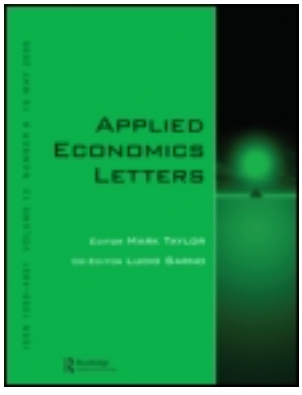


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# Modelling the Spanish imports of vehicles using a source differentiated demand system

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# *Modelling the Spanish imports of vehicles using a source differentiated demand system*

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This paper models the Spanish imports of vehicles, differentiated both by goods and by origins, during the period 1963–1992, using a source differentiated Almost Ideal Demand System. We consider three vehicle goods, namely trucks, cars and tractors, which are imported from six different origins, Germany, the USA, France, the UK, Italy and other countries. Having first shown that the estimated model does not exhibit autocorrelation problems, the results are presented using the expenditure and price estimated elasticities. French trucks and tractors and US cars are the most luxurious imported vehicles. The Marshallian own-price elasticities reflect that Italian trucks, German cars and US tractors had the most insentitive demands to own-price changes. Finally, cross-price elasticities show weak effects.



## I. INTRODUCTION

In recent years efforts have been made to estimate the behaviour of the imports of manufactures (see, for instance, Brenton and Winters, 1992, in Germany; Winters, 1984a and 1984b, and van Heeswijk *et al.*, 1993, in the UK; Martínez *et al.*, 1991, in Spain). One common characteristic of all these papers is the use of the aggregated good (manufactures), which becomes a limitation if one wishes to obtain detailed results with respect to each individual product. Therefore, an analytical approach that differentiates goods by origin appears to be a convenient way to complete an exhaustive study of imports. In this line, the increasing quantitative importance of the Spanish imports of vehicles, basically after Spain's integration into the European Union in 1986, coupled with the fact that there is no empirical evidence available on Spanish vehicle imports, has motivated us to carry out this analysis.

The objective of this paper is to model the Spanish imports of vehicles, differentiated by specific goods and by origins, during the period 1963–1992. To this end, we have chosen a source differentiated version of the Almost Ideal Demand System (AIDS) proposed by Deaton and Muellbauer (1980), where the expenditure function is rewritten to approximate import behaviour that differentiates goods by origin. The AIDS system was originally used by Winters (1984) for import demand estimation because of its properties (flexibility, ease of estimation and interpretation and theoretical acceptability). However, the applications of the AIDS model to import demand have two limitations. First, it assumes origin aggregation, under which the demand model does not differentiate the goods by source and, secondly, the AIDS system assumes separability among goods, which allows the model to consist only of share equations for one good imported from different origins. To avoid these limitations, this study uses a source differentiated AIDS model, formulated in such a way that the good sources are differentiated, in order to estimate the demand for vehicles imported into Spain. The results of these estimations are presented in the form of expenditure and price elasticities.

To satisfy this objective we assume a two-stage budgeting process, which postulates that agents allocate total import expenditures, first to broad groups of goods based on a price index for each group and thereafter allocate expenditure within groups, based on group individual prices and group expenditures. In our particular case, we estimate the second stage by employing vehicle data. We divide the import expenditure in this main group into three specific goods, namely trucks, cars and tractors, which are imported from six different origins, Germany, the USA, France, the UK, Italy and other countries. Thus, the allocation of vehicle expenditure to individual items depends only on the total number of vehicles imported and the specific price of items in this particular group. Weak separability of the utility function therefore justifies the exclusion of other prices, and is both necessary and sufficient in order for this second stage to be consistent with the utility maximization of individual preferences.

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The paper is organized as follows. The source differentiate Almost Ideal Demand System is explained in Section 2. In section 3 the data and estimation procedure are described. Section 4 presents the empirical results, and, finally, the last section contains the conclusions of the study.

## II. THE SOURCE DIFFERENTIATED AIDS MODEL

Given that the objective of this paper requires that the model allows us to differentiate among several origins, we follow Yang and Koo (1994), who specified the source differentiated Almost Ideal Demand System, SDAIDS, formulated in its budget share form:

$$w_{i_h} = \alpha_{i_h} + \sum_{j}^{n}\sum_{k}^{m} \gamma_{i_h j_k} \log p_{j_k} + \beta_{i_h} \log\left(\frac{y}{P}\right) \qquad (1)$$

with $P$ being the index price:

$$\log P = \alpha_0 + \sum_{i}^{n}\sum_{h}^{m} \alpha_{i_h} \log p_{i_h} + \frac{1}{2}\sum_{i}^{n}\sum_{j}^{n}\sum_{h}^{m}\sum_{k}^{m} \gamma^{*}_{i_h j_k} \log p_{i_h} \log p_{j_k} \qquad (2)$$

and where $\alpha_0$, $\alpha_{i_h}$, $\beta_0$, $\beta_{i_h}$ and $\gamma^{*}_{i_h j_k}$ are parameters. The subscripts $i$ and $j$ denote goods ($i,j = 1,\ldots,n$), and $h$ and $k$ denote origins ($h,k = 1,\ldots,m$), that is to say, goods $i$ and $j$ may be imported from $m$ different origins.

Model (1) allows for different responses on the part of an importing country to different goods and their origins. Hence, the SDAIDS may suffer from a degrees of freedom problem in empirical applications. To avoid this, that is to say, to reduce the number of parameters, we can introduce the assumption of block substitutability $\gamma_{i_h j_k} = \gamma_{i_h j}$, which indicates that cross-price effects of different sources in good $j$ on the demand for origin $h$ in good $i$ are the same for all goods from different sources in good $j$. For example, block substitutability says that the Spanish demand for German cars shows the same cross-price response as tractors from France or tractors from Italy. Therefore, this assumption enables us to rewrite model (1) as:

$$w_{i_h} = \alpha_{i_h} + \sum_{k}^{m} \gamma_{i_h i_k} \log p_{i_k} + \sum_{j\neq i}^{n} \gamma_{i_h j} \log p_j + \beta_{i_h} \log\left(\frac{y}{P}\right) \qquad (3)$$

where $\log p_j = \sum_k^m w_{jk} \log p_{jk}$. This restricted model, RSDAIDS, has only $m + (n-1) + 2$ parameters in each equation, whereas the SDAIDS model has $mn + 2$ coefficients. Thus, the RSDAIDS model would be a practical alternative for most import demand studies.

The basic demand restrictions for import behaviour are expressed in terms of the coefficients of the RSDAIDS model, that is, adding-up:

$$\sum_{i}^{n}\sum_{h}^{m} \alpha_{i_h} = 1,$$

$$\sum_{h}^{m} \gamma_{i_h k} = \sum_{i}^{n}\sum_{h}^{m} \gamma_{i_h j} = \sum_{i}^{n}\sum_{h}^{m} \beta_{i_h} = 0;$$

homogeneity:

$$\sum_{k}^{m} \gamma_{i_h k} + \sum_{j\neq i}^{n} \gamma_{i_h j} = 0;$$

and symmetry: $\gamma_{i_h k} = \gamma_{i_k h}$.

## III. DATA AND ESTIMATION

The data used in this paper consist of Spanish annual time-series of imported vehicles for the period 1964–1992. We have divided the total imports into three goods: (1) trucks, (2) cars and (3) tractors. Each good was imported from six different origins: (1) Germany, (2) the USA, (3) France, (4) the UK, (5) Italy and (6) other countries. All statistical information (quantities and values in Spanish pesetas) has been obtained from a number of issues of the *Contabilidad Nacional de España (Instituto Nacional de Estadistica)*. Import prices for individual vehicles by origin are not publicly available. Thus, as a proxy for the import price we have employed the unit value obtained by dividing the value by the quantity.

Table 1 provides a brief descriptive analysis, which includes the time evolution of budget shares. It can be seen that car imports represent, on average, more than half of total vehicle imports, 57%, whereas tractors represent 23.4% and trucks 19.6%. The time evolution indicates that the budget shares of cars have steadily increased over the whole sample period, except in the years immediately after the oil crisis of 1973; note that the value of 1975 is the lowest of all sample years, and that thereafter the shares continue to increase until the end of the sample period. By contrast, the expenditure share of tractors shows a decreasing time evolution during the last three decades. Finally, the trucks share has increased from the beginning of the sample period up to the mid 1970s, and thereafter it has remained over 11%.

With respect to disaggregated budget shares, we can observe that the majority of vehicles were imported from Europe, whilst a small percentage have their origin in the USA. In particular, we can note that cars were imported mainly from Germany over the whole sample period, 40.3% on average, that 15.1% of imports came from France and that only 2.2% of cars had their origin in the USA. The time evolution shows a decrease of car imports from Italy and the UK from the beginning of the sample period until 1980, when the shares started to increase. As regards tractors, the country which shows the highest expenditure share is Italy, 32.7%, followed by Germany, 21.5%, and, again, the origin with the

Table 1. *Budget shares (%)*

| | 1963 | 1970 | 1975 | 1980 | 1985 | 1992 | Mean |
|---|---|---|---|---|---|---|---|
| Trucks | 20.4 | 24.5 | 36.6 | 11.1 | 11.5 | 10.2 | 19.6 |
| Germany | 16.5 | 39.3 | 28.4 | 6.3 | 32.1 | 24.2 | 28.7 |
| USA | 24.6 | 15.8 | 29.3 | 24.6 | 0.4 | 3.6 | 13.5 |
| France | 11.0 | 0.8 | 3.1 | 5.1 | 8.7 | 10.6 | 6.4 |
| UK | 37.1 | 19.3 | 8.4 | 5.7 | 2.5 | 13.1 | 13.3 |
| Italy | 19 | 13.7 | 2.2 | 16.4 | 38.6 | 23.7 | 15.8 |
| Other countries | 8.9 | 11.1 | 28.6 | 41.9 | 17.7 | 24.8 | 22.3 |
| Cars | 38.5 | 43.9 | 32.1 | 61.6 | 71.8 | 84.5 | 57.0 |
| Germany | 33.3 | 30.8 | 42.0 | 61.4 | 48.0 | 35.8 | 40.3 |
| USA | 3.0 | 4.6 | 2.4 | 1.6 | 0.3 | 1.2 | 2.2 |
| France | 18.3 | 18.5 | 13.2 | 6.8 | 15.0 | 19.6 | 15.1 |
| UK | 30.4 | 27.7 | 7.1 | 2.8 | 4.9 | 11.0 | 12.4 |
| Italy | 11.6 | 12.4 | 8.0 | 6.2 | 7.2 | 7.8 | 10.3 |
| Other countries | 3.4 | 6.0 | 27.3 | 21.2 | 24.6 | 24.6 | 19.7 |
| Tractors | 41.1 | 31.6 | 31.3 | 27.3 | 16.7 | 5.3 | 23.4 |
| Germany | 20.6 | 12.9 | 14.6 | 16.4 | 28.4 | 31.6 | 21.5 |
| USA | 8.8 | 4.2 | 8.1 | 4.8 | 1.8 | 2.6 | 5.6 |
| France | 5.0 | 9.9 | 4.4 | 4.4 | 7.0 | 8.2 | 7.7 |
| UK | 42.0 | 17.7 | 10.2 | 8.0 | 5.7 | 5.1 | 13.7 |
| Italy | 17.0 | 47.2 | 50.7 | 52.2 | 33.1 | 26.9 | 32.7 |
| Other countries | 6.6 | 8.1 | 12.0 | 14.2 | 24.0 | 25.6 | 18.8 |



lowest share is the USA, 5.6%. The most significant aspect in the evolution of these budget shares is the significant decrease of tractors imported from the UK over the whole sample period, from 42% in 1963 to 5.1% in 1992. Finally, Spain imported trucks from Germany, 28.7% on average and from Italy, 15.8%, with the lowest import share corresponding to France, 6.4%. We can observe a marked decrease of truck imports from the USA and the UK.

The initial specification of the model (3) generates equations which are non-linear in their parameters. To avoid non-linear estimation, our paper uses an approximation of the Stone (1954) index, which also allows us to avoid the simultaneity problem that causes the Stone price. In our approximation, $P^*$, lagged shares have been used instead of current shares. With this transformation, and adding an error term that captures taste shifts, measurement errors in the dependent variable and the effects of left out variables, the stochastic version of the RSDAIDS model, with homogeneity and symmetry imposed, is:

$$w_{i_h} = \alpha_{i_h} + \sum_{k}^{m-1} \gamma_{i_h i_k} \log\left(\frac{p_{i_k}}{p_{i_m}}\right) + \sum_{j \neq i}^{n} \gamma_{i_h j} \log\left(\frac{p_j}{p_{i_m}}\right) + \beta_{i_h} \log\left(\frac{y}{P^*}\right) + u_{it} \tag{4}$$

where $\log P^* = \sum_i^n \sum_h^m w_{i_h-1} \log p_{i_h}$, with $w_{i_h-1}$ being the lagged budget share and where $u_{it}$ is a vector of error terms which are assumed to be contemporaneously correlated, but serially uncorrelated.

Due to the adding-up restriction, the covariance matrix is singular and the likelihood function undefined. The usual procedure followed in this study has been to drop one of the equations, to estimate the remaining system and to calculate the parameters in the omitted equation via the adding-up condition. In our case, the dropped equation is tractor imports from other countries.

Moreover, because the RSDAIDS model has been estimated with the theoretical conditions of homogeneity and symmetry as maintained assumptions, each equation of the demand system has nine parameters (one intercept, five price coefficients of countries, two price parameters of goods and one expenditure coefficient), which are estimated with thirty effective observations.

Model (4) is technically a simultaneous equation system and, therefore, was estimated by using the SURE method of Zellner (1962), employing the TSP version 4.2 proposed by Hall (1991). Because of the nature of our data, that is to say, time series, we have tested individual first-order autocorrelation by means of the Godfrey (1978) test. Furthermore, the theoretical restrictions of the system were tested by means of the Wald test.

As the results are presented in the form of elasticities, the expenditure and Marshallian price expressions corresponding to the linear RSDAIDS model (4) are $e_{ih} = 1 + \frac{\beta_{i_h}}{w_{i_h}}$ and, secondly,

$$e_{i_h i_h} = -1 + \frac{\gamma_{ihh}}{w_{i_h}} - \beta_{i_h}, \quad e_{i_h i_k} = \frac{\gamma_{ihk}}{w_{i_h}} - \frac{\beta_{i_h} w_{i_k}}{w_{i_h}}$$

$$\text{and} \quad e_{i_h j} = \frac{\gamma_{i_h j}}{w_{i_h}} - \frac{\beta_{i_h} w_j}{w_{i_h}}$$

## IV. EMPIRICAL RESULTS

The results of the estimation are reported in Tables 2 and 3. In Table 2 we show the estimated parameters and the Godfrey test (G). As can be seen, the trucks equation has the highest number of estimated parameters significant at the 5% level, namely 18, whereas the cars and tractors equations have the same number of coefficients individually significant at the 5% level, namely 12. With respect to the specification test, none of the equations of the model show autocorrelation problems, because all values of this test are clearly lower than the critical value at the 5% level of significance, $\chi^2(1) = 3.84$. Hence, our specification is acceptable from an econometric point of view.

Table 3 shows the expenditure and Marshallian price elasticities, evaluated at the mean point of the explanatory variables. These values are reasonable in signs and magnitude and, for the most part, are individually significant.

All expenditure elasticities are positive and significant at the 5% level. Expenditure on trucks are elastic from the European countries, with imports from France and the UK having the highest values, 1.453 and 1.434, respectively, more

Table 2. *Estimated parameters*

| | $\alpha_{ih}$ | $\gamma_{ih1}$ | $\gamma_{ih2}$ | $\gamma_{ih3}$ | $\gamma_{ih4}$ | $\gamma_{ih5}$ | $\gamma_{ih1}$ | $\gamma_{ih2}$ | $\gamma_{ih3}$ | $\beta_{ih}$ | G |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Trucks | | | | | | | | | | | |
| Germany | −0.099 | 0.005 | 0.002 | −0.001 | −0.023* | −0.002 | | −0.127* | 0.138* | 0.009 | 0.63 |
| USA | 0.219* | | 0.008* | −0.001 | 0.002 | −0.005* | | −0.001 | −0.002 | −0.019* | 0.49 |
| France | −0.050* | | | 0.312 | −0.003 | 0.0005 | | −0.028* | 0.031* | 0.005* | 3.38 |
| UK | −0.131* | | | | −0.006 | −0.019* | | −0.049* | 0.113* | 0.013* | 0.11 |
| Italy | −0.021 | | | | | 0.024* | | −0.045* | 0.021 | 0.003 | 1.05 |
| Cars | | | | | | | | | | | |
| Germany | 0.999* | 0.128* | 0.016* | 0.010 | 0.015 | −0.001 | −0.202* | | 0.054 | −0.047* | 1.05 |
| USA | −0.132* | | −0.0002 | −0.005 | −0.0008 | −0.009* | −0.026 | | 0.057* | 0.009* | 1.85 |
| France | −0.109 | | | −0.012 | 0.003 | 0.002 | 0.041 | | −0.042 | 0.178 | 0.54 |
| UK | −0.128 | | | | −0.037* | −0.011 | −0.002 | | 0.032 | 0.012 | 1.40 |
| Italy | −0.269* | | | | | 0.006 | 0.042 | | −0.035 | 0.030* | 0.20 |
| Tractors | | | | | | | | | | | |
| Germany | 0.244 | 0.002 | 0.003 | 0.0007 | 0.007 | 0.003 | −0.011 | 0.005 | | −0.017* | 3.06 |
| USA | 0.113* | | 0.002 | −0.002* | −0.004* | 0.011* | −0.014 | 0.018 | | −0.008* | 0.91 |
| France | −0.029 | | | −0.002 | −0.004 | 0.001 | 0.014 | −0.009 | | 0.003 | 3.73 |
| UK | 0.032 | | | | −0.014* | 0.028* | 0.018 | −0.001 | | 0.0001 | 1.21 |
| Italy | 0.331* | | | | | −0.066* | 0.014 | −0.020 | | −0.027* | 0.06 |

*Note:* *Denotes significant at the 5% level.

Table 3. *Expenditure and price elasticities*

| | Germany | USA | France | UK | Italy |
|---|---|---|---|---|---|
| Expenditure | | | | | |
| Trucks | 1.163* | 0.379* | 1.453* | 1.434* | 1.133* |
| Cars | 0.756* | 2.036* | 1.212* | 1.196* | 1.506* |
| Tractors | 0.617* | 0.429* | 1.216* | 1.000* | 0.660* |
| Price | | | | | |
| Trucks | | | | | |
| Germany | −0.918* | 0.037 | −0.029 | −0.405* | −0.040 |
| USA | 0.116 | −0.690* | −0.044 | 0.104 | −0.168* |
| France | −0.168 | −0.154 | −0.725* | −0.324 | 0.033 |
| UK | −0.777* | 0.072 | −0.117 | −1.222* | −0.651* |
| Italy | −0.083 | −0.213* | 0.017 | −0.727* | −0.091 |
| Cars | −2.302* | 0.302 | −2.837* | −1.854* | −1.757* |
| Tractors | 2.359* | 0.048 | 2.710* | 3.569* | 0.753 |
| Cars | | | | | |
| Germany | −0.395* | 0.070* | 0.064 | 0.082* | 0.007 |
| USA | 1.460* | −1.034* | −0.665 | −0.159 | −1.056* |
| France | 0.074 | −0.066 | 1.171* | 0.027 | 0.018 |
| UK | 0.204 | −0.015 | 0.037 | 1.600* | −0.191 |
| Italy | −0.145 | −0.161* | 0.001 | −0.222* | −0.922* |
| Trucks | −0.811* | −3.043 | 0.455 | −0.078 | 0.615 |
| Tractors | 0.290 | 5.881* | −0.554 | 0.464 | −0.708 |
| Tractors | | | | | |
| Germany | −0.919* | 0.077 | 0.022 | 0.172* | 0.107 |
| USA | 0.246 | −0.836* | −0.170* | −0.242 | 0.798* |
| France | 0.031 | −0.161* | −1.159* | −0.240 | 0.059 |
| UK | 0.192* | −0.105 | −0.106 | −1.392* | 0.744* |
| Italy | 0.060 | 0.148* | 0.022 | 0.366* | −1.807* |
| Trucks | −0.029 | −0.818 | 0.802 | 0.499 | 0.248 |
| Cars | 0.337 | 1.571 | −0.664 | −0.031 | −0.063 |

*Note:* *Denotes significant at the 5% level.

than four times higher than that corresponding to the USA, 0.379. By contrast, the imports of cars from the USA show the highest expenditure elasticity, 2.036, with imports from Germany being the most inelastic, 0.756. Finally, expenditure on tractors from France and the UK are elastic, 1.216 and 1.000, respectively, with imports from the USA being the most inelastic, 0.429. These findings suggest that French trucks and tractors and US cars are the most luxurious imported vehicles, that is to say, as the imports of trucks, cars and tractors increased, Spanish consumers showed a greater preference for those from France, the USA and France, respectively.

All Marshallian own-price elasticities are negative, as theory predicts, and significant at the 5% level. With respect to trucks, only the imports from the UK are elastic, −1.222, whereas, Italy shows the smallest own-price elasticity, −0.091. Car imports from the USA, France and the UK are elastic, −1.034, −1.171 and −1.600, respectively, whereas imports from Germany are the most inelastic, −0.395. As regards tractors, imports from France, the UK and Italy are elastic, −1.159, −1.392 and −1.807, respectively, and the smallest values are displayed by the USA, −0.836. In summary, these values reflect that Italian trucks, German cars and US tractors had the most insentitive demands to own-price changes.

Cross-price elasticities show the substitutability and complementary relations among both origins and goods. With respect to the first, truck values smaller than one show weak effects. In particular, three out of the ten pairs are positive, indicating substitute origins, Germany and the USA, the UK and the USA, and Italy and France. By contrast, the following pairs are negative: Germany and the rest of the European countries (France, the UK and Italy), the USA and France, the

USA and Italy, France and the UK, and the UK and Italy. Germany-UK and Italy-UK are the strongest substitutions. Car elasticities display several substitute origins: Germany and the USA, Germany and France, Germany and the UK, France and the UK, and France and Italy. On the other hand, the pairs made up of the USA and France, the USA and the UK, the USA and Italy, and the UK and Italy are negative, indicating complementary relations. Finally, in the tractors market, Germany competes with the rest of the countries (the USA, France, the UK and Italy), and Italy competes with the USA, with France and with the UK. By contrast, three negative elasticities indicate complementary relations: the USA and France, the USA and the UK, and France and the UK.

With respect to the relations among goods, trucks show a substitutability relation with US cars and with tractors imported from every origin. Cars display a complementary relation with trucks from Germany, the USA and the UK, and with tractors from France and Italy. Finally, tractors show a substitutability relation with tractors from France, the UK and Italy, and with cars from Germany and from the USA.

## V. SUMMARY AND CONCLUSIONS

This paper models the imports of vehicles into Spain during the period 1963–1992, using a source differentiated Almost Ideal Demand System. We consider three vehicle goods, namely trucks, cars and tractors, which are imported from six differents origins, Germany, the USA, France, the UK, Italy and other countries. Having shown that the estimated model does not exhibit autocorrelation problems, the results are presented using the expenditure and price estimated elasticities.

All expenditure elasticities are positive and significant at the 5% level. French trucks and tractors and USA cars are the most luxurious imported vehicles, that is to say, as the imports of trucks, cars and tractors increase, so Spanish consumers showed a greater preference for those from France, the USA and France, respectively. All Marshallian own-price elasticities are negative, as theory predicts, and significant at the 5% level. These values reflect that Italian trucks, German cars and USA tractors had the most insentitive demands to own-price changes. Cross-price elasticities show the substitutability and complementary relations, whose values, smaller that one, show weak effects. The significant UK-Germany and Italy-UK substitutions are the strongest in the market for trucks. By contrast, cross-price effects in cars show the lowest values (in absolute terms) in the Italy-France pairing. Finally, with respect to tractors, the lowest values are shown by the Italy-Germany pairing.

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