Interregional Trade Changes in Spain Caused by the Introduction of a Road Fee-Charge for Heavy Goods Vehicles

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SUMMARY

The introduction of a homogeneous road charging system according to the Directive 2011/76/EU for the use of roads is still under development in most European Union (EU) member states. Spain, like other EU members, has been encouraged to introduce a charging system for Heavy Goods Vehicles (HGVs) throughout the country. This nation-wide charge has been postponed because there are serious concerns about their advantages from an economic point of view.

Within this context, this paper applies an integrated modeling approach to shape elastic trade coefficients among regions by using a random utility based multiregional Input-Output (RUBMRIO) approach and a road transport network model in order to determine regional distributive and substitutive economic effects by simulating the introduction of a distance-based charge (€/km) considering 7,053.8 kilometers of free highways linking the capitals of the Spanish regions. In addition, an in-depth analysis of interregional trade changes is developed to evaluate and characterize the role of the road charging approach in trade relations among regions and across freight intensive economic sectors. For this purpose, differences in trade relations are described and assessed between a base-case or *"do nothing"* scenario and a road fee-charge setting scenario. The results show that the specific amount of the charge set for HGVs affect each region differently and to a different extent because in some regions the price of commodities and the Generalized Transport Cost will decrease its competiveness within the country.

1 A ROAD CHARGING POLICY APPLIED TO HEAVY GOODS VEHICLES

There is a long-running debate about the implementation of road charging schemes throughout the world. Although there are recommendations and identified benefits for charging, there are skeptical concerns about cost-based pricing, cost allocation, and potential benefits in regions and countries that are also being widely researched. Indeed, there are many multifaceted discussions regarding the appropriate cost-based pricing system (fuel tax, distance-based or commodity-based charging), as well as, the cost allocation methodology (congestion, roadway costs, environmental externalities, among others).

According to Button and Verhoef (1998), road pricing is not new, and was initially defined using Pigou's idea, published in 1920, of setting up prices to internalize the externalities of a given activity. However, only until the 1960s and 1970s the discussion of optimal taxes for roads was started, and up today several discussions have been developed in order to define: (i) a cost allocation schema to be applied; (ii) how to best tackle with barriers and constraints; and (iii) the acceptability of the policy. More details regarding all these aspects are detailed in de Palma and Lindsey (2011), Glazer et al.(2003), Izquierdo and Vassallo (2002), Link (2008), and Nash and B. Matthews (2001, 2005), among others.

The importance of a charging policy has been widely recognized through different European Union (EU) research projects and researchers from abroad considering the establishment of the tariff (cost allocation), the cost-based system, the application and the deployment, the use of revenues and the acceptability, as well as the consideration of urban and interurban schemes. Indeed, road user charges have already been dealt with separately urban road and interurban road transport. Urban transport is focused on the private car while freight for interurban transport.

With regard to the cost allocation schema to be applied, several authors pointed out that users should be charged their marginal external costs which make sure that the consumer pays both the private costs and the external costs (see more details in Button and Verhoef (1998), de Palma and Lindsey (2011), Nash and B. Matthews (2001, 2005), Quinet (2005), Rouwendal and Verhoef (2006). In addition, A. May and Milne (2000) say, road charging systems have been developed by considering charges based on time spent travelling (time-based), time spent in congestion (congestion pricing), and distance travelled (distance-based). As a result, the cost allocation has been the primary mean to charge transport externalities, but also finance, construction, operation and maintenance costs are considered fundamental in setting the charges according to the Directive 2011/76/EU.

Charges can be collected in a variety of ways, such as: a vignette system, manually or by electronic payment covering specific areas. EU countries have been progressively implementing a distance-based system for Heavy Goods Vehicles (HGVs) which is based on distances driven (e.g. Germany, Czech Republic; Austria, Poland, and Slovakia). This system has the advantage of making the charge collection directly from the users of the infrastructure by considering various fares according to the type of vehicle, location, and time period.

Although in the EU exists cost-based systems based on the distance traveled or based on the time of use of infrastructure, the implementation of a charging policy based on the externalities, and the fee-charges to haulers for infrastructure costs, such as construction, maintenance, operation of the infrastructure, and the tolling system costs, is unknown in some countries such as Spain.

2 THE ASSESSMENT OF THE ROAD CHARGING POLICY

2.1 Introduction

Most of the existing assessment methodologies of road charging policies have been concentrated on desk-based studies by applying economic models focused on economic efficiency. These models took into account social surplus and other welfare measures in a variety of road charging schemes: e.g. cordon-based, area-based, and congestion charging. In addition, Tsekeris and Voß (2008) remark that the potential deployment of a number of ─mostly, welfare-improving─ road pricing schemes have been studied on the grounds of feasibility, efficiency, revenue generation and acceptability in various urban areas around the world.

Besides of the existing research on the topic mentioned above of assessing transport economic efficiency by considering welfare measures, other assessments of transport policies considering economic impacts have also been developed. Economic impacts of charging HGVs have been studied in several countries of the EU. For example, Kleist and Doll (2005), and Doll and Link (2007) used ASTRA to estimate the impact of road tolling in macroeconomic variables such as the GDP at national levels of the EU. At the regional level, Hilbers et al. (2007) have assessed the economic effects of a road pricing scheme in the Netherlands through a SCGE model distinguishing the agglomeration enhancing effect. Similarly, Jensen-Butler and Madsen (2001), and Larsen and Jensen-Butler (2005) have used an Interregional General Equilibrium model (LINE) linked to a transport model to assess the regional effects of road pricing in Denmark on total demand and production. Also, as Kveiborg (2005, 2006) acknowledged, Input-Output model has been used in Germany while CGE, and SCGE models have been applied in Denmark and Norway to assess economic impacts of HGVs road pricing.

At the EU level, Christidis and Brons (2010) have used the TRANSTOOLS model to assess the road charging policy in six different road corridors across the EU. The results of this evaluation estimates the impact on final product prices and how it would lead to a redistribution of costs and benefits between users, regions and productive activities depending on the level of externalities their transport operations generate. Similarly, the model SCENES was applied to the EU ─NUTS2 regions level─ by Raha et al. (2003). The results have identified impacts in the changes of routes used by trucks, changes in the fleet of trucks, a shift to combined transport, including rail and shipping, increased sourcing of production inputs and consumer goods from local suppliers, and changes between EU regions in the location of manufacturing and service industries. Moreover, the ASTRA model was used by W. Schade and Doll (2005) for impact analysis of pricing policies in a macroeconomic context in the EU considering such variables as employment, GDP, exports, and emissions. Additionally, the IASON project of the fifth framework program has assessed regional impacts of pricing policies in the EU on GDP (see more details in Schneekloth and Bröcker (2003)).

Besides the EU, the economic impact assessment of road pricing has been carried out in other countries. Safirova et al. (2007) has evaluated the case study of Washington D.C. metropolitan area. In this analysis, they used an integrated strategic transportation planning model with a spatial disaggregated GE model (LUSTRE). This model was capable of measuring welfare changes as well as GDP changes. Also, Sato and Hino (2005) used a SCGE to assess the impacts of road pricing on location of household and business, regional economy and transport in Tokyo. Similarly, this model found changes in the distribution of population and employees, in the Gross Regional Product (GRP), in the land rents, in the road traffic volume, and estimated the total toll revenue.

Furthermore, other road charging analyses have been carried out exclusively at the household level using CGE models. For example, Kalinowska and Steininger (2009) have assessed the introduction of car road user charging occurring within the private household sector in Austria and Germany.

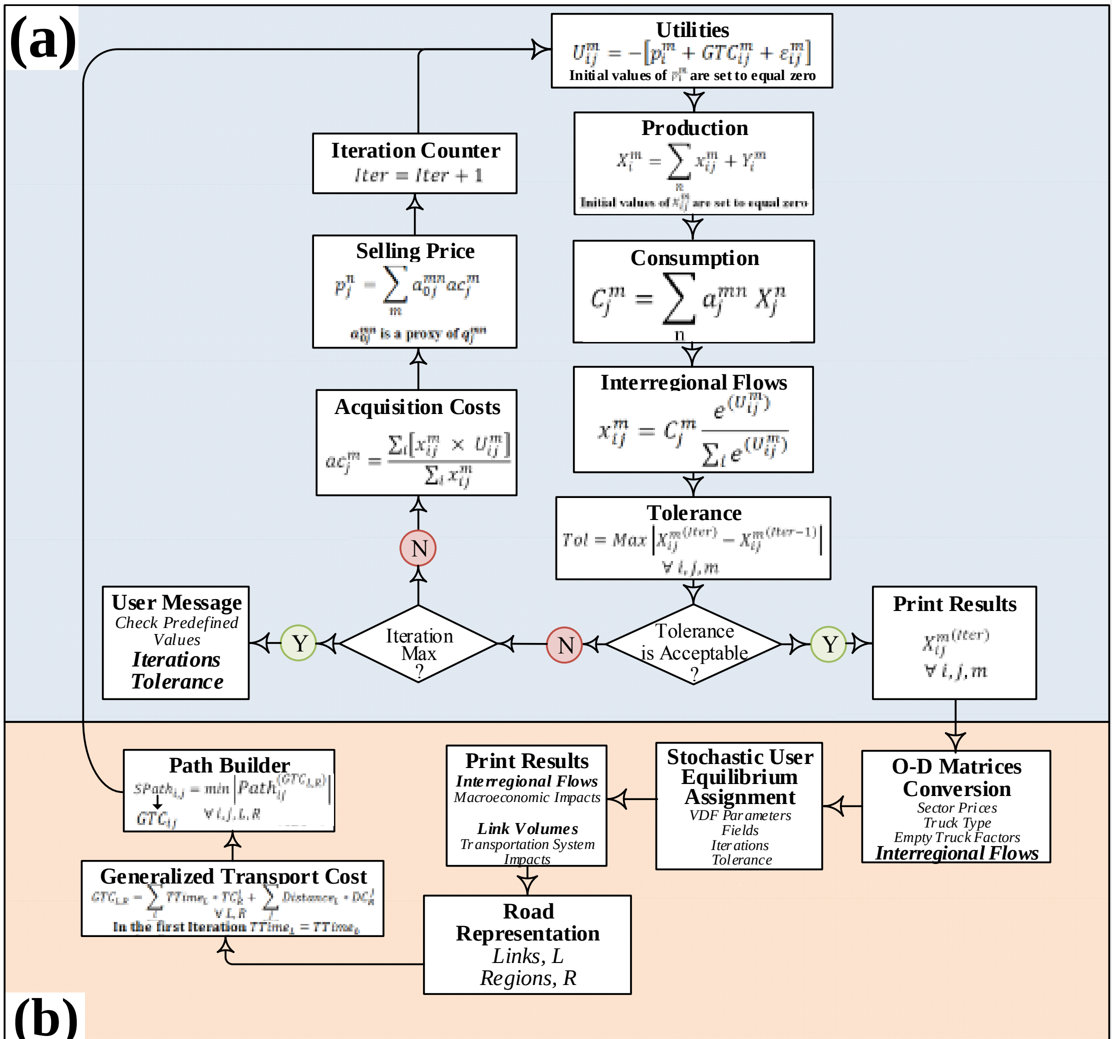
It is worth noting that there has not been sufficiently researched evaluating the impact of charging HGVs on macroeconomic aggregates at the regional level. Even if there are recommendations and overall explored benefits of charging, there is a skeptical concern about the potential macroeconomic benefits in regions such as Spain that are being widely researched. Therefore, a constant need for developing adequate and high quality economic impact assessment models has pushed to develop new integrated models to overcome the weakness of the typical modeling approaches

2.2 An Integrated Approach to Assess the Impact of a Fee-Charge Applied to Heavy Goods Vehicles

To assess the impact of a possible road fee-charge applied to HGVs over the whole network of a country such as Spain, we have considered a modeling approach capable of making more endogenous components such as transport costs by considering interactions between spatial economics ─considering the technical structure of the industry and the requirements for trade─ and transport system dynamics. The modeling approach analyzes both output-supply and input-demand relationships through trade flow patterns among regions using a road freight transportation system. The integrated approach is made up of a RUBMRIO approach (**Figure 1.a**), and a road network model (**Figure 1.b**).

2.2.1 The Random Utility-Based Multiregional Input-Output (RUBMRIO) Approach

The RUBMRIO approach replicates observed conditions of trade among regions through a Multiregional Input Output table (MRIO) by considering technical coefficients and trade coefficients. In fact, the MRIO table displays the economic relations among different production sectors, and among regions of a country instead of considering these relationships as spatially homogeneous (Duchin & Steenge, 2007). The MRIO table displays the economic relationships among different sectors by intersectional relationships of Input-Output coefficients or demand functions, and it is also capable of representing the spatial distribution of the flow of goods by using random utility-based models (Wegener, 2004).



Step 1) RUBMRIO input is generated from the road transport network model considering the free-flow time $TTime_0$ for the estimation of the Generalized Transport Cost among regions (GTC_{ij}).
Step 2) Estimation of the utility (U_{ij}^m) for origin region *i* of moving goods of sector *m* to be consumed in region *j*, considering the Generalized Transport Cost (GTC_{ij}^m). Initial values of the purchasing prices (p_i^m) in the origin region *i* are set to equal zero, and a random error term (ε_{ij}^m).
Step 3) Regional production of any given sector *m* in a producer region *i* (X_i^m) is evaluated including intermediate demand (x_{ij}^m - endogenous) and final demand (Y_i^m- exogenous). Initial values of interregional flow of goods and services x_{ij}^m are set to equal zero.
Step 4) Consumption of sector *m* in region *j* (C_j^m), is calculated considering the set of technical coefficients (a_j^{mn}) for the production process of all sectors considering region *j* and total production (X_j^n).
Step 5) Interregional flows (X_{ij}^m) are distributed considering utility variations.
Step 6) The tolerance criterion is evaluated. In the case of achievement the procedure stops, and these interregional flows are the inputs for the road network model.
Step 7) If tolerance was not achieved, acquisition costs (ac_j^m) are updated, to represents the average weighted cost of commodity *m* in region *j*.
Step 8) new prices (p_j^n) are computed considering technical coefficients without import considerations (a_{0j}^{mn}) as a proxy of the quantity of sector *n* needed for the production of one unit of sector *m* in region *j* (q_j^{mn}), and acquisition costs (ac_j^m). Sales price depends on the costs of purchasing raw materials, labor and necessary services form other producers. The new prices are used to run a new iteration until the equilibrium of interregional flow is achieved.
Step 9) Once the interregional flow is achieved; *OD* matrices per sector are prepared considering the interregional flows and conversion factors (e.g. prices, truck types, and empty truck factors).
Step 10) The route assignment is performed, and volumes of HGVs traffic is determined for each of the 17,422 links
Step 11) The results of the assignment are updated in the Generalized Transport Cost function $GTC_{L,R}$ considering the new travel time $TTime_L$.
Step 12) The new input for RUBMRIO is generated, and the process is repeated until convergence.

Fig. 1 – An Integrated Approach for Transportation Impact Assessment: (a). RUBMRIO Algorithm; (b) the Road Transport Network Model

As a result, the RUBMRIO model traces the linkages of inter-industry purchases and sales among regions within a given country by using transport, and in so doing it reproduces with more detail and realism freight transport services through a commodity-based structure rather than a trip-based or truck trip-based structure. Therefore, the RUBMRIO approach is able to show shifts between industries/sectors and regions supporting generative, redistributive, substitutability and complementarity effects through trade patterns.

It is important to note that the practical application of the RUBMRIO approach is facilitated through the consideration of the supply prices of different sector products. The price at origin has been determined through an iterative single fixed-point algorithm that defines a sole spatial equilibrium solution —assumptions about the procedure are extensively described in Zhao and Kockelman (2004). Also, Marzano and Papola (2008) have proposed the RUBMRIO model solution through a double fixed-point formulation by considering the introduction of a new feedback in the model. However, the conditions for attaining a solution taking into account the uniqueness of the double fixed-point approach are still under development.

RUBMRIO applications to transport cover different "*ex-ante*" topics such as: construction of transportation corridors, changes in travel times, infrastructure investment, operational cost variation, fuel taxes, road charging, trade pattern changes, and regional transport conditions (see more details in: Cascetta, Marzano, and Papola (2008), Guzman and Vassallo (2013), Huang and Kockelman (2010). These applications have found out important indirect effects of transport policies at the regional level on various macroeconomic aggregated indicators. However, they do not evaluate the impact on the transportation system (e.g. congestion reduction, time savings, traffic flow deviation, pollution and reduction of emissions). Therefore, in the integrated approach we have included a transport network model in order to address these effects. More detailed discussion on the transport network model will be provided later on in this paper.

2.2.2 The Road Network Model

The road network model should deal with the spatial representation of transport flows on a road network considering: 1) the conversion of interregional flows to vehicle flows so as to generate OD matrices; 2) an assignment procedure used to predict the traveler's choice of routes in the road transport network. For this purpose, the model considers the fact that link travel times are flow dependent through a volume-delay function (VDF) which reflect traffic behavior as is shown in Equation (1). This traditional formulation was proposed by the Bureau of Public Roads (BPR) in 1964, and has been used ever since to specify how sensitive the network times are to traffic congestion; and 3) determine possible routes between any two locations through a cost minimization criterion given by Equation (2).

$$TTime_L = TTime_o \times \left[1 + \alpha \left(\frac{v}{c}\right)^{\beta}\right] \qquad (1)$$

$$GTC_{L,R} = \sum_i TTime_L * TC_R^i + \sum_j Distance_L * DC_R^j \qquad (2)$$

$TTime_L$ is the travel time when the link L is reached. $TTime_o$ is the free-flow travel time. v is the traffic volume. c is the practical capacity is used to mean the maximum possible flow of vehicles that can be allowed in a road section per time period (usually one hour).

2.2.3 Integrated Approach Assembly and Solution

The integration is done on the basis of the algorithm shown in **Figure 1**. From the road transport network, the values of $\mathrm{GTC_{ij}}$ among regions are calculated considering $\mathrm{TTime_o}$ according to Equation (2). These values are used to generate the RUBMRIO input. RUBMRIO algorithm is performed sequentially by using the single fixed-point algorithm implemented through a macro program based on Visual Basic for Applications (VBA) in Excel. This algorithm is executed until consecutive trade flows stabilize with an error lower than 1% defined by the tolerance criterion —see **Figure 1.a**. Afterwards, the road network model —see **Figure 1.b**— establishes OD matrices by transforming monetary values of the MRIO table into vehicles considering each economic sector, these matrices are assigned to the road transport network in order to update costs based on the updated $\mathrm{TTime_L}$. The integrated approach is re-run, with the updated $\mathrm{GTC_{L,R}}$ through an iterative feedback process until equilibrium is reached.

2.3 Interregional Trade Changes Assessment

The quantification of the interregional trade changes of a road fee-charge applied to HGVs in Spain is assessed through the changes represented by MRIO tables of both base-case and fee-charge scenarios. Interregional trade changes will make known the changes in the economic structure ─production and consumption─ when a transport policy such as a road charge is included over the whole network..

3 CASE STUDY: A DISTANCE-BASED FEE-CHARGE FOR HGVs IN THE ROAD NETWORK OF SPAIN

3.1 Description

In 2007 Spain's road transport network for HGVs has more than 20,000 kilometers distributed in high-capacity roads, and conventional roads. In this sense, it is important to note that the Spanish road transport network has witnessed the development of a vast modern high-capacity road network ─11,276 kilometers (7,007 miles) of tolled highways, free highways, and multilane highways─ over the last two decades (see **Figure 2.a.**).

With regard to freight transport, it is important to highlight that the road mode is by far the prevailing mode in Spain. Official statistics given in the Permanent Survey of Transport of Goods by Road ─MFOM (2011) states that in 2010, 1,567 million tonnes ─98.7%─ were transported by road. Rail freight transport, by contrast, amounted only for 21.44 million tons ─1.3%─ in 2010 (FFE, MFOM 2011).

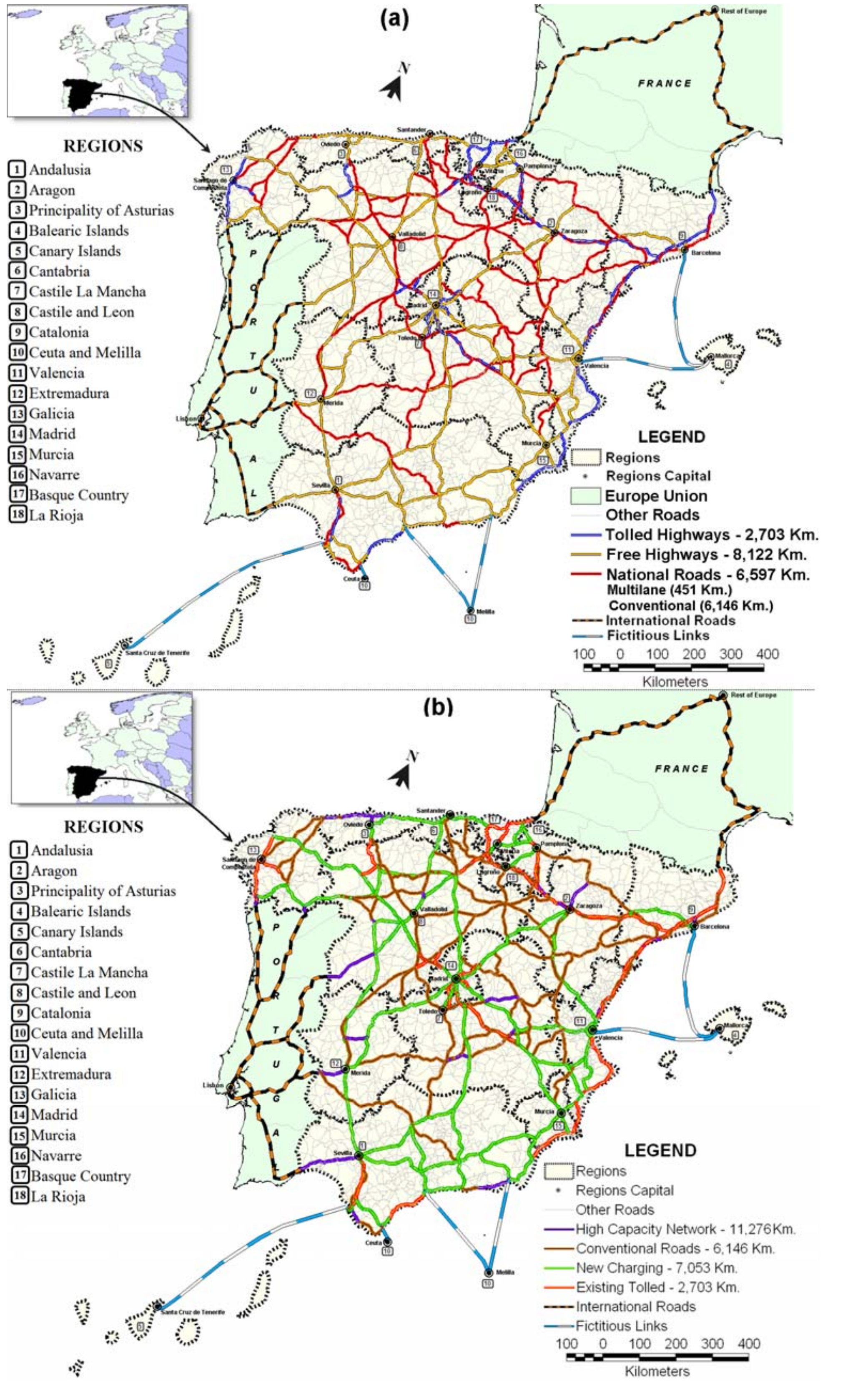


Fig. 2 – Road Network for Freight Transportation: (a) Base-Case; (b) Road Fee-Charge Scenario.

The selected road network adopted for the road charging scenario is made up of high-capacity roads (tolled, free highways and national multilane roads) connecting the capitals of the regions (see **Figure 2.b.**). The length of the road network where the road charges could be introduced is 7,053 km ─4,382 miles.

3.2 Application of the RUBMRIO Approach to the Base-Case

In order to construct the model for Spain, we used the existing interregional IO table developed by the DESTINO research project (Consortium DESTINO et al., 2011) for the year 2007. A simplifying procedure was developed to aggregate sectors identified as freight transport intensive sectors (MFOM 2008a) ─see **Table 1─**, non-freight transport intensive sectors (e.g. Trade and Repairs of Vehicles, Finance and Real State, Tourism, Education, among others), and to discard multi-sector relationships among sectors (m to n) to build up a MRIO compatible with the transportation data available.

Concerning the utility function, we adopted a Nested Logit (NL) model representing the choice of regions in two relevant nests (within-region and outside-region), and four relevant alternatives (same, close, near and far) as it is presented in Equation (3). Though some utility models have included rail in the NL structure (Cascetta et al., 2008; Huang & Kockelman, 2010), we did not do the same because rail's market share is negligible in Spain. The NL structure was a way of overcoming problems detected in the single level multinomial logit formulation.

$$U_{ij}^{m} = -p_{i}^{m} + \lambda^{m}\, ln\left[\sum_{R} exp(U_{ij,R}^{m})\right] \qquad (3)$$

$$U_{ij,R}^{m} = \theta^{m} GTC_{ij,R}^{m} \qquad (4)$$

U_{ij}^{m} shows the utility for region j of acquiring commodity m in region i. The systematic utility of the lower nest $U_{ij,R}^{m}$ is defined in Equation (4). p_{i}^{m} is the price of goods/services of sector m in region i. λ^{m} and θ^{m} are the logit model parameters. GTC_{ij}^{m} is the Generalized Transport Cost of sector m goods from production or origin region i to consumer region j. Total GTC between production and consumer regions was incorporated to avoid possible multicollinearity problems.

The parameter estimates of the NL utility model ─shown in **Table 1─** were obtained by using the NLOGIT with the maximum likelihood method. The estimated coefficients have the expected signs because costs have a negative effect on utility. Moreover, the Wald statistic (values in brackets) rejects the null hypothesis that the coefficient is zero with a level of 90% confidence ─p-values for each parameter are reported. Also, it is convenient to measure goodness of fit analogous to those in linear statistical models. Indeed, the Likelihood Ratio Index ─McFadden Pseudo R^2 (ρ^2)─ provides a convenient basis for comparing different models when estimating more than one alternative. Pseudo R^2 values between 0.2 and 0.4 are fairly good reliable according to McFadden (1977).

Low values in these two tests could be explained by the lack of sufficient data at this point (Kockelman, 2008). This indicates that more data about flows of goods would be required in order to obtain more accurate results, but unfortunately these data are not available for the case of Spain.

The road network model was built using the software TransCAD. Capacity (vehicles/hour) and speed targets are defined by the government for each classification of roads by function. We have included these values as inputs for each link of the road network. In addition, the greater the slope of a road the greater the reduction, in both speed and capacity, of the traffic on that road. Therefore, we have reduced both speed and capacity by considering factors reflecting the slope of the road. We have used the traffic count data taken from (MFOM 2008b), sorted by type of vehicle, included for each link in order to validate the base-case year assignment model. We had to consider that in the model not only truck traffic ─affected by the introduction of LHVs─ but also cars and buses use the same road network. Therefore we treated these traffic flows as a pre-load volume, because we are not including them in our integrated modeling approach.

		Sector	θ^m	λ^m	**Likelihood Ratio Index McFadden Pseudo R2 (ρ^2)**
Freight Transport Intensive	**1**	Agriculture, Fishing, Wood and Cork	-0.00370* (-1.791)	0.602	0.151
	2	Food and Kindred Products	-0.00221 (-1.618)	0.398	0.174
	3	Non-metal Minerals and Kindred Products	-0.00310** (-2.469)	1.212	0.174
	4	Energy, Petroleum and Petroleum Products	-0.00359* (-1.662)	0.286	0.101
	5	Mining	-0.00292** (-2.393)	0.999	0.328
	6	Metal minerals and Kindred Products	-0.00262* (-1.942)	0.759	0.123
	7	Construction	-0.00363** (-2.508)	1.730	0.365
	8	Chemical and Allied Products, Paper, Edition and Kindred Products, Rubber Materials	-0.00186* (-1.726)	0.534	0.166
	9	Textiles, Clothing, Leather and Shoes, Industrial Machinery and Equipment, Electric and Electronic Equipment, Transportation Equipment, and Other Manufacturing Industries	-0.00252* (-1.68)	0.417	0.144

( ) Wald statistical significance test
* p<0.10
** p<0.05

Table 1 – Input-Output Economic Sectors and Estimated Parameters for the Nested Logit Model

Conversion factors from the RUBMRIO model were applied so as to convert the measurement of the commodity trade in the transportation system from monetary units (Euros) to tonnes, and from tonnes to trucks per year, and finally, to trucks per day. This conversion used an average price per tonne for a specific commodity (€/tonne), the Heavy Goods Vehicles (HGVs) configuration of each sector, and a factor reflecting the percentage of trips of empty trucks. This procedure enabled us to obtain OD matrices per sector.

The percentage of empty HGVs was adopted from the Ministry of Transportation of Spain (MFOM 2008a), considering pickup/delivery truck operations in both directions of origin-destination pairs as a proxy since detailed information required to build up an empty trip model for Spain was not available. Additional information regarding external trips (imports and exports to/from other peripheral countries as Portugal, and elsewhere in Europe) were also incorporated (Gutiérrez, Condeço-Melhorado, Martin, & Román, 2012), since it was not included in the RUBMRIO.

A Multi-Modal Multi-Class Stochastic User Equilibrium assignment (SUE) procedure was conducted to assign the HGVs traffic of the resulting OD matrices as user classes and considering VDF functions for each functional classification class through TransCAD for the base-case scenario. These functions incorporated individual variations of generalized cost perceptions. We adopted a time period of 24 hours (one day) since detailed information about time periods was not available taking into account that daily capacity is calculated by multiplying the hourly capacity by a daily expansion factor.

The process of validation was conducted on the basis of comparisons between predicted and observed flows in all the links of the base-case scenario in order to determine whether the assignment model is loading HGV trips for each functional class in a reasonable way. VDF parameters and daily expansion factors changes were introduced in an iterative process intended to minimize deviations between assigned and observed traffic flows

3.3 Application of the RUBMRIO Approach to the Road Charging Scenario

The road charging scenario was developed by considering the implementation of charges to HGVs. A study that applied the calculations of the *"Eurovignette"* Directive to the case of Spain (Vassallo, Gómez, Saldaña, Sierra, & Di Ciommo, 2012) showed that the average charge to HGVs applicable in Spain is €0.079 per kilometer (US$ 0.156 per mile). We will use this charge for the macroeconomic impact analysis conducted in this paper.

The charging scenario is developed by considering: (i) the changes in the GTC function (Equation 2) by implementing a fee-charge of 0.079 €/km to HGVs in the selected network (distinguishing tolled and non-tolled highways); (ii) the sequentiality of the RUMBRIO approach considering the approach solution describe in section 2.2.3 on the basis of these new values used to generate RUBMRIO input. The final MRIO matrix obtained from the algorithm is used to analyze the interregional trade changes expected from the fee-charge scenario in comparison to the base-case scenario.

4 ANALYSIS OF RESULTS

4.1 Interregional Trade Changes

The results of the integrated modeling approach determine, on the one hand, GTC changes, and the resulting commodity prices. On the other hand, interregional sector flows which are converted through factors defined in the base-case scenario in HGVs volumes and in a multiple sector OD matrix related to region pairs of Spain. The detailed results of trade pattern changes per regions considering the commodity price change and the GTC function are displayed in **Figure 3**.

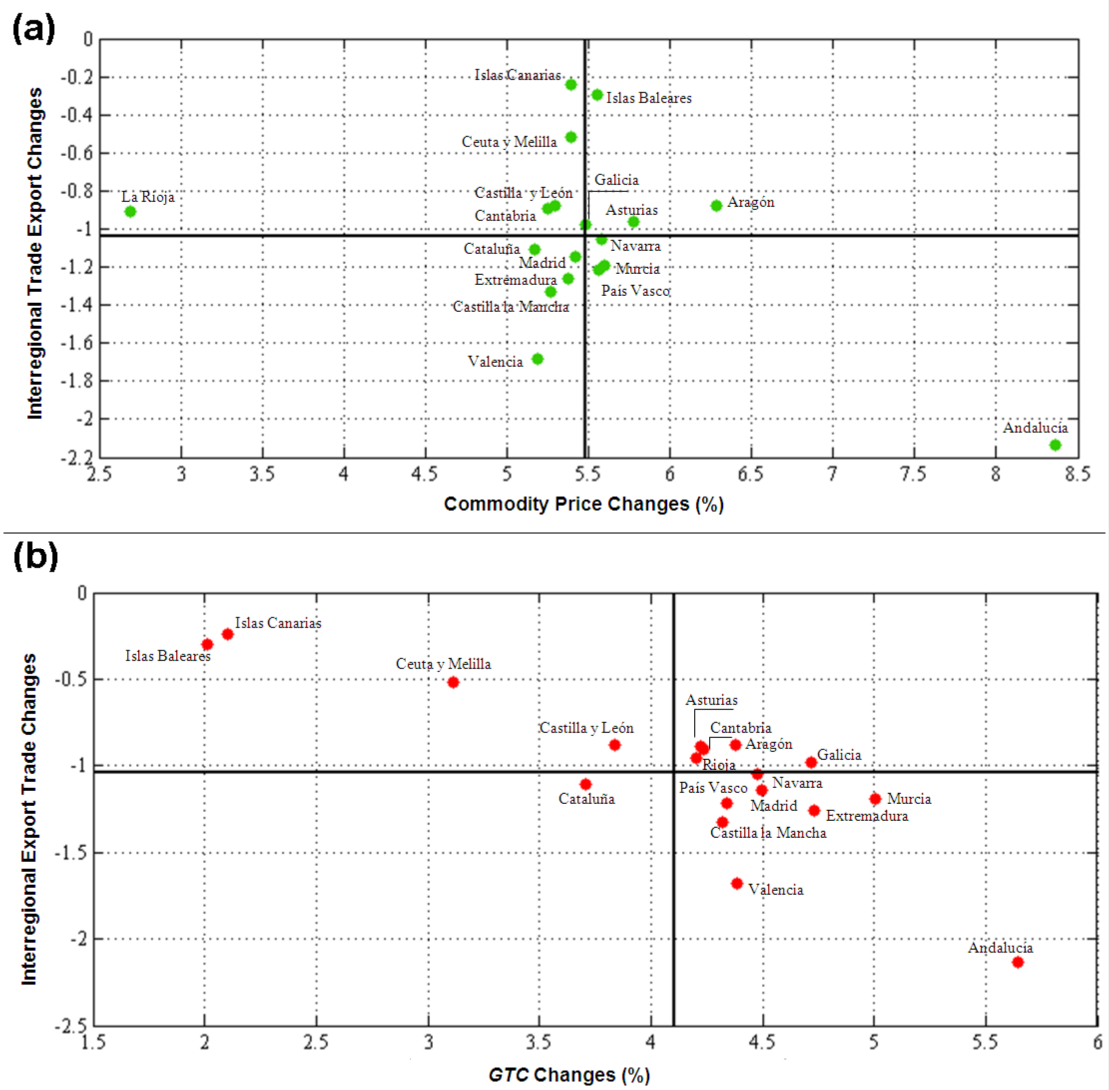


Fig. 3 – Interregional Trade Changes: (a) Commodity Price Changes; (b) GTC changes.

Trade pattern changes have shown a number of interesting results within Spain. A key issue that emerged in all the regions of Spain was that internal production and consumption increased due to the constraints imposed by the Generalized Transport Cost (GTC) because exports to other regions have decreased as shown in **Figure 3**.

With regard to the detailed results per regions, some regions, such as the Islands (Balearic, and Canary) and Ceuta and Melilla, Castile and Leon, Cantabria, La Rioja, Galicia, Aragón, and the Principality of Asturias have registered the low decreases in exports (until -1%) with commodity prices and the GTC rises variables between 1,5% and 5,0%. The remaining regions, registered exporting trade changes between -1,5% and -2,5% to other regions with commodity prices and the GTC increase between 4,0% and 6,0%.

These resulting patterns have highlighted important changes among regions and sectors showing substitution effects. In fact, some regions such as Andalusia, Valencia, Castile La Mancha, and Extremadura have the most important interregional trade changes. Indeed, the particular geographical situation of regions such as Andalusia, Valencia, and Extremadura could not benefit trade form these regions or to these regions because existing businesses, which incur additional costs as a result of their remoteness, being located as they are in one of the outermost regions of Spain.

However, other regions such as Cantabria, Galicia, Navarra, which are also outermost regions of Spain, will not experience greater decreases in interregional trade patterns even if the prices have registered important increases. This trade changes have shown that economic sectors were essential in trade relations in each region. In fact, some regions' commodities like food and kindred products, energy, petroleum, and petroleum products, chemical and allied products, paper, printing, rubber products and textiles, clothing, leather and shoes, industrial machinery and manufacturing industries were the most important sectors exchangeable, but mining and construction were not included in the substitution among regions.

On the whole, trade pattern changes show that substitution among regions is concentrated in mainland Spain and some regions does not choose to trade with, and they are unable to fulfill their production requirements internally.

5 CONCLUSIONS

This paper provides the impact on the interregional trade of Spain caused by a transport policy measure such as a road fee-charge applied nationwide. The results demonstrate that the model developed in this research is able to forecast the indirect effects produced on trade. In addition, this model provides a useful tool for policy makers, governmental, and transportation authorities to evaluate the impacts of transport policy measures.

The first conclusion of this research is that the introduction of a road fee-charge for HGVs influences interregional trade. Trade decreases over the regions of Spain. The substitution effects of this policy are evidenced in trade patterns which are dependent on the transport services offered. The extents to which regions are affected were conducted through the comparison of the MRIO table of the base-case and the new MRIO resulting from the policy scenario. The region directly affected by this policy was Andalusia, which has to make more use of their local resources internally.

The interregional trade analysis performed in this research has become a real challenge to national authorities of Spain because they have to maintain the trade links among regions without generating the disparities evidenced in the results of the road fee-charge scenario.

The second conclusion is that the flow of trucks in the network is expected to diminish slightly because exports (sales) among regions decrease. Although this trend is favorable for the environment and on those stretches of highway that exhibit congestion problems, might have a negative impact in obtain sufficient raw materials.

The third conclusion is that this paper has intended to explain the changes that might occur in the Spanish economic activity of regions paying special attention to the role that a the road fee-charge have played, that is, trying to see to what extent the greater and the lower changes have been based on the economic structure of the regions, or on the concentration of economy in sectors such as the construction, or food. This analysis of how the economy changes in the policy scenario, without doubt, serve to evaluate the present situation and to suggest future paths of development.

Overall, the results have pointed out that our integrated modeling approach based on a commodity-based structure assesses the impact of transport policy measures on freight flows running on the road transportation network. This approach overcomes the undesirable limitations of models based on truck-trips. As a result, this research has proposed, and constructed, a comprehensive approach to better forecast interregional trade impacts, upon the introduction of a new fee-charge for freight vehicles (HGVs) within a country like Spain. Moreover, the detailed results of the integrated modeling approach determine the regions, and the economic sectors to which government should strengthen its efforts aimed at giving economy a boost in order to diminish the undesirable effects of a road fee-charge applied to HGVs in the road network of Spain.

7. ACKNOLEDGEMENTS

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