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World Exports of New and Used Automobiles: A Gravity Model Comparison among the European Union, Japan and the United States

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ABSTRACT This paper considers new and used automobile exports of the European Union, Japan and the United States within a gravity model framework. This standard framework has similar explanatory power for the new and used automobile exports of the European Union and the United States, as well as for the new automobile exports of Japan, but not for Japan's used automobile exports, a finding the paper associates with the importance of left-hand driving in determining the markets for Japan's used (but not 'made to order' new) automobile exports. The paper concludes that, while used automobiles are somewhat more important to lower income markets, controlling for discrimination and other factors, used automobile trade clearly supplements new automobile trade from the perspective of the importing country.

KEY WORDS: Gravity model, international automobile trade, new trade theory
JEL CLASSIFICATIONS: F13, F14

Introduction

New automobiles have featured prominently in the empirical analysis of international trade, with early contributions including Feenstra (1984, 1985), Becuwe and Claude (1992) and Feenstra *et al.* (1996). More recently, attention has turned

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Table 1. Descriptive statistics on new and used automobile exports, 2001 (number of automobiles)

Value	European Union		Japan		United States	
	New	Used	New	Used	New	Used
Observations ^a	121	121	122	122	123	123
Mean	64,140	2042	25,538	3150	11,257	977
Median	2132	92	997	11	162	30
Maximum	1,331,981	36,554	1,757,244	112,345	833,441	39,034
Total	7,760,926	247,090	3,115,690	384,318	1,373,385	119,148
Percent used to new	3		12		8	

Note: ^aNumber of valid export destinations.

Sources: Eurostat Comex Database, Japanese Customs and Tariff Bureau and US International Trade Commission.

to the empirics of used automobile trade with the contributions of Clerides (2008) and Pelletiere and Reinert (2004, 2006). The latter reflect early contributions to the theory of trade in used capital goods in general (Sen, 1962) and the particular case of used automobiles (Grubel, 1980). The emergence of datasets on the used automobile exports of the European Union, Japan and the United States invites a comparison between new and used automobile trade, the subject of this paper.

Within most domestic markets, used automobile sales far exceed those of new automobiles.¹ It has been well established that used capital goods trade, including used automobiles, can differ substantially from that of new capital goods trade. Further, as discussed in Pelletiere and Reinert (2004), discriminatory trade regimes in the used automobile trade are well developed and predominantly motivated by domestic industry protection. These authors also found evidence for the so-called ‘Grubel effect,’ i.e. that lower wage countries import a greater proportion of used automobiles than countries with higher per-capita incomes (Grubel, 1980). A few issues concerning the relationship of new and used automobile trade remain, however. These include the relationship of new and used imports: whether countries that import more new vehicles also import more used vehicles from the same source; whether they import used and new automobiles but generally not both from the same source; or whether some countries altogether specialize in used and others in new.

Along with expressly investigating the interaction of new and used trade flows, the paper also extend the earlier analysis of the United States and Japan’s trade (Pelletiere & Reinert, 2006) to data for the European Union. Table 1 presents some basic, descriptive statistics of the new and used automobile exports of the European Union, Japan and the United States. What is clear from this table is that, while in terms of gross trade, the European Union is the largest source of new automobiles (both absolutely and relative to used automobiles), Japan is the

¹For example, in 2006, 16.9 million new vehicles were sold in the United States compared with 42.4 million used vehicles. The recorded value of the sales was roughly equivalent (Bureau of Transportation Statistics, National Transportation Statistics Tables 1–17, retrieved 9 May 2007 from www.bts.gov/publications/national_transportation_statistics/html/table_01_17.html).

largest source of used automobiles (both absolutely and relative to new automobiles). Flows also tend to be concentrated within the full set of destinations, with the mean flows of both new and used automobiles being at least an order of magnitude greater than the median flows. The questions to be addressed here are: (1) to what extent can the flows of Table 1 be adequately explained using a standard gravity model framework? And (2) For each source of trade, do new and used automobiles serve the same or different export markets?

The Models

To address these two questions, we model the new and used automobile exports of the European Union, Japan and the United States in the year 2001 using a gravity model framework.² In most instances, gravity models do turn out to have significant explanatory power, leading Deardorff (1998) to refer to them as a ‘fact of life.’ In applying them to automobile trade, however, we need to account for a few idiosyncrasies of these markets. To be specific, we model exports from the European Union, Japan or the United States ($i = EU, Japan, United States$) to the set of destination countries in our sample ($j = 1, \dots, n$) using the following equations:

$$\ln new_{ij} = \alpha_0 + \alpha_1 \ln gdp_j + \alpha_2 \ln pop_j + \alpha_3 \ln dist_{ij} + \alpha_4 left_j + \alpha_5 avgtar_j + \varepsilon_{ij} \quad (1)$$

$$\ln eused_{ij} = \alpha_0 + \alpha_1 \ln gdp_j + \alpha_2 \ln pop_j + \alpha_3 \ln dist_{ij} + \alpha_4 left_j + \alpha_5 protect_j + \alpha_6 \ln new_{ij} + \varepsilon_{ij} \quad (2)$$

In these two equations, new_{ij} and $eused_{ij}$ are the exports of new and used automobiles, respectively, from the European Union, Japan or the United States to destination country j as measured by the Eurostat Comex Database, the Japanese Customs and Tariff Bureau and the US International Trade Commission. The first right-hand side variable in both equations is the natural log of GDP in country j as measured by 2001 World Bank purchasing power parity (PPP) data.³ Representing total income in country j , the sign of this variable is expected to be positive.

The second right-hand side variable is the natural log of 2001 population of country j as measured by World Bank data. The sign of this variable is expected to be negative because increases in population reduce measured, per-capita income.⁴ The third right-hand side variable is the natural log of distance from country i

²The gravity model of spatial interaction has a very large literature going back to the 19th century (see Haynes and Fortheringham, 1984). The theoretical foundations of the gravity equation in international trade analysis are well established under alternative assumptions. See, for example, Anderson (1979), Bergstrand (1985, 1989), Deardorff (1998) and Feenstra *et al.* (2001).

³In cases where World Bank data are not available (e.g. Taiwan), we use US Central Intelligence Agency World Fact Book estimates.

⁴In some instances in the gravity model literature, population variables are interpreted in terms of market size and are therefore considered to have a positive expected sign. That said, the possibility of import substitution effects can turn this expected sign negative. We take a different approach here, thinking in terms of GDP per capita when assigning expected signs.

to country j , as measured between capital cities. Data for this variable are taken from 'How Far Is It?' which uses data from the US Census and a supplementary list of cities around the world to find the latitude and longitude of two places to calculate the straight-line distance between them.⁵ Its expected sign is negative.

The fourth right-hand side variable is a dummy variable for left-hand side driving patterns. We expect this dummy to have a negative sign for the United States and a positive sign for Japan.⁶ While the majority of the countries and the population in the European Union drive on the right, and the expected sign is therefore positive, it must be noted that England and Ireland are both left hand drive countries.

After this point, the two models diverge. In the new automobile model, we include the average tariff in destination countries, and we expect this variable to have a negative sign. In the used automobile model, we include a dummy variable indicating the presence of significant discrimination against used automobiles in the importing country's trade regime.⁷ We expect this variable also to have a negative sign. Finally, we include the natural log of *new* automobile exports to assess the relatedness of new and used automobile trade due to a common trade regime for the two types of goods.⁸

Estimation Results

The estimation results for the gravity models of equations (1) and (2) are presented in Tables 2 and 3. The estimation utilizes the HC3 procedure for producing heteroskedasticity-consistent standard errors.⁹ For both new and used models, the GDP and population variables have the expected signs. Almost all of these are statistically significant¹⁰ except for the case of Japan's exports and GDP for US exports of used automobiles. Distance has the expected sign in both models and is statistically significant except for Japan's exports. These differences in export behavior on the part of Japan are consistent with the findings of Pelletiere and Reinert (2006).

Left-hand-side driving patterns have the expected negative signs for the European Union and the United States, but these are not statistically significant. In the

⁵See <http://www.indo.com/distance/>. For the external trade of the European Union, Brussels is used. For intra-European Union trade, rather than using differentiated capital-to-capital distances, we arbitrarily set distance to 1 to account for the special relationship and proximity of countries within this grouping relative to those outside of it. Unpublished results indicate that, while relative distance is an important variable in differentiating new and used automobile flows, the findings are not particularly sensitive to the precision of the distance measure.

⁶This refers to the side of the road the vehicle drives on. For a list of the left-hand side and right-hand side driving countries in our sample, see Pelletiere and Reinert (2006).

⁷Further description of how this dummy variable is determined and a table of examples of the policies considered and the number of countries with various levels of discrimination are presented in Pelletiere and Reinert (2006).

⁸This variable further justifies dropping of the average tariff variable in this model and increasing the number of observations.

⁹HC3 is used for sample sizes of less than 250. See White (1980), MacKinnon and White (1985) and Long and Ervin (2000).

¹⁰Statistical significance is defined at the 5% level in this discussion.

Table 2. Gravity model results for new automobiles

Variables	European Union New			Japan New			United States New		
	Coeff.	White Std. Error	Sign.	Coeff.	White Std. Error	Sign.	Coeff.	White Std. Error	Sign.
Constant	-15.181**	2.24	0.000	-22.104**	4.63	0.000	-5.209	2.75	0.061
lngdp	1.322**	0.11	0.000	1.567**	0.10	0.000	1.331**	0.10	0.000
lnpop	-0.414**	0.16	0.011	-0.664**	0.13	0.000	-0.496**	0.18	0.007
Indist ^a	-0.225**	0.04	0.000	0.249	0.39	0.530	-1.574**	0.31	0.000
left	-0.501	0.35	0.155	0.718*	0.31	0.023	-0.264	0.40	0.506
avgtar	-0.014	0.01	0.119	-0.025**	0.01	0.004	-0.012	0.01	0.114
<i>n</i>	102			101			101		
R-Square	0.828			0.802			0.745		

^a Intra-European Union distance set to 1 for European Union data.

* denotes statistical significance at the 5% level, and ** denotes statistical significance at the 1% level.

Table 3. Gravity model results for used automobiles

Variables	European Union Used			Japan Used			United States Used		
	Coeff.	White Std. Error	Sign.	Coeff.	White Std. Error	Sign.	Coeff.	White Std. Error	Sign.
Constant	16.778**	2.73	0.000	-1.755	9.64	0.856	12.602**	2.58	0.000
lngdp	-1.163**	0.20	0.000	-0.349	0.31	0.268	-0.287	0.16	0.068
lnpop	0.697**	0.15	0.000	0.355	0.23	0.119	0.281*	0.13	0.028
Indist ^a	-0.235**	0.08	0.003	0.402	0.73	0.585	-1.150**	0.33	0.001
left	-0.664	0.37	0.075	5.035**	0.48	0.000	-0.094	0.31	0.761
protect =2,3	-1.031*	0.42	0.015	0.092	0.58	0.874	-0.525	0.28	0.061
lnnew	0.888**	0.12	0.000	0.477**	0.15	0.003	0.705**	0.10	0.000
<i>n</i>	122			121			121		
R-Square	0.637			0.515			0.773		

^a Intra-European Union distance set to 1 for European Union data.

* denotes statistical significance at the 5% level, and ** denotes statistical significance at the 1% level.

case of the Japan, left-hand-side driving patterns have the expected positive signs and are statistically significant. Indeed, the structure of Japan's exports of used automobiles is largely determined by left-hand-side driving patterns.

With regard to protection, for the new automobile results of Table 2, the average tariff has the expected negative sign, but is only statistically significant for Japan. For the used automobile results of Table 3, the ordered protection variable has the expected negative sign for both the European Union and the United States, but is only statistically significant for the European Union (it is *nearly* statistically significant at the 5% level for the United States). For Japan, it has an unexpected although not statistically significant positive sign. Once again, this difference in export behavior on the part of Japan is consistent with the findings of Pelletiere and Reinert (2006).

Finally, for used automobile exports, the exports of new automobiles has the expected sign and is statistically significant for all three exports sources, the European Union, Japan, and the United States. While the sign of the GDP variable indicates that lower income countries import a greater number of used automobiles, the results also suggest that all else being equal, used automobile exports supplement the offering of new automobile exports, although Japan's used automobile exports are less sensitive to new automobile exports than the cases of the European Union and the United States.¹¹

Summary

Whereas new automobiles have featured prominently in empirical trade analysis, used automobile trade has received substantially less attention. This paper has considered both types of automobile trade, in the form of exports of the European Union, Japan and the United States, within a gravity model framework. This standard framework has the expected explanatory power for the new and used automobile exports of the European Union and the United States as well as for the new automobile exports of Japan. It does not have the usual explanatory power for Japan's used automobile exports, however. This appears to be due, in part, to the overriding importance of left-hand side driving patterns in defining and limiting the market for this country's used automobile exports. That said, patterns of new automobile exports do help to explain Japan's used automobile exports in the same way, if at a lower magnitude, than those of the European Union and the United States.

Another related factor is Japan's environmental and safety regulatory regime. The Japanese regime, despite some liberalization, continues to be much less tolerant of used automobiles than that in the US regime or even the countries of the European Union. In Japan, automobiles are subject to a costly inspection and maintenance regime that serves to substantially increase the rate at which vehicles depreciate for consumers in Japan. This limits the used market in Japan, which in turn has been speculated to generate a 'push' of Japanese vehicles into the world market, where they may have a significantly higher value relative to used automobile imports from other countries without such restrictive regimes.

In integrating multiple sources of trade data and capturing trade policy variables, we chose to focus on export data for a single year, namely 2001. As data on used exports and the regime governing used automobile trade, particularly for Japan, become more readily available and better understood, future researchers will be able to re-estimate the models in this paper with panel data or data smoothed using multi-year averages, as was done by Pelletiere and Reinert (2004) using US data alone. This will help ensure the results do not merely reflect the idiosyncrasies of a particular year.

Despite this limitation, it still appears that there are significant differences among the three major used automobile exporters of the world economy, and

¹¹For example, an increase in new automobile exports by one percentage point results in an increase in used automobile exports of nearly 0.9% for the European Union and 0.7% for the US but only 0.5% for Japan.

this contributes to our evolving understanding of used, durable goods markets. The sign and significance of the new exports variable in the used exports model for all three exporters, as well as the degree of overlap in new and used trade patterns, suggest that there may be value in considering new and used durable goods trade together rather than as two unrelated markets.

Finally, new and used goods can be considered as an underappreciated dimension of product differentiation in the sense of new trade theory (e.g. Helpman and Krugman, 1985). From the standpoint of destination countries, used automobile trade makes the offering of automobiles more diverse, thereby enhancing Spence-Dixit-Stiglitz conceptions of utility and calling into question the wisdom of extensive protection in a number of countries of used automobile trade.

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