generated as a consequence of the economic transactions originated, the induced effects are also included, which would be the effects caused by the income generated by the previous ones.

2.1. Construction and Commissioning: Investments and Assumptions Made

Table 1 includes an investment program for the adaptation of the logistics corridor of Extremadura, which includes not only the improvement works in the rail freight corridor between Puertollano and Badajoz, but also the actions associated with the development of regional logistics nodes.

Investment distribution in the period 2015–2017 is attached in Table 2.

The ballast is obtained in Extremadura, supplying sleepers and rails from other Spanish regions. Hence, 35% of the investment corresponding to manufactures are produced in Extremadura and the remaining 65% is imported from other regions.

Table 1. Construction and Commissioning phase. Investment program in the Cofemanex [36].

Cofemanex. Investment 1st Phase. Period 2015–2017		
1	Renewal of rail track	€ 83,216,412.89
2	Signaling, security installations and block system	€ 18,200,000.00
3	Rail track electrification	€ 20,372,330.60
4	Logistics facilities. Intermodal Logistics Platform in Southwestern Europe	€ 24,950,000.00
5	Logistics facilities. Railway connections	€ 14,454,810.52
	Total Investment Cofemanex. 1st PHASE	€ 161,193,554.01

Table 2. Construction and Commissioning phase. Investment distribution and sectoral allocation of demand.

Investment	Million €	161.194	2015	2016	2017
			1%	45%	54%

Sectoral allocation of demand		Manufacturing activity distribution	
Manufactures	25%	Interior production	35%
Civil construction	65%	Import	65%
Studies/assistance	8%		
Others (planning, insurance, . . .)	2%	Transportation (import)	8% (*)

(*) Imports will generate returns in the activity of road transport that are estimated at 8% of the costs assigned to them [10] (Consultrans, 2005).

2.2. Exploitation Phase: Billing, Investments and Assumptions Made

Five years are considered since the commissioning of the high-performance rail freight network in Extremadura. In this case the period 2018–2022. It is considered that the optimal exploitation of the railway infrastructure will generate returns/impacts in the following products/activity components:

(a) Maintenance of infrastructure in the Badajoz-Puertollano section. The Spanish Railway Infrastructure Manager [37] values the average maintenance cost of one kilometer of conventional rail network per year in Spain at € 33,000/km-year (single track and Iberian gauge). The total cost of maintenance is distributed among the productive sectors of construction and manufacturing, at a ratio of 60 (maintenance of the track)/40 (maintenance of infrastructure and facilities).

(b) Rail freight transport to/from intermodal terminals (increase in demand). Table 3 shows the potential demand that can be collected by the railway under two premises: Badajoz-Puertollano railway section is dedicated to the freight transport and the improvement of the Portuguese rail network in the Sines-Badajoz section, scheduled for 2020.

Table 3. Potential freight demand from Cofemanex. Period 2018–2022 [38].

Tons Transported	2018	2019	2020	2021	2022
Origin-Destination Extremadura	1,163,940	1,190,711	1,220,478	1,263,195	1,326,355
Transit	1,225,588	1,253,776	1,931,745	1,999,356	2,099,324
Total	2,389,528	2,444,487	3,152,223	3,262,551	3,425,679

Based on this potential demand, the expectations for the increase of rail freight traffic in the reference logistic rail corridor are monetized, knowing that only the impacts linked to the import/export rail traffic with origin/destination in Extremadura will be taken into consideration. These impacts will be reflected in two levels: road transport to/from intermodal terminals in the region (the only level contemplated in the model), reduction of transport externalities and gains in competitiveness for the region's production companies due to the reduction of their logistic costs. Freight transport distances by road within

Extremadura are estimated at 120 km. The cost of one ton of merchandise transported by road in an articulated truck of 25 t is 1.23 €/Km [39]. Table 4 encloses the monetization of the demand for freight transport in the high-performance logistics rail corridor in Extremadura for the reference time horizon (2018–2022).

Table 4. Monetization of the demand for freight transport in Extremadura. Period 2018–2022.

Monetization of the Demand					
Road Transport					
Units	**2018**	**2019**	**2020**	**2021**	**2022**
Thousands t·km	139,673	142,885	146,457	151,583	159,163
Thousands €	6872	7030	7206	7458	7831

(c) Related or auxiliary activities of the previous ones, such as training, consultancy, hotel services, etc. A billing estimate of 2.0% of the total invested is made.

(d) Other investments that are complementary to the development of the high-performance railway corridor and the regional logistics system. Within this chapter are computed the investments destined to the enhancement of logistics and rail freight traffic, such as the actions linked to the line electrification and the rail connections (accesses) of the territory logistics nodes. The sectoral allocation of this investment will correspond entirely to the construction sector. For the period 2020–2022, Coloma and García [36] justify a complementary investment of € 79.538 million, divided into € 69.528 million for the electrification of the line and € 10.01 million for the execution of railway accesses. The total amount of the investments planned during the exploitation of Cofemanex is attached in Table 5.

Table 5. Exploitation Phase. Annual investments planned.

				2018	**2019**	**2020**	**2021**	**2022**
Maintenance (€ thousands)				**9867**	**9867**	**9867**	**9867**	**9867**
Construction (track)			60%	5920	5920	5920	5920	5920
Manufactures (facilities)			40%	3947	3947	3947	3947	3947
Conventional network cost	33,000	€/km-year						
Length of the section	299	km.						
Annual cost	9867	€ thousands						
Complementary actions (€ thousands)			79,538	**2018**	**2019**	**2020**	**2021**	**2022**
Line electrification			69,528			23,176	23,176	23,176
Railway access			10,010			3337	3337	3337
Total year (€ thousands)				**0**	**0**	**26,513**	**26,513**	**26,513**
Monetization of the Demand (€ thousands)				**2018**	**2019**	**2020**	**2021**	**2022**
				6872	**7030**	**7206**	**7458**	**7831**
Related activities (€ thousands)				**2018**	**2019**	**2020**	**2021**	**2022**
2%	Operating amount			**335**	**338**	**872**	**877**	**884**

Appendix A describes the design of the reference macroeconomic scenario and Appendix B describes the procedure followed to estimate the socioeconomic impact and its effects.

3. Results

3.1. Simulation Tool

The model designed is introduced in a simulation tool that allows comparing different levels of impact depending on the intensity of the investments made or the activity developed after the commissioning of the new rail freight corridor. In order to be easy to manage, it has been chosen to develop the tool in a standardized spreadsheet of Microsoft Excel.

Tables 6 and 7 quantify the total and disaggregated economic impact, both in absolute and relative terms, of the investments for adapting the existing rail line into a high-performance rail freight corridor in Extremadura.

Table 6. Impact in absolute terms of investments (2015–2022).

Effects in terms of Production								
€ thousands	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total	**4952**	**153,725**	**182,971**	**40,431**	**40,815**	**111,957**	**112,546**	**113,407**
Direct	1988	61,693	73,415	17,276	17,439	44,980	45,238	45,621
Indirect	1956	60,710	72,245	14,492	14,593	43,843	44,004	44,243
Induced	1008	31,322	37,312	8663	8784	23,134	23,304	23,543
Effects in terms of GVA (income generated)								
€ thousands	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total	**2613**	**81,124**	**96,562**	**22,554**	**22,791**	**59,055**	**59,418**	**59,949**
Direct	943	29,279	34,842	9058	9159	21,161	21,322	21,561
Indirect	1044	32,414	38,573	8122	8183	23,542	23,639	23,783
Induced	625	19,431	23,147	5374	5449	14,352	14,457	14,605
Effects in terms of Employment (unitary needs)								
Jobs	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total	**61**	**1874**	**2210**	**518**	**518**	**1315**	**1305**	**1300**
Direct	24	738	870	229	230	526	524	524
Indirect	23	703	829	171	170	483	478	474
Induced	14	433	511	117	118	305	303	302
Tax purposes								
€ thousands	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total	**588**	**18,238**	**21,704**	**5078**	**5126**	**13,220**	**13,297**	**13,410**
Family Income Tax	156	4858	5787	1344	1362	3588	3614	3651
Companies Income Tax	165	5129	6095	1441	1446	3624	3638	3660
Social contributions	67	2082	2480	576	584	1538	1549	1565
Indirect taxes	199	6169	7341	1718	1734	4470	4496	4534

3.2. Effects in Terms of Production

The total economic impact of the investment made in the construction and commissioning of the high-performance rail freight corridor in Extremadura, as well as in the development of the regional logistics system, exceeds 341 million euros in the period 2015–2018, equivalent to a return on regional production of 2.12 euros for each euro of investment. The disbursement of the planned investments will cause a drag effect (indirect more induced) in the regional economy of more than 205 million euros in the period 2015–2017, which represents a multiplier effect of 1.49. This means that for every euro of direct demand in the regional productive system a drag effect of 1.49 euros is generated in the economy of the territory. The impact of investments in terms of production is shown in Figure 2.

Table 7. Impact in relative terms of investments (2015–2022).

Effects in terms of Production								
Expressed as % of GDP	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total	**0.03%**	**0.93%**	**1.09%**	**0.24%**	**0.24%**	**0.64%**	**0.63%**	**0.62%**
Direct	0.01%	0.37%	0.44%	0.10%	0.10%	0.26%	0.25%	0.25%
Indirect	0.01%	0.37%	0.43%	0.09%	0.08%	0.25%	0.25%	0.24%
Induced	0.01%	0.19%	0.22%	0.05%	0.05%	0.13%	0.13%	0.13%
Effects in terms of GVA (income generated)								
% GDP	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total	**0.02%**	**0.49%**	**0.57%**	**0.13%**	**0.13%**	**0.34%**	**0.33%**	**0.33%**
Effects in terms of Employment (unitary needs)								
% Employees	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total	**0.02%**	**0.56%**	**0.66%**	**0.15%**	**0.15%**	**0.39%**	**0.38%**	**0.38%**
Tax purposes								
% GDP	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total	**0.004%**	**0.110%**	**0.129%**	**0.030%**	**0.030%**	**0.075%**	**0.074%**	**0.074%**

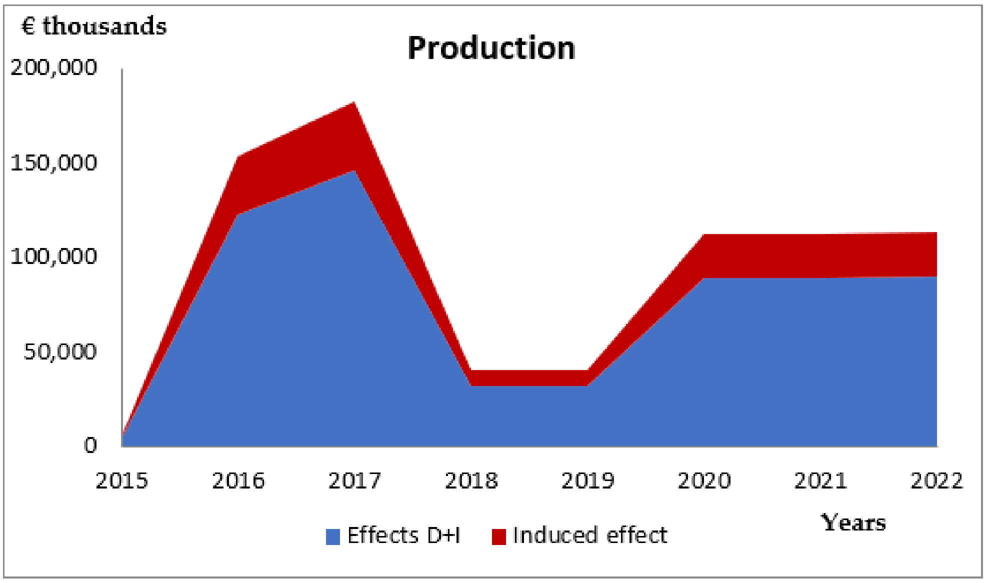

Figure 2. Impact of investments in Production (2015–2022).

For annuities, it is worth highlighting the year 2017, where the total effects on production come to represent 1.10% of the regional GDP for that year.

During the exploitation phase, complementary actions in the regional logistics system mediate the results. Highlights the effect derived from investment flows in the regional productive system, before 2018 and 2020 onwards.

3.3. Effects in Terms of GVA (Income Generated)

The aggregate of investments for the period 2016–2018 comes to represent 1.19% of the autonomous GVA of 2015 [23]. Construction, industry and services are the main motor activities. With respect to the estimated regional GDP, the GVA generated in the reference time horizon represents up to 0.57% of the GDP of Extremadura in the year 2017. Figure 3 shows the impact of the investments on the GVA.

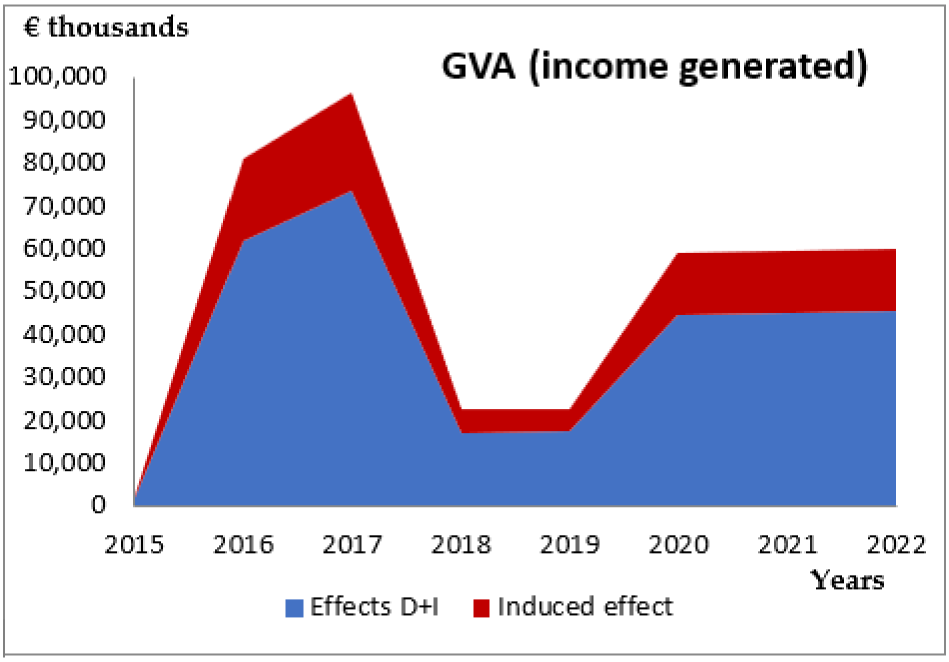

Figure 3. Impact of investments on GVA (2015–2022).

3.4. Effects in Terms of Employment (Unitary Needs)

The unitary employment needs for the period 2015–2017 (construction phase) are estimated at more than 4100 jobs. Figure 4 shows the impact of investments on employment.

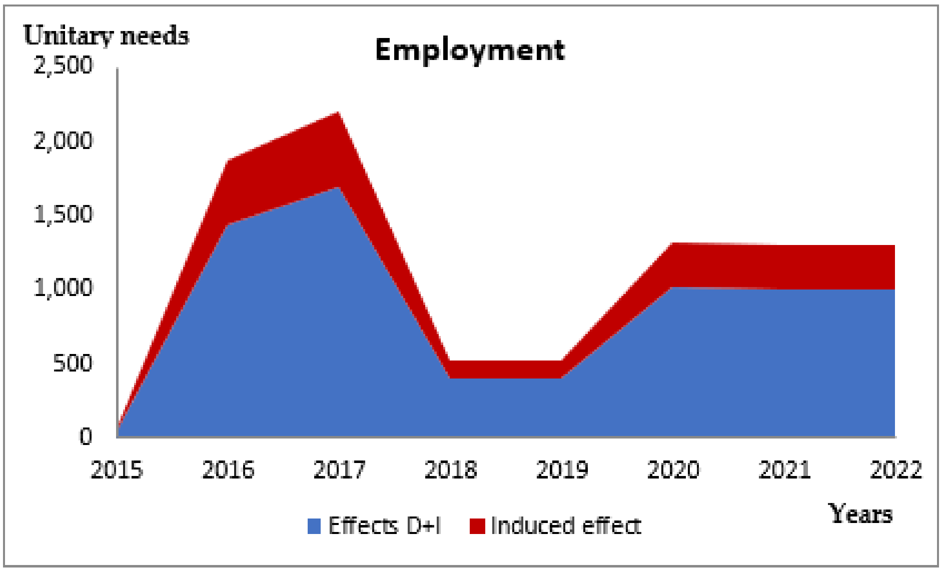

Figure 4. Impact of investments on employment (2015–2022).

For the exploitation phase, the annual employment detail associated with the operation of the high-performance rail freight corridor, offers employment generation figures ranging from practically 500 jobs per year for the first two years of operation of the improved line, to the 1300 from the period 2020–2022. This is due to the increase in transport demand and particularly from new investments to improve the regional logistics system.

In relative terms, the volume of employment generated during the construction phase of the Badajoz-Puertollano line and the development of the regional logistics system is equivalent to 1.24% of the total employed in Extremadura [22]. In addition, the employment ratio associated with the volume of investment made a unit cost of 39,000 euros for employment generated in the period 2015–2017.

The employment forecast in Extremadura is represented by the number of employed in the macroeconomic scenario of reference (Figure 5). During the construction phase, the volume of additional employment generated in 2017 represents 0.66% of the total number of employed persons in the region. In the exploitation phase, the relative impact falls to 0.38%.

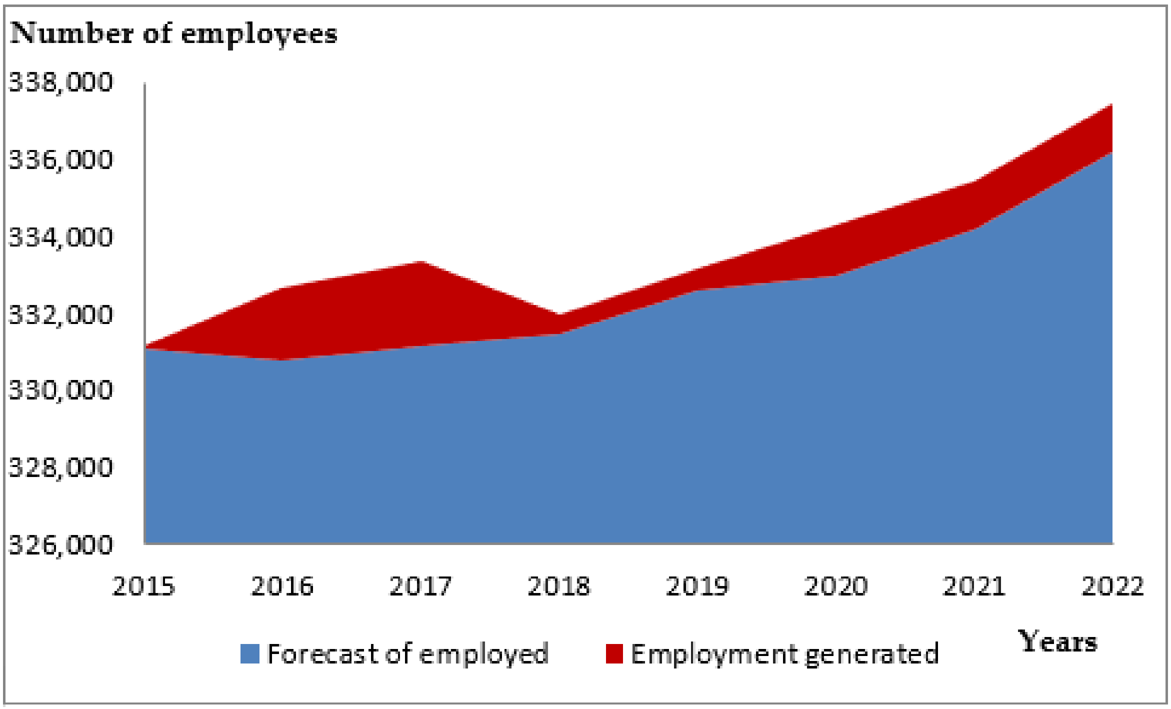

Figure 5. Additional generation of employment on basic scenario (2015–2022).

3.5. Tax Purposes

The tax returns computed over the reference time horizon (2015–2022) amount to around 90 million euros, disaggregated as follows: 45% during the construction phase and 55% during the exploitation period. Taxes return ratio from the adaptation investments of the railway corridor and the regional logistics system (2015–2017) stands at 0.25; therefore, each euro invested in the improvement of Cofemanex generates a tax return of 25-euro cents, including in that calculation the direct and indirect taxes, and the social contributions of the jobs generated.

4. Discussion

These types of investment studies are usually carried out in the medium term (10–20 years). However, in this case, it has been decided to carry out a study of a first 3-year investment for the start-up of the high-performance rail freight corridor and a subsequent 5-year investment for its connection to the logistics nodes and supply electricity to the line, making investment more feasible for the administration.

The generated demand model allows to quantify, for any branch of activity contemplated in the Input-Output table of reference, two interesting economic phenomena:

(a) How this activity diffuses or transmits the variations of its own final demand throughout the economic system, that is, the sensitivity of production, income or employment of the economic system to the situation of the final demand of that activity.
(b) How this activity absorbs the variations of the final demand of other activities or of the whole economic system, that is, the sensitivity shown by the production, income or employment of the activity in the context of the final demand of other sectors of the economy.

However, since it is an estimative method, it also has some drawbacks:

(a) A wealth of very detailed statistical information is needed on the intersectoral relationships of the industries that make up the structure of a certain region or country. All this information is collected in the TIO. The great number of resources necessary to be able to elaborate the TIO implies, in practice, that they are made every certain year. Therefore, in case of using the table to analyze a year that does not correspond to the elaboration of that TIO, it is necessary to suppose that the technical coefficients have not changed in time.
(b) On the other hand, Barro [40] criticizes the use of multipliers to justify the profitability of a public investment. De Rus [41] recommends the use of Cost Benefit Analysis (CBA) to evaluate the impact of infrastructure investment. Boscá et al. [42] consider that the multiplier of the Spanish economy stands at 1.05, well below the 2.12 obtained in this study. This could show that the effect of investments in less developed regions produces a higher impact than in more developed regions.

In any case, the long tradition of studies based on input-output tables, their disaggregated nature, and availability, advise the use of this procedure for this research.

5. Conclusions and Future Research

This research analyzes the effects of the investment made to upgrade the conventional railway line Cofemanex in a high-performance rail freight line of a sparsely populated region such as Extremadura (Spain). The results obtained show the profitability of this investment since each euro that is invested in Cofemanex, returns in more than 2 euros in the production system of Extremadura. In addition, in a region such as Extremadura that suffers a high rate of unemployment (29.23%, [22]), it is very necessary to create more than 4100 jobs that are expected in the construction and commissioning of the freight corridor. In the first 5 years of operation of the corridor, the forecasts for job creation are also high, exceeding 1300 jobs/year. The simulated fiscal return also yields positive data since it is expected that in the construction phase of Cofemanex, 25 cents will be collected for each euro invested.

Finally, it is necessary to emphasize that the socioeconomic impact measured is limited to evaluating the consequences generated by the new infrastructure on the current economic structure. The growth of production, income and employment caused by the exploitation of the new business opportunities that the railway corridor will produce, have not been contemplated in the calculation. Nor is included in this quantification the evaluation of the effects derived from the increase of the productivity of the companies, thanks to the liberation of the time of journey in the displacements.

For future research will be interesting to evaluate the effects linked to the saving of external costs (energy, road accidents, emissions, etc.) as a result of the transfer of freight from the road to the railway in future scenarios. Furthermore, it would be of interest implementing a new cost-benefit analysis considering all the life stages of the railway line (not only 5 years), analyzing the positive and negative effects on populations, property values, land use and location of production activities.

The future of the freight transportation has lots of uncertainties, mainly due to two factors: vehicle automation and global pandemic. In terms of vehicle automation, the recent development of electric automated freight trucks is making truck-based freight transportation more and more appealing [43]. In terms of the global pandemic, regional and global trade, along with passenger travel behavior, have been shaped greatly [44,45]. Future research should consider these factors and study their effects.

This research shows that conventional rail lines can be adapted to high-performance freight lines with small investments (compared to high-speed infrastructure), making them more profitable and advantageous to operate. It can be concluded that the effects of rail freight corridors in low-population regions are positive, profitable, sustainable and very necessary for regions such as Extremadura.

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Abbreviations

CBA	Cost Benefit Analysis
CE	Coefficient of Employment
COFEMANEX	Manchegan-Extremaduran Rail Freight Corridor
CVA	Coefficient of Value Added
FAME	Freight Activity Microsimulation Estimator
GDP	Gross Domestic Product
GVA	Gross Value Added
PIT	Personal Income Tax
RAS	Regional average salary
TIO	Input-Output table
TIO-R	Regiomal Input-Output table
TEN-T	Trans-European Transport Network
TEU	Twenty-foot Equivalent Unit
VAT	Value Added Tax

Appendix A. Design of The Reference Macroeconomic Scenario

A reference macroeconomic scenario is built in order to adequately contextualize the results of the impact analysis. This scenario extends throughout the time horizon considered for the analysis and includes the main indicators of impact selected: Production, GVA, Employment and Tax Return.

Projection of Variables in Extremadura: Keys and Assumptions

The fundamental variables to be projected in the reference time horizon will be:

(a) Resident population. The Statistical Institute of Extremadura [46] provides the projected series of resident population in the region.

(b) Nominal GDP. The National Institute of Statistics [23] provides the historical series of Regional Accounting for Spain and details the evolution of GDP in Extremadura at current prices (Nominal GDP) for the period 2000–2017. For the projection of 2017 and successive, the following criteria are followed:

- Weak economic growth or stoppage of activity in the euro zone.
- Level of indebtedness of the Autonomous Community that limits the ability to streamline actions.
- Low diversification of productive activity, lack of competitive dynamism and human capital.

In this context, a growth between 1 and 2% interannual for the period 2017–2022 is considered.

(c) GDP deflator. It is based on the cycle of the Spanish historical series since 2000. Forecast of the following years, the Bank of Spain's economic bulletin [47] is used as a reference source, which points to a weak and sustained inflation over time. For practical purposes, a constant inflation of 0.4% year-on-year for the entire time horizon is considered, on which Real GDP (at constant prices) is determined for the reference time horizon.

(d) Productivity per employee. Apparent productivity is expressed as the quotient between Real GDP and the number of employed. Therefore, from [46,47] the apparent productivity of Extremadura can be calculated in the historical series 2000–2017. In this sense, we can see how the performance of productivity per employee suffers increases in the years of crisis, because the adjustment of companies to changes in the situation of the economy as a whole is mainly through employment. This would explain the growth of productivity per employee, around the 1.4% year-on-year average since 2009. For calculations of the economic model, an interannual increase in apparent productivity is considered of 0.75–1.00% for the period 2018–2022, weaker than the one recorded in the historical series.

(e) Average wage. The National Institute of Statistics [48] provides the 2014–2015 series of labor costs. For the projection of the average salary in the reference time horizon, the trend of the historical series is taken into account together with the macroeconomic context, estimating an interannual growth of the average wage of 1% for the period 2016–2017 and 1.5% for the rest of exercises. The reference macroeconomic scenario of the socioeconomic impact model is detailed in Table A1.

Table A1. Macroeconomic basic scenario.

	2008	2009	2010	2011	2012	2013	2014	2015
Resident population						1,101,309	1,098,909	1,096,327
Resident population interannual variation							−0.22%	−0.23%
Population of 16 years and over						931,767	930,171	928,466
Proportion of active employees						**57%**		
Nominal GDP current prices (€ thousands)	17,628,677	17,144,187	17,176,789	16,954,368	16,371,570	16,199,826	16,167,426	16,506,942
Interannual variation Nominal GDP	0	−2.7%	0.2%	−1.3%	−3.4%	−1.0%	−0.20%	2.10%
Income per capita: Nominal GDP/Total population (€/people)						14,710	14,712	15,057
GDP deflator (base 2008 = 100)	100	100.1	100.2	100.2	100.2	100.8	101.20	101.60
Interannual variation Real GDP: Variation Nominal GDP-Deflator	0.0%	−2.8%	0.1%	−1.3%	−3.4%	−1.6%	−0.60%	1.70%
Real GDP constant prices (base 2008) in € thousands	17,628,677	17,127,060	17,142,504	16,920,527	16,338,892	16,071,256	15,975,718	16,246,990
Total Employed (in thousands of people)	396.9	374.6	370.4	361.2	343.4	332.4	328.78	332.70
Apparent productivity: Real GDP/Employed	44,416	45,721	46,281	46,845	47,580	48,349	48,591	48,834
Interannual variation Productivity	0	2.94%	1.23%	1.22%	1.57%	1.62%	0.50%	0.50%
Average salary (euros)	17,983	18,820	19,198	19,473	19,084	18,419	18,603	18,789
Interannual variation of the average salary	0	4.65%	2.01%	1.43%	−2.00%	−3.48%	1.00%	1.00%

	2016	2017	2018	2019	2020	2021	2022
Resident population	1,093,573	1,090,675	1,087,597	1,084,382	1,081,040	1,077,600	1,074,152
Resident population interannual variation	−0.25%	−0.27%	−0.28%	−0.30%	−0.31%	−0.32%	−0.32%
Population of 16 years and over	926,872	925,315	923,607	921,818	920,194	918,528	918,529
Proportion of active employees							
Nominal GDP current prices (€ thousands)	16,795,814	17,047,751	17,303,467	17,563,019	17,870,372	18,227,780	18,592,335
Interannual variation Nominal GDP	1.75%	1.50%	1.50%	1.50%	1.75%	2.00%	2.00%
Income per capita: Nominal GDP/Total population (€/people)	15,359	15,630	15,910	16,196	16,531	16,915	17,309
GDP deflator (base 2008 = 100)	102.00	102.40	102.80	103.20	103.60	104.00	104.40
Interannual variation Real GDP: Variation Nominal GDP-Deflator	1.35%	1.10%	1.10%	1.10%	1.35%	1.60%	1.60%
Real GDP constant prices (base 2008) in € thousands	16,466,484	16,648,194	16,832,167	17,018,430	17,249,394	17,526,711	17,808,750
Total Employed (in thousands of people)	335.52	336.69	337.88	338.24	339.43	341.48	343.53
Apparent productivity: Real GDP/Employed	49,078	49,446	49,817	50,315	50,818	51,326	51,840
Interannual variation Productivity	0.50%	0.75%	0.75%	1.00%	1.00%	1.00%	1.00%
Average salary (euros)	18,977	19,262	19,551	19,844	20,142	20,444	20,750
Interannual variation of the average salary	1.00%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%

Appendix B. Socioeconomic Impact. Estimation of Effects

This model provides an approximation to the direct, indirect and induced effects of an exogenous demand shock of the type contemplated in this study, triggered by investments in the railway corridor and in the regional logistics system.

Appendix B.1. Direct Effects

For the construction stage, direct effect will be formed by all those investments that are made for the adaptation of the railway corridor. For the exploitation phase, it will be necessary to identify the total billing amounts generated by the different agents linked to the logistics corridor, which must include, not only the strict activities of freight transport, but all those services generated around the railway axis (maintenance of infrastructure, hotel services, training, etc.).

For each one of the contemplated branches of activity, it's been calculated the structure of purchases of intermediate consumption for each unit produced $A_{i,j}$, as well as the coefficients of Value Added (*CVA*) and Employment (*CE*), enclosing the unit needs for employment.

The values of the direct effect on value added and employment, as well as the impact vectors for the determination of indirect effects, are obtained starting from these coefficients and applying them to the estimated billing amounts for the different "*s*" activities linked to the railway corridor in year "*t*". That is, $DVA_s^t = Invoicing_s^t \times CVA_s$, $EMP_s^t = Invoicing_s^t \times CE_s$ and $IMP\_V_{si,j} = Invoicing_s^t \times A_{i,j}$.

In addition to the direct effects, it is also necessary to quantify the indirect effects that are generated with the purchases of goods and services, as well as the income generated, both from direct and indirect suppliers, that is, the drag effect on the rest of the economic system (induced effects).

Appendix B.2. Indirect Effects

Pulido [49] describes the way to obtain the total effect generated on the set of the economic system *X*, measured in terms of production. Starts from an initial demand *W*, which is called the impact vector, and from the corresponding matrices of technical coefficients *A*, that collect the unitary requirements of intermediate consumption for each unit produced (Equation (A1)).

$$X = [I - A]^1 \times W \quad \text{(A1)}$$

In this way, it will be necessary to generate an impact vector W10x1 that reflects the direct demand received by each of the 10 branches of activity considered and in each of the years included in the analysis (2015–2022).

This impact vector *W* will be constituted by the direct demand received by each of the branches in the corresponding year expressed in homogeneous monetary units. In our case, thousands of euros in 2008, so the values in current terms of each year will have to be applied the value of the GDP deflator in base 2008 in that year. Its value is obtained from Equation (A2).

$$W_t{}^{2008} = W_t / ([DefGDP]_t{}^{2008}) \times 100 \quad \text{(A2)}$$

These impact vectors during the construction stage (2015–2017) will be constituted by the total purchases made to each sector as a result of the investment executed. In the operation stage (2018–2022) they will be constituted by the purchases of goods and intermediate services performed by the different agents to the rest of the productive system, calculated from the technical coefficients $A_{i,j}$. This matrix of intermediate consumption by sectors is attached in Table A2.

Table A2. Intermediate consumption matrix by sector.

	1	2	3	4	5	6	7	8	9	10
Agriculture, forestry and fishing	0.1030199	0.1086359	0.0001996	0.008791	0.000008238	0.0004196	0.000157	0.0003357	0.0003349	0.0037791
Extractive industries; manufacturing industry; electric power supply	0.215515	0.2156995	0.1832946	0.1264162	0.0564339	0.0087329	0.0232369	0.0948247	0.0317364	0.0660325
Construction	0.0149005	0.0155663	0.2753325	0.0105162	0.00643	0.0077481	0.0880072	0.0121835	0.0120142	0.0116284
Wholesale and Retail; repair of motor vehicles and motorcycles; transportation and storage; hotel services	0.0402621	0.0891109	0.0532176	0.1228313	0.0305643	0.0080998	0.0162538	0.0342351	0.035117	0.039765
Information and communications	0.0009183	0.0063537	0.0037436	0.0060513	0.0875893	0.0048314	0.0019522	0.0176537	0.0088313	0.0045536
Financial and insurance activities	0.014329	0.0070679	0.0161052	0.0129175	0.0060188	0.034643	0.0484991	0.013413	0.0058284	0.0039154
Real estate activities	0.0035486	0.0182709	0.0154348	0.0585113	0.0194304	0.0139256	0.0096268	0.035136	0.0119275	0.0424071
Professional, scientific and technical activities; administrative activities and auxiliary services	0.012051	0.0452245	0.0215529	0.0189914	0.0583813	0.0226163	0.0482506	0.034574	0.0191386	0.0218412
Public administration and defense; compulsory social security; education; health and social services activities	0.0028249	0.0066821	0.000242	0.0065362	0.0054257	0.0018135	0.0030117	0.0036874	0.0554365	0.0059839
Artistic, recreational activities and entertainment; repair of household items and other services	0.0001612	0.0020967	0.0001017	0.0059419	0.0036371	0.0009361	0.000204	0.0366384	0.0107719	0.1806384

If the billing estimated by activity "s" in period "t" is denominated as BAC_s^t, the corresponding impact vector W_s^t would be calculated multiplying that billing by the technical coefficients of the sector s and expressed in homogeneous monetary units; that is, thousands of euros in 2008, according to the expression of Equation (A3).

$$W_t^s = \left[\frac{BAC_t^s}{DefGDP_t^{2008}} \times 100\right] \times a_{i,s} \quad \text{(A3)}$$

Bearing in mind that there may be different activities linked to the operation of the railway corridor, the final impact vector for each period "t", will be formed by the sum of the impact vectors originated in each activity "s", according to the expression of Equation (A4).

$$W_t = \sum_s W_t^s \quad \text{(A4)}$$

From the values obtained in terms of the total production generated in each year "t" (X_t) the added value generated can be estimated, as well as the total employment linked to this production according to the expressions $GVA_t = X_t \times CVA$ and $EMP_t = X_t \times CE$, where the CVA (value added coefficients), and the CE (employment coefficients) are used.

The added value coefficients are calculated as the quotient between the total production and the added value of each branch of activity and represent the amount of added value generated by each branch of activity for each unit produced. On the other hand, the employment coefficients are calculated by quotient between the total number of jobs used by each productive branch and the total production of that branch and represent the unit labor requirements for each unit produced. Tables available refer to the year 2008, so the employment coefficients have been slightly modified to collect the possible productivity gains that are generated over time, and they are collected through apparent productivity per employee, as described in Equation (A5).

$$CE_t = \frac{CE_{t-1}}{\Delta Productivity_t} = \frac{CE_{t-1}}{Productivity_t / Productivity_{t-1}} \quad \text{(A5)}$$

Based on the estimated employment levels, the salary incomes generated SI_s are calculated by multiplying that employment by the average salary in each of the AS_s productive branches, as shown in Equations (A6) and (A7). Similar to the employment coefficients, average salaries by sectors have been revitalized using the projections made for the regional average salary (*RAS*):

$$SI_t^s = EMP_t^s \times AS_t^s \tag{A6}$$

$$AS_t^s = AS_{t-1}^s \times \Delta RAS_t = AS_{t-1}^s \times \left(\frac{RAS_t}{RAS_{t-1}}\right) \tag{A7}$$

Appendix B.3. Induced Effects

The economic impact analysis in addition to the so-called direct and indirect effects, generated "Induced Effects" as a result of the economic transactions originated in the analyzed activity. These effects are caused by the income generated from the previous ones.

Monchon and Beker [50] identify two types of induced effects, those strictly denominated as "Income Effects" and those known as "Fiscal Effects". Income effects include all production, added value and employment, which is generated from direct and indirect wage income and its subsequent application to consumption. The fiscal effects, collect all the tax collection that would be generated from production, added value and employment, both direct, indirect and induced.

For the determination of the income effects, it would be taken from the total income generated (IS_t) to which it would be deducted, both direct taxes (TAX_d^t) and social contributions (CS_t), in order to obtain a figure of disposable income ID_t according to the expression $ID_t = IS_t - TAX_d^t - CS_t$. To this disposable income, the average propensity to consumption (*apc*) would be applied, obtaining, finally, a total consumption figure linked to said direct and indirect jobs, according to the expression $CON_t = ID_t \times apc$. From this CON_t consumption figure and using the average sectoral distribution structure obtained from the TIO_s, a new induced impact vector W_{it} would be calculated. A similar treatment is applied to the calculation of indirect effects, including, once again, a correction by price evolution collected through the GDP deflator, and using the structure of final consumption to each branch "*i*" derived from table c_i, composed of the quotients of the household consumption vector in each branch of activity "*i*" among the total, according to described in Equation (A8).

$$WI_t = \left[\frac{CON_t}{DefGDP_t^{2008}} \times 100\right] \times c_i \tag{A8}$$

In the case of tax effects, the main tax figures (direct and indirect taxes) linked to production, added value and employment, both direct and indirect, are identified and, the total tax induced would be obtained through the application of average tax rates.

These tax figures include both the indirect tax burden (VAT and special taxes) calculated as a percentage of GDP, as well as social contributions and direct personal income taxes (PIT) and companies (Corporation Tax). Table A3 includes the tax rates with which the impact model operates.

Table A3. Tax rates applied in the impact model.

Average rate PIT	% over Income	14%
Average rate Social contributions	% over Salaries	6%
Medium type Business surplus	% over Surplus	19%
Average type Indirect Taxes	% over GDP	10%
Marginal propensity to consumption	% over Available income	70%
Real tax rate (PIT + Quotes)		20%

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