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**Automobile Exports: Export price and retail price\***

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## Abstract

Given the recent theoretical emphasis on firm-level heterogeneity in international trade, we examine the price-setting behaviors of Japanese automobile exporting firms as they correspond with the fluctuations of foreign exchange rates. We do so by employing international trade datasets revitalized by the use of the geographical locations of exporting firms within an exporting country. With this technique, we transform a national-level dataset into a quasi-firm-product-level dataset. First, by restricting the dataset to the two exporting ports, we are able to estimate the price-setting behaviors of one particular Japanese automaker. Consistent with the multi-product exporter model, we find heterogeneity among auto-models in the exchange rate pass-through (ERPT) even when we restrict the dataset to a single automaker. Second, coupled with the manufacturer's suggested retail price (MSRP) in the US market, we examine the dynamic behaviors of model-specific price margins for US distributors and Japanese automakers. The price margins for US distributors have shrunk substantially, particularly when the US dollar depreciated after the global financial crisis.

*Keywords:* Automobile, Distribution sector, Exchange rate pass-through, Export price, Multi-product, Retail price, Sales margin

*JEL classification:* F14, L11

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## 1. Introduction

Automobiles are produced in over 40 countries and shipped out globally. There are, in general, three layers to the international distribution system. Automobile manufacturers establish local distributors, which are usually fully owned by a single manufacturer, in the destination countries<sup>4</sup>. The local distributors exclusively import automobiles manufactured by the parent manufacturer and redistribute them to local dealers dispersed throughout the country, sometimes even crossing borders to serve neighboring countries. Finally, consumers visit their local dealers and place purchase orders with the dealers. The corresponding prices at the three layers of the distribution system are the export price, the distributor price, and the retail price. An export price is determined by a contract negotiated between the foreign automakers and the local distributors. A distribution price is set between the local distributors and the local dealers. The retail prices are set by local dealers. These relationships are depicted in Figure 1.

{Insert Figure 1 here}

Given this multilayer distribution system, an initial price adjustment at one of the three stages, induced by changes in cost structures or demand shifts, may spill over to prices at other stages in a complicated manner. For example, an export price in terms of local currency should decline if the export price remains fixed in the currency of the exporters when the exchange rate depreciates for the exporting country. This case represents a complete exchange rate pass-through (ERPT). Through a change in the export price, the exchange rate should also affect the distribution price and the retail prices. Because of price responses at these latter stages, the ERPT at the retail price level, as faced by consumers, may not be complete even if ERPT at the export price level is complete (Goldberg and Hellerstein, 2008 and Nakamura and Zerom, 2010).

Another example of price change spillovers is when retail prices decline as the models age (in terms of months). Local dealers cut the effective price for consumers

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<sup>4</sup> There are, of course, many exceptions. In 1998 (by Japanese Overseas Companies, Toyo Keizai Publisher) Mazda Motor of America in the US, Mazda Motors GmbH in Germany, and Mazda Motor De Portugal in Portugal were jointly owned by Mazda and Japanese general trading companies, whereas Mazda Motor Europe located in Belgium was fully owned by Mazda. For Mazda Motor España in Spain, Mazda only owned a 32 percent share. Toyota, on the contrary, held a 100 percent share of local dealers for many cases.

through cash-back offers, rebates and other sales campaigns<sup>5</sup>. Do local distributors also reduce the distributor price to compensate local dealers for their sales struggles? Hellerstein (2008) investigates the beer industry and finds that foreign manufacturers take a greater exchange rate fluctuation risk than local retailers. Unfortunately, because of the lack of availability of distribution prices for automobiles, which is the focus of this study, we cannot show the pricing behaviors of automobile distributors beyond anecdotal evidence. However, the pricing behaviors of distributors and dealers combined as a distributor sector can be investigated using available retail prices coupled with export prices.

{Insert Figure 2 here}

The export dataset categorized by the Harmonized System (HS) used in previous studies is aggregated at the national level. Even for a specific product category of the HS, however, products that are produced by different plants/manufacturers or models may be different even for the same manufacturer. For example, Figure 2 depicts that the locations of automobile production plants in Japan are widely dispersed across Japan. The aggregation over different production plants causes within-category heterogeneity bias, although the HS classification at the six-digit level can be considerably product-specific. To mitigate this aggregation problem, in this study, we utilize export data disaggregated at the port level. In addition, by focusing on the automobile sector, we carefully match export data disaggregated at the engine size and at the port level with production plant information at the product (model) level and at the port level. Through this matching, we obtain a quasi-firm-product-level dataset and successfully reduce the within-product heterogeneity bias that is widely persistent in the export prices provided by customs offices.

One important aspect of the automobile industry highlighted in this study is associated with the recent attention to multi-product exporters in the international trade literature, such as Bernard, Redding, and Schott (2011), Eckel and Neary (2012), and Mayer, Melitz, and Ottaviano (2014). As in other industries, an exporter in the automobile industry exports many products (in terms of model-trim) to many destinations. One lesson we have learned so far from the literature is that efficiency or productivity should be observed at the product level, and they are heterogeneous among

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<sup>5</sup> Bilal and Klenow (2004) investigate goods and services more in general and find evidence that half of the prices change in 4-5 months. Nakamura and Steinsson (2008) also document that 9-12% of prices change per month, excluding sales.

products even for the same exporter. This, in turn, results in observed heterogeneity at the product level in export prices, export volumes, and extensive margins in terms of destination markets. This heterogeneity even extends to the ERPT at the product level of the same exporter; Chatterjee, Dix-Carneiro, and Vichyanond (2013).

We first examine whether the ERPT elasticities are different among products even when we restrict the data to a single automaker. Consistent with previous studies that examine multi-product firms, we find heterogeneity in the ERPT among models for the same exporting automaker. Furthermore, the estimated ERPT of the core product is the lowest. Notably, the ERPT of different trims (represented by different engine sizes) of the same model are not statistically significant. However, when the import market is restricted to the US, a wide discrepancy reemerges between different trims in the ERPT in terms of export price. In addition, we further examine the ERPT on prices at the retail level for a limited set of products for which we successfully identify a specific model. Again we find heterogeneity between trims in the sales margin's response to fluctuations in the exchange rates.

The remaining part of this study is structured as follows. Section 2 reviews the recent developments in the ERPT literature. Section 3 describes how we identify exports at the make-model level. Section 4 describes how product-value weighted exchange rates are constructed at a quarterly frequency and provides the estimated result for the ERPT via port-product-destination panel data regressions. Section 5 examines the fluctuations of the retail prices of Japanese automobiles in the US and compares them with export prices. Section 6 provides a discussion by checking our results for robustness. Section 7 offers conclusions.

## **2. Literature review**

Shifting from a macroeconomic view to a microanalysis of exporters' behaviors, Goldberg and Verboven (2001) and Hellerstein and Villas-Boas (2010), among other studies, focused on the automobile industry because its oligopolistic market structure is served by a limited number of manufacturers with product-specific characteristics that are comparable among competing models. We follow this line of studies on the automobile industry and examine Japanese automobile exports in detail to a degree not reached in previous studies.

More recent studies in the ERPT literature often use firm-level data, coinciding with vigorous empirical analysis on international trade, as surveyed by Bernard et al. (2007). Therefore, these empirical studies are generally based on panel datasets that consist of exporting firms, products, and destination markets. Using Chinese firm data,

Manova and Zhang (2012) explore the relationship between firm revenue on the one hand and export price and destination markets on the other. A Latin American country dataset used by Carballo, Ottaviano, and Martincus (2013) even allows for the investigation of the bilateral relationship between exporting firms and importing firms. These authors find cases of many importers for a specific exporter-product and investigated the causes of price dispersion. In contrast, we focus on the automobile industry in this study because it guarantees a stable (long-term contract) relationship between local distributors and foreign automobile exporters.

With regard to the recent developments in theoretical models, distribution costs and multiproduct firms are particularly relevant to this study. Distribution costs were reported by Burnstein, Neves, and Rebelo (2003) to be approximately 40-60 percent of retail prices and were reported by Goldberg and Campa (2010) to be 30-50 percent of the prices of household consumption goods in 21 industrialized countries. The explicit inclusion of the distribution sector in the theoretical macroeconomic model is investigated by Burstein et al. (2003) and Corsetti and Dedola (2005). In this study, we specifically compare the export price and retail price of the same product (at the quasi-trim level), and the difference between these prices should reflect the distribution costs.

Because single automakers provide their customers with a variety of auto models, varying from compact to luxurious cars, they are 'multi-product' firms. Recent theoretical models on multi-product exporters include Bernard, Redding, and Schott (2011), Eckel and Neary (2012), and Mayer, Melitz, and Ottaviano (2014). Bernard et al. (2011) extend the heterogeneous-technology firm model by adding product attributes in a symmetric manner with firm productivity. In their model, a more productive firm exports a greater number of products to more destinations. Eckel and Neary (2012) add the concept of core competence, adherence to which increases firms' efficiency, and investigates the tension between two gains, i.e., the gain from expanding product variety and that from concentrating on core products.

The multi-products firm model is also applied to the ERPT. Chatterjee et al. (2013) develop the multi-products exporter model with heterogeneous productivity at the product level and local distribution costs and empirically examine Brazilian firms' ERPT behaviors. They find that the ERPT of the core product is significantly lower than that of other products. Chen and Juvenal (2014) consider a multiproduct firm model with heterogeneous quality and investigate the model prediction for the exchange rate pass-through for Argentinean wine exports. In the model of Chen and Juvenal (2014), the ERPT is lower for higher quality products.

### 3. Exports of a single Japanese automaker

Without export data at the firm level, empirical investigations on export behaviors at the firm-product level cannot be conducted. The Argentinean wine exports study by Chen and Juvenal (2014) relies on a dataset that approximates the traded volume and values for each wine at the firm-product level. In contrast, the publicly available export dataset classified as a HS, provided either for each country by sovereign governments or for the world by the UN Comtrade, cannot provide breakdowns beyond broad product categories. For example, automobiles with the HS 6-digit classification code, i.e., the most disaggregate level for worldwide use, HS8703.23 (automobiles with a gasoline engine of a size ranging from 1,500 cc to 3,000 cc) can be distinguished only from HS8703.24 (automobiles with a gasoline engine of a size exceeding 3,000 cc). A wide variety of make-model products fall within the same classification.

There is an exception to the above rule. Some countries further break down exports into regions within a country, but most countries only report exports at the national level. For example, Japanese Customs reports exports disaggregated at over 100 international ports for each 9-digit HS classification code<sup>6</sup>. If a production plant can be matched with a corresponding international port and no other plants utilize the same port, we can obtain export data at the firm (or plant) level. In addition, if a product (and only this product) of a firm (or a plant) is exclusively associated with a unique HS classification code, we can identify export data with a one-to-one correspondence to products at the make-model level.

By carefully combining several sources of information, we are able to identify a few products at the automaker-model level, especially for one specific model even at the semi-trim level<sup>7</sup>. First, we scrutinize the website of each Japanese automobile maker for their production plants in Japan. These Japanese automobile makers are Honda, Mazda, Mitsubishi, Nissan, Suzuki, and Toyota. Using the address of plant locations, we exclude ports that are utilized by multiple automakers. For example, Nissan and Toyota use the Kanda port located in Fukuoka prefecture. For this study, we exclude automobile export data from ports similar to the Kanda port.

At the second step, we checked whether the production plants that passed the first screening produce a single product at the most disaggregated classification code. For example, Toyota has several plants co-located in one district of Aichi prefecture, and

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<sup>6</sup> Another example includes the Spanish data used by Márquez-Ramos (2014).

<sup>7</sup> We refer to World's Automotives for the printed documents and manufacturers' homepages and MSN AUTOS for the website resources.

these plants use the same port (the Nagoya port). Although automobile exports from the Nagoya port can be identified as Toyota, we cannot identify the model because Toyota produces several models within each category of the HS 9-digit level. Therefore, for this study, we must disregard the data for automobile exports from the ports similar to the Nagoya port. With this procedure, we find that Mazda has two production plants located at different international ports, i.e., Hiroshima and Yamaguchi (Mitajiri-Nakanoseki). For a few classification codes, we find that the automaker-model product can be identified. Table 1 shows the exported units of all models of Mazda shipped from the two ports for the period between 2000 and 2012. One feature is noteworthy: The Mazda-3 consists of 43-56% of all Mazda exports from 2004 onwards. The Mazda-3 is the major export of Mazda regardless of whether the product with the greatest amount of exports applies to the concept of ‘core’ products in Chatterjee et al. (2013).

{Insert Figure 3 here} {Insert Table 1 here}

Figure 3 represents an example of how we match different databases and identify a single model or even a semi-trim product. Two trims of Model A are categorized into two different HS9 categories, (1) and (2). Two trims of Model B are in categories (2) and (3). In this example, HS9 categories (1) and (3) have a one-to-one correspondence with the model-trim product. It should be noted that this matching is only made possible because of the use of port-level exports. The HS9 category (2) is associated with two model-trims; therefore, within-category heterogeneity exists. However, the sales data in the destination market may reveal that the HS9 category (2) corresponds with only one model-trim if, for example, the other model-trim is sold only in the European market.

#### **4. Export price analysis**

To estimate the ERPT elasticities of automobile exports at the quasi-firm-product level, we decided to use a quarterly frequency. The dataset at the monthly frequency is better in terms of providing a greater number of observations, but is also likely to have more ‘zero’ trades. Instead of aggregating to annual observations, we choose an intermediate level of frequency.

##### *4-1. Quarterly dataset*

Quarterly data are constructed from monthly data for the sample period between January 1988 and December 2013. Nine categories of automobiles with HS 9-digit classifications include six sizes of gasoline-engine cars and three sizes of diesel-engine

cars. The six sizes of gasoline engine automobiles are ‘under 550 cc’, ‘550-1,000 cc’, ‘1,000-1,500 cc’, ‘1,500-2,000 cc’, ‘2,000-3,000 cc’, and ‘over 3,000 cc’. The three sizes of diesel engine automobiles are ‘1,500-2,000 cc’, ‘2,000-2,500 cc’, and ‘over 2,500 cc’. A total of 14 exporting ports exceed 1,000,000 unit exports during the entire sample period. These ports (port code) are Yokohama (200), Kawasaki (202), Yokosuka (203), Chiba (220), Kobe (300), Mizushima (322), Hiroshima (345), Sakai-Izumikita (402), Nagoya (500), Mikawa (504), Shimizu (520), Yokkaichi (540), Kanda (602), Mitajiri-Nakanoseki (626). Out of these 14 ports, Hiroshima and Mitajiri-Nakanoseki are selected in the manner described in section 3. From these two ports, no automobiles are exported under the two categories with the smallest sized gasoline engine, i.e., ‘under 550 cc’ and ‘550-1,000 cc’; therefore, we work with four categories of gasoline engines and three categories of diesel engines in the following analysis.

Two caveats for the classification change in 2002 should be noted. First, there are two more categories, i.e., ‘under 1,000 cc’ and ‘1,000-1,500 cc’, for diesel engines prior to 2002, but they are merged to a single category after 2002. These categories are excluded from our analysis. Second, new automobiles and used automobiles are not distinguished prior to 2002. After the classification change in 2002, new and used automobiles are classified into different categories. Given that the ratio of new automobiles to total automobiles exceeds 90 percent after 2002, we suspect that the inclusion of used automobiles prior to 2002 should affect the qualitative results in the following analysis. However, we address this issue indirectly by splitting the sample.

To avoid a ‘zero’ trade problem in the sample, the 20 destination countries are selected based on the largest trade volumes, i.e., destination countries with over 1,000,000 units during the entire sample period. These countries (country code) are China (105), Hong Kong (108), Saudi Arabia (137), Israel (143), UAE (147), the UK (205), the Netherlands (207), Belgium (208), France (210), Germany (213), Switzerland (215), Spain (218), Italy (220), Austria (225), Canada (302), US (304), Puerto Rico (324), Chile (409), Australia (601), New Zealand (606)<sup>8</sup>.

Quarterly weighted exchange rates are constructed using monthly engine-specific trade values. Therefore, for each foreign currency, we have 9 different quarterly exchange rates. However, the difference among these engine-specific exchange rates should be minimal if the underlying monthly exchange rates are relatively stable. We define the quarterly exchange rate,  $er$ , as follows:

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<sup>8</sup> The number of observations for Mazda exports vary with destination markets, see appendix table A2. For example, diesel-engine cars are not exported to the American continent whereas gasoline-engine cars are exported to all countries.

$$er_{j,q}^k = \sum_{t \in \{t|q\}} \frac{X_{j,t}^k}{\sum_{t \in \{t|q\}} X_{j,t}^k} ER_{j,t} \quad (1)$$

where  $k$  denotes the automobile engine size,  $j$  is destination country, and  $q$  is quarter (time).  $ER$  is the nominal exchange rate as the foreign currency value of the Japanese yen, and  $X$  is the value of automobile ( $k$ ) exported to destination country ( $j$ ) in month ( $t$ ). Thus, an increase in  $er$  indicates an appreciation of the Japanese yen.

Data on the export prices of Japanese automobiles are compiled from Japanese Customs data. The Customs data provide the value and quantity of each HS (Harmonized System) 9-digit level product for each destination. The export prices in this study are unit prices calculated from the Customs data<sup>9</sup>. These monthly unit data are then averaged over three months to convert them into a quarterly time series. We then express the unit export price in the destination's currency (JPY unit price is multiplied by the exchange rate in terms of the destination's currency value per unit of the Japanese yen).

#### 4-2. Single-firm panel regression analysis

Now we turn to the pricing behavior of a single automaker with respect to fluctuations in the exchange rate. For each automobile size  $k$ , port  $i$  being either Hiroshima or Yamaguchi (Mitajiri-Nakanoseki), and importing country  $j$ ,

$$\ln p_{ijt} = \beta \ln er_{jt} + \lambda_{ij} + \eta_t + \varepsilon_{ijt} \quad (2)$$

where  $p_{ijt}$  is the quarterly unit price in the destination currency for port  $i$ , destination country  $j$ , automobile size  $k$ , and quarter  $t$ ; and  $er_{jt}$  is the weighted quarterly exchange rate calculated as in equation (1) for each destination country. Note that we suppress the automobile size  $k$  for convenience, although  $er$  differs among automobile sizes (see the definition in the previous section).  $\lambda$  is a port-country fixed effect (I times J),  $\eta$  is a quarterly fixed effect, and  $\varepsilon$  is the disturbance term. With our definitions for exchange rate and export price, a complete pass-through is indicated when  $\beta$  is equal to 1.

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<sup>9</sup> These unit prices are also investigated by Takagi and Yoshida (2001), Parsons and Sato (2008), and Yoshida (2010).

We estimate equation (2) by OLS, and the Durbin-Watson (DW) statistics are very low, indicating the possibility of positive serial correlations. We choose the AR(2) specification after comparing the DW statistics of OLS, AR(1), and AR(2) regressions. For the AR specifications, it should be noted that quarterly fixed effects must be dropped. The alternative specifications of equation (2) are also estimated with the lagged terms of the exchange rate, up to the four lagged term as in Campa and Goldberg (2006). However, for the most estimates using equation (2) and the following equations, the lagged exchange rate terms are not statistically significant. For the rest of the paper, we retain only the current exchange rate term in the AR(2) regression equations<sup>10</sup>.

{Insert Table 2 here}

Table 2 provides estimation results for four sizes of gasoline engines and two sizes of diesel engines. The two-letter acronym in the first row indicates G for a gasoline engine and D for a diesel engine. The number in the acronym indicates the engines size category in ascending order. The two categories of smaller gasoline engine sizes are not estimated because Mazda does not produce any models with an engine smaller than 1,000 cc. The top block shows the estimated ERPT elasticity along the fitness of the regression, the DW statistics, and the number of observations for each automobile category. Even fixing the automobile maker to a single make, i.e., Mazda, we find significant variation in the ERPT elasticities. The lowest ERPT is 0.06 (not significantly different from zero) for the smaller diesel engine (D1), and the highest ERPT is 0.50 for the middle-sized gasoline engine (D4).

Before further delving into interpreting the estimation results, we should note that several factors affected the Japanese automobile industry since 1988, the starting year of the sample period. For the automobile trade between the US and Japan, voluntary export restraints (VER) were in effect from 1981 to 1994. Despite the arguments raised against the effectiveness of the VER on the automobile sector—because actual exports were less than the limit set by the VER—a number of studies have found evidence that the VER had a significant effect on Japanese automobile exports; see, for example, Feenstra (1988), Goldberg (1994), and Berry, Levinsohn, and Pakes (1999). These results are consistent with theoretical results with imperfect competition models surveyed in Krishna (1990). Berry et al. (1999) found that the prices of Japanese automobiles were higher between 1986 and 1990 because of the VER.

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<sup>10</sup> The detailed estimation results are available in the appendix tables, not reported with this paper. These tables are available upon requests.

Moreover, the Japanese economy experienced the bubble economy and its consequent crash, which peaked in 1989-1990, and the more recent global financial crisis that started in 2007-2008. In addition, the Japanese trade data were modified after 2002, with new categories separating used cars from new ones, as discussed in subsection 4-1. Due to possible structural changes in the 26-year sample period, we re-estimate equation (2) in three ten-year subsamples with two-year overlaps between adjacent subsamples. Due to the small number of observations, the subsample regressions are not estimated for category G6.

The estimation results for three subsamples are shown in the bottom three blocks of Table 2. First, the estimated ERPT are much higher in the first ten years (1988Q1-1997Q4) than in the entire period, and the ERPTs in general show a declining trend in the later two sub-samples. For the first subsample, the point estimates range from 0.84 (G4) to 1.21 (G5), and the null hypothesis of complete pass-through (i.e.,  $\beta = 1$ ) cannot be rejected for any estimates except for G3<sup>11</sup>. For the second subsample (1996Q1-2005Q4), the point estimates for five categories are much lower and range from -0.06 (D1) to 0.41 (G5). ERPT elasticity estimates for all categories are interpreted as “incomplete”, i.e.,  $\beta < 1$ , and the null hypothesis of zero pass-through cannot be rejected for two categories of diesel engines. In the last subsample, the ERPT estimates fall in an even lower range, between -0.19 (D2) and 0.22 (G5). For two categories of diesel engines, the ERPT estimates are shown to be statistically below zero, i.e., “perverse ERPT”.

Second, across gasoline engine automobiles, ERPTs are generally higher for a larger sized engine; only one exception occurs in the first subsample. This finding is consistent with the traditional models of ERPT in which demand side plays an important role. For a luxurious model car, the ERPT should be greater because the demand elasticity is smaller. If a larger engine size reflects higher quality, the result in Table 2 is also consistent with the theoretical prediction of Chen and Juvenal (2014) that a higher quality product is associated with a higher degree of ERPT. However, the engine size of an automobile should be interpreted as just one component of many potential attributes (although it may be the most important), and this association between quality and engine size should not be pursued further here. In next section, when we utilize retail price information, we can associate different qualities (trims) with different prices for the specific make-models within the same engine size category.

These findings indicate that different pricing strategies are actually implemented

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<sup>11</sup> Technically speaking, the null hypothesis of  $H_0 : \beta \geq 1$  cannot be rejected for G5. ERPT exceeding the unity is called excessive ERPT.

by the specific automobile maker for its products/models. However, we should note that the pricing strategy may reflect a variety of underlying causes, such as the market size of the automobile category (compact car or luxury car), the quality ranking of the product within the category, or the number of competing models by different automobile makers. Despite these different possibilities, we find within-firm heterogeneous ERPT across products of the same firm, and this finding is consistent with the multi-product exporter models of Chatterjee et al. (2013) and Chen and Juvenal (2014).

#### 4-3. Single-plant panel regression analysis

To highlight a possible difference in the exporting behaviors of automobile models of the same firm, we further disaggregate Mazda exports into the Hiroshima port and the Yamaguchi (Mitajiri-Nakanoseki) port. In other words, we focus on single-plant exports in contrast to single-firm exports in the preceding subsection. By fixing exports to only the Hiroshima port, for each engine size  $k$  and destination  $j$ , we estimate the following equation:

$$\ln p_{jt}^{Hiroshima} = \beta \ln er_{jt} + \lambda_j + \varepsilon_{jt} \quad (3)$$

Similarly, for the Yamaguchi (Mitajiri-Nakanoseki) port, we estimate the following:

$$\ln p_{jt}^{Yamaguchi} = \beta \ln er_{jt} + \lambda_j + \varepsilon_{jt} \quad (4)$$

Similar to the results estimated by equation (2), we find the low DW statistics for equations (3) and (4); therefore, we implement the AR (2) estimation method on above equations, and the time dummies are dropped.

{Insert Table 3 here}

The ERPT elasticities estimated by the single-plant panel regression are provided for Hiroshima in Table 3 and Yamaguchi in Table 4. As found in the results for all Mazda exports in Table 2, we find a similar pattern of the declining ERPT of exports for each individual port. The differences in ERPT among different sizes of engines are also clear. A more interesting analysis is to compare the ERPTs of the same category between two ports. These exports are relatively similar in terms of automobile size, within the size range of corresponding category, but they represent different models. The differences in the estimated coefficients range from zero (G4 in the last subsample) to 32 points (D1 in the middle subsample). To formally test whether the ERPT

elasticities are different even when we control for engine size category, we estimate equation (2) with an interaction term between exchange rate and the dummy variable for the Yamaguchi port, as shown in the following equation.

$$\ln p_{ijt} = \beta_0 \ln er_{jt} + \beta_1 \text{Yamaguchi} D_i \ln er_{jt} + \lambda_{ij} + \varepsilon_{ijt} \quad (5)$$

By testing whether  $\beta_1 = 0$ , the difference in ERPT between the Hiroshima and Yamaguchi ports is found to be statistically significant for the G4 category in the middle subsample at the five percent level and G5 in the first subsample at the ten percent level. For the D1 category, the ERPT elasticity is not statistically significant for any subsamples, although the difference in the ERPT between Tables 3 and 4 is the largest for the middle sample.

When we control for engine size using HS9 categories, we find weak evidence for the difference in the ERPT elasticity between the Hiroshima port and the Yamaguchi port. We should note that, for example, specifically for the 1,500-2,000 cc engine size in 2007, there are two corresponding models (a smaller engine size for the Mazda-3 and a smaller engine size for the Mazda-6) in this category for the Yamaguchi port, whereas there are three models (MX-5 Miata, a smaller sized Mazda-5, and the smallest sized Mazda-8 only from 1999 to 2006) for Hiroshima port. The differences in the ERPT elasticities are more pronounced between the different size categories of the same port than between different ports for the same size category<sup>12</sup>.

## 5. Sales margins of US distributors

In this section, we analyze the response of the US retail prices of Japanese automobiles with respect to exchange rate fluctuations. This analysis complements the CPI sensitivity study of Goldberg and Campa (2010). They examined the degree of CPI response to exchange rate changes in 21 countries by investigating the distribution margins and imported input use of 29 industries. For the US market, the distribution margins of 24 percent (averaged across industries) is the largest among the sample countries. Consequently, the estimated ERPT elasticity of US CPI is only 0.01 and is not statistically significant. Furthermore, the distribution margins are shown to decrease

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<sup>12</sup> We estimated for each port an unrestricted regression with three sizes of gasoline engines in a pooled dataset and a restricted regression imposing the ERPT elasticity to be equal for all three sizes. The F-test rejects the null of the equality of ERPT elasticities for the entire sample (at the ten percent level), the first subsample of Yamaguchi (at the one percent level) and the first sample of Hiroshima (at the five percent level).

when the home currency depreciates. The contribution of our study is to present new evidence at the product level in the US market to complement the aggregate price indices employed in Goldberg and Campa (2010).

An individual automobile product can be specified by make, model, year, and trim. For example, Mazda (make), Mazda-3 (model), 2007 (year), i sport 4-door (trim) is one specific product in the industry. In the US automobile market, the retail prices for each trim are disclosed publicly. These prices are known as MSRPs (manufacturer's suggested retail prices). Once new MSRPs are announced, they are fixed for the year, whereas the effective retail price, e.g., the net payment after cash back, tends to decline over the course of the year. These effective retail prices are calculated using the Edmond's value. For example, Hellerstein and Villas-Boas (2010) use the Edmond's TMV (true market value) for pass-through analysis.

{Insert Table 5}

Even within a specific model, the exterior design and engine size may be different across trims, and prices therefore differ accordingly. For example, in Table 5, there are 5 trims of the 2005 Mazda-3 (Axela in Japan): i4-door, s4-door, s5-door, SP23 5-door, and SP23 4-door. The MSRPs for these 5 trims are \$13680, \$16615, \$17105, \$18685, and \$18685, respectively. The trims are differentiated by interior options, exteriors (doors, sunroof, etc.), and engine size. The first trim (i4-door) has an engine less than 2,000 cc, whereas the other trims have an engine greater than 2,000 cc. With respect to matching the international trade classification, they can be matched to two distinct HS9 categories: a 1,500-2,000 cc gasoline engine automobile and a 2,000 cc-3,000 cc gasoline engine automobile.

In the previous section, we could not narrow the products down to a single product even when automobile exports are disaggregated by ports. For example, the G4 category (1,500-2,000 cc) contains two models from Yamaguchi and three models from Hiroshima. However, pinning down a single product becomes possible when the destination market is restricted to a single country instead of 20 destination countries, as in this section. This is possible because not all the models are exported to every destination due to local production or market-specific sales strategies. By using the publicly available production and export information for Mazda, we are able to match two HS9-category exports of Yamaguchi to the specific model (actually to the quasi-trims): 1) the HS9 category for automobiles with engine sizes ranging from 1,500-2,000 cc, corresponding with the first trim of the Mazda-3, and 2) the HS9

category for automobiles with engine sizes ranging from 2,000-3,000 cc, corresponding with the next four trims of the Mazda-3. The matching procedure is described in the appendix.

Because we concentrate only on the US retail market, we further investigate whether the US market differs from other destination markets for the Mazda-3 (Axela) exports by adding an interaction term between the exchange rate and the US dummy. For the Yamaguchi port and gasoline engine sizes of either 1,500-2,000 cc or 2,000-3,000 cc and for Hiroshima ports and gasoline engine sizes of 1,500-2,000 cc, we estimate the following regression.

$$\ln p_{jt} = \beta_0 \ln er_{jt} + \beta_1 D.US \cdot \ln er_{jt} + \lambda_j + \eta_t + \varepsilon_{jkt} \quad (6)$$

{Insert Table 6 here}

The estimation results are shown in Table 6. As in the previous tables, we estimate equation (6) for both the entire sample and the three ten-year subsamples. First, we look at the results for Yamaguchi exports. For both sizes of gasoline engines, the price responses to exchange rate fluctuations in the US market behave in a different manner than for other destination countries for the middle and last subsamples. In the middle subsample (1996Q1-2005Q4), the ERPT elasticity for the US market is well below zero, whereas the ERPT is 0.18 (for G4) and 0.52 (for G5) for other markets. In the last subsample (2004Q1-2013Q4), the ERPT elasticity for the US market is greater than that for other markets, with a statistical significance. The ERPT of MX-5 exports to the US market is different (and great than) from those to other markets only during the last subsample (2004Q1-2013Q4). For later reference, the US ERPT, i.e.,  $\beta_0 + \beta_1$ , for the Mazda-3 and the MX-5 in the last subsamples are noted here: 0.63 for the Mazda-3 (G4), 0.48 for the Mazda-3 (G5), and 0.81 for the MX-5 (G4).

Now we are ready to analyze the retail price response to exchange rates changes. As in the previous section, the export prices of Japanese automobiles are compiled from the Japanese Customs data and are then expressed by the unit export price in US dollars (the JPY unit price is multiplied by the exchange rate in terms of the dollar value per unit of the Japanese yen) to be consistent with US retail prices. For US retail prices, we obtained the MSRP from the MSN AUTOS website.

{Insert Figure 4 here}

In Figure 4, we plot the dollar unit price of (1,500-2,000 cc) and (2,000-3,000 cc) from Yamaguchi to the US along the minimum MSRP and the maximum MSRP for the Mazda-3 in the US between 2004 and 2012<sup>13</sup>. The export prices are plotted with a dotted line, and the MSRP are plotted with solid lines. The exchange rates (USD/JPY) are plotted against the scale on the right-hand axis. First, we observe that the export prices are well below the corresponding retail prices. However, the sales margins (the retail price over the export price) are time-varying, and the margins appear to have reduced in recent years, when the Japanese yen experienced its post-war historical level of appreciation in the wake of the global financial crisis. Second, the crossing of export prices and retail prices occurs in 2012 for the smaller sized Mazda-3. This crossing is consistent with the margin reduction and is reasonably possible if combined with a composition change among trims within the smaller sized Mazda-3. It should be noted that the number of trims in general expands over the course of years.

Prior to our study, Gagnon and Knetter (1995) also examined the US retail prices of Japanese and German automobiles at the model level. They found that the decline in the US retail prices of these imported automobiles was much smaller than the depreciation of the exporters' currencies. Instead of focusing directly on retail price, as in Gagnon and Kentter (1995), we examine the sales margin with respect to a change in exchange rate because we can utilize the export price from the preceding analysis. The sales margin for the Mazda-3 trims with engine sizes less than 2,000 cc is defined as follows:

$$SM_{small}^{Mazda-3} = \ln\left(\frac{Min(MSRP_{trim})}{\$ \text{ unit price (Yamguchi to US, 1,500 cc - 2,000 cc)}}\right), \quad (7)$$

where  $Min(MSRP)$  is the lowest retail price of the Mazda-3, and the sales margin for the Mazda-3 trims with an engine size greater than 2,000 cc is defined as follows:

$$SM_{large}^{Mazda-3} = \ln\left(\frac{Max(MSRP_{trim})}{\$ \text{ unit price (Yamguchi to US, 2,000 cc - 3,000 cc)}}\right). \quad (8)$$

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<sup>13</sup> Mazda 3 was introduced to the US market in 2004, although a small number of the 2004 model was already exported from Yamaguchi in the previous year; see Table 1.

where  $Max(MSRP)$  is the highest retail price of the Mazda-3.

{Insert Figure 5 & Figure 6 here}

Figures 5 and 6 show the plots of sales margins against exchange rates. We should note that the sample period (2004-2012) for this exercise is relatively short because we focus on the period in which the specific model is being sold in the US market, but the period matches with the last ten-year subsample in the preceding regressions. The sales margin of both engine sizes in the US market declined with the recent appreciation of the Japanese yen (see figure 3 for the recent movements of the Japanese yen). The exchange-rate elasticity of the sales margin is -0.64 for category 4 (1,500-2,000 cc) of the Mazda-3 and -0.35 for category 5 (2,000-3,000 cc) of the Mazda-3. The degree of decline (in percentage terms) is larger for a smaller engine size or for the least expensive trim within the specific model category. This relationship implies that US automobile dealers are able to retain a larger sales margin for the higher-spec trim. This finding is evidence that 'quality matters for pricing strategy'.

{Insert Figure 7 here}

We have conducted a similar exercise for the MX-5 exports from the Hiroshima port. There are two different details in the analysis of the MX-5 with respect to that of the Mazda-3. First, the sample period is between 1992 and 2012, longer than that of the Mazda-3. Second, only category 4 (1,500-2,000 cc) is investigated because all trims of the MX-5 fall into this category. As a consequence, we have calculated two sales margins using two extreme retail prices, as before, but with the common export price of category 4. Figure 7 shows the plots of sales margins against the exchange rates. The exchange-rate elasticity of sales margins are negative with a statistical significance at a one percent level, indicating a decline in the sales margin with respect to the appreciation of exporters' currency. Again, the degree of decline (in percentage terms) is higher for a less expensive trim: -1.02 for the MX-5 trim with the lowest retail price and -0.65 for the MX-5 trim with the highest retail price.

By combining these results and the preceding results on ERPT, we can infer how the automobile price evolves at the national border and in the foreign retail market. First, the retail prices of Mazda models are rather independent from the fluctuations of the exchange rate. This result is obtained by combining two channels of price transmissions.

The export prices of the Mazda models do not fully increase (i.e., from 48% to 81%) in accordance with the appreciation of the Japanese yen, and in addition, the local retail price is even less responsive because of the sales margin reduction (from 35% to 65%). Second, the price responsiveness to the exchange rate is different at intermediate stages, although that of retail prices, i.e., the price at the last stage, is similar across models. At the export price level, the ERPT is 0.81 for the MX-5 (G4), 0.63 for the Mazda-3 (G4), and 0.48 for the Mazda-3 (G5). Third, and conversely to the above two results, a proportionately higher increase in the export price in response to an appreciation of an exporter's currency is absorbed similarly in a higher proportion in the reduction of the sales margin. A higher ERPT corresponds with a higher exchange elasticity of sales margins. The exchange-rate elasticity of sales margin reduction is -0.65 for MX-5 (G4), -0.64 for Mazda-3 (G4), and -0.35 for Mazda-3 (G5).

## **6. Discussions and robustness checks**

In this section, we discuss issues that are relevant to the exchange rate pass-through but not brought to the focus in the previous sections. These issues are the quantity response of automobile trades and the retail price response in the home market with reference to pricing-to-market behaviors. In addition, we examine through a robustness check whether the three subsamples studied in the previous sections adequately represent the dynamics of ERPT elasticity during the last 26 years.

After the global financial crisis, world trade experienced a disproportionate fall from the preceding period. The so-called 'Great Trade Collapse' in international trade has been examined by numerous studies that attempt to find explanations for this unprecedented decline; see Ahn, Amiti, and Weinstein (2011), Amiti and Weinstein (2011), Bems, Johnson, Yi (2011), and Bussière et al. (2013). So far, we have only focused on the price component of international trade in this paper. In this section, we examine how the quantity in automobile trade evolved during the crisis period.

{Insert Figure 8a & 8b & 9 here}

Figures 8a and 8b show the volumes of automobile exports of Japan (not restricted to Yamaguchi and Hiroshima) for each HS9 category. We find that automobile exports declined drastically in volume (and therefore also in value) in 2009. For the diesel engine automobiles in Figure 8b, Japanese exports show some rebound in 2010 but experience a further decline in more recent years. This is primarily due to the fact that diesel engine exports are concentrated in Europe, where the global financial crisis

hit the hardest and was most prolonged. For gasoline engine automobiles, Japanese exports experience a similar pattern except for the category 4 (1,500-2,000 cc), which continued to rise after the trough in 2009. Figure 9 shows the automobile units exported from Yamaguchi and Hiroshima combined. In general, Mazda exports follow the similar pattern of exports of aggregate Japan. However, category 5 (2,000-3,000 cc) of Mazda shows a distinctively different pattern from that of category 5 of aggregate Japan. Instead of going down after the rebound in 2010, it rises to a level higher than the past trend. Determining how much of this rise of Mazda exports is due to the pricing strategy unraveled in the previous analysis is beyond the scope of this paper; however, the stabilizing retail price in the destination country must have upheld the sales quantity.

{Insert Figure 10 here}

Next, we move to a comparison of the retail prices of the same model in different markets. Similar to the retail price in the US, we can find the MSRP in the Japanese automobile market from information vendors of automobile industry, such as Car Sensor by Recruit Inc. Figure 10 plots the natural log ratio of the US retail price to the Japanese retail price (in terms of US dollars) of the Mazda-3 against the natural log of the exchange rate, US dollar value for one unit of Japanese yen. Two ratios, one corresponding to the highest prices and the other corresponding to the lowest prices, are shown with the fitted estimates. First, both the highest and lowest retail price ratios decline in response to the appreciation of the Japanese yen. In fact, the estimated elasticity coefficients are below zero, with a statistical significance at the one percent level. If retail prices are fixed in the local currency, i.e., the Japanese yen in the Japanese market and the US dollar in the US market, in accordance with pricing-to-market behavior, the denominator (as defined in US dollars) will increase with an appreciation of the Japanese yen, therefore causing the ratio to decline. On the contrary, if both retail prices are fixed in the exporter's currency, i.e., no pricing-to-market, the retail price ratios are stabilized irrespective of exchange rate fluctuations, causing the estimated elasticity to be equal to zero. Second, the estimated exchange rate elasticity is larger in absolute terms for the trim with the lowest price. In fact, the estimated elasticity is -0.97 and is not statistically different from minus one. This implies a one-to-one correspondence between the exchange rate and the retail price ratio. A ten percent appreciation of the Japanese yen leads to an approximately ten percent decline in the ratio. On the contrary, the ratio of the highest price trim changes only six percent when the Japanese exchange rate appreciates ten percent. This gap, i.e.,

four percent, must come from either a decrease in the Japanese retail price in terms of the Japanese yen or an increase in the US retail price in response to the appreciation of the Japanese yen.

{Insert Figure 11 here}

We have demonstrated that the ERPT can be quite different across three ten-year subsamples. To see how the ERPTs have evolved during the entire sample period, we estimated the ERPTs based on rolling windows of ten years, i.e., 40 quarters, for Hiroshima and Yamaguchi combined for 20 destination markets. The estimated ERPT for G3, G4, and G5 are shown in Figure 11. Consistent with the subsample analysis, the ERPT elasticity started at a high level, approximately 1.0, and continued to decline at a relatively steady level to approximately 0.2. The high level of ERPT in the earlier part of the sample corresponds with the period of voluntary export restraint in the automobile industry in Japan. These rolling window estimates support our choice of selecting three ten-year subsamples, which capture the major swing of ERPT during the entire sample.

{Insert Figure 12 and 13 here}

We have discussed several possible causes for gradual structural changes in ERPT subsection 4-2, i.e., the voluntary export restraints, the rise and burst of the bubble economy, and the global financial crises. The higher ERPT in the late 80s and early 90s coincides with the period when voluntary export restraint was effective and the prices of Japanese automobiles were set higher in the US. These forces were exogenous shocks to the automobile industry; however, there still remains the endogenous shock that may have caused the structural changes in the ERPT. We suspect that the evolving pattern of destination countries may have caused the changes in the ERPT, as in Bergin and Feenstra (2009). Figures 12 and 13 plot the shares of the top five destination countries in automobile exports, respectively, of the Hiroshima and Yamaguchi ports. In Figure 12, for Hiroshima port, the shares of top five are relatively stable, and the US dominates other destination markets. This evidence reinforces the argument that lifting the VER in the US affected the ERPT of Hiroshima ports. In contrast, in Figure 13, the shares of the top five changes more dramatically. For the late 80s and early 90s, Germany was the dominating figure; however, the US was tops in the Yamaguchi automobile export destinations in the 2000s. Coupled with the findings of low ERPT to the US market,

these drastic changes in the destination country may have contributed to the decline of ERPT found in this study<sup>14</sup>. This evidence is consistent with the findings of our complementary paper, which examines the ERPT of the automobile industry covering all manufacturers, that show that destination country matters more for the observed heterogeneity in ERPT than engine size, manufacturer, or model.

Finally, we discuss the subject of the long-run and short-run ERPT. We estimated the alternative model with the lagged exchange rate, and these results are in unreported appendix tables. The fourth lag, i.e., a one-year lag, sometimes appears to be statistically significant. However, the sum of the contemporary coefficient and the fourth-lag coefficient is roughly equal to the estimated coefficient of the model without the lags whenever the fourth-lag is statistically significant. Therefore, the results of our paper adequately represent the long-run ERPT; however, the short-run movements within a year may be more complicated.

## 7. Conclusions

Given the recent theoretical emphasis on firm-level heterogeneity in international trade, empirical investigations are required to use trade datasets with a much finer level of disaggregation than is currently provided by national governments or international organizations. We revitalize international trade datasets via matching, using the geographical locations of exporting firms within an exporting country. With this method, we transform a national-level dataset into a quasi-firm-level dataset.

Through the careful examination of firm-level information for production plant location and the use of local ports for exports at the firm level, specific auto make-models are matched with a port-product pair based on HS 9-digit export data. By restricting ourselves to two exporting ports, we are able to estimate the price-setting behaviors of one particular Japanese automaker. We examine the price-setting behaviors of Japanese automobile exporting firms in correspondence with fluctuations in the foreign exchange rates. By estimating the ERPT regressions for port-model-destination panel data, we find that heterogeneity in the ERPT still exists across models even when we control for automobile manufacturer and engine size. As evident from the size of the estimated ERPT for gasoline engine automobiles, we observe a positive relationship between engine size and the degree of ERPT.

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<sup>14</sup> It should be noted that the ERPT plots in Figure 11 are un-weighted average across destination markets. So what matters the most for the change in the ERPT is not the shares of the top five but entering and exiting of destination countries from the sample. The number of destination countries over the course of years, in turn, is affected by the shares of the top five.

Berman, Martin, and Mayer (2012) find that high-performing firms react to a depreciation by significantly increasing their markups and increasing less their export volumes. Chatterjee, Dix-Carneiro, and Vichyanond (2013) build a theoretical trade model in which an exporter produces multiple products. They show that an exporter will increase its markups in response to a depreciation, but an increase in the markup of each product depends on the product-specific marginal cost. Automakers in this study are multi-product manufacturers. The predictions of Chatterjee et al. (2013) support our results that a Japanese automaker varied its response by adjusting markups among models in response to fluctuations in exchange rates.

Coupled with the MSRP in the US market, we examine the dynamic behaviors of model-specific price margins for US distributors and Japanese automakers. We find heterogeneity among auto-models in price-margin behaviors even when we control for automakers' characteristics. The price margins for US distributors have shrunk substantially, particularly when the US dollar depreciated after the global financial crisis. With the limited sample of specific models, we find that US consumers faced a slight increase in Japanese automobile prices in terms of the USD because of the following two pricing behaviors. The (model-specific) ERPT elasticities for the US market are very small. We should note that the US price still experienced a slight increase when the JPY appreciated. However, even this slight increase was absorbed by a reduction of sales margins.

## Appendix

### The matching procedure:

For each model, the Mazda produces several trims with different engine sizes. The range of engine sizes often crosses over adjacent HS9 categories even when we focus on a single port/plant. For example, in 2007, the Mazda export Mazda-3 and Mazda-6 from the Yamaguchi port, and the models overlap in category 4 (1,500-2,000 cc) and category 5 (2,000-3,000 cc). This overlap can sometimes be mitigated for two reasons when we focus on a single destination market. First, not all trims (or engine sizes) are necessarily sold in every destination country. Second, some models are also produced locally. We show the second case as an example in this appendix.

According to the data taken from the Customs office, in 2007, the exported automobile units from the Yamaguchi port to the US is 72,298 for category 4 and 49,748 for category 5. According to the information collected by Mazda and other automobile information vendors, two models (Mazda-3 and Mazda-6) are sold in both categories. At this point, we can distinguish between neither different trims within the same model nor different models within the HS9 category.

However, we also have information that shows that the Mazda-6 is also produced in the US. Coupled with information on units produced and sold in the US, we find that Mazda-6 exports from Yamaguchi to the US are either negligible or, in fact, zero. On the other hand, US sales of the Mazda-3 (120,291 units) must be matched with the Yamaguchi exports to the US because the Mazda-3 is neither produced in the US nor imported from countries besides Japan. Assuming all size 4 exports from Yamaguchi to the US are Mazda-3s with smaller engines and all size 5 exports are Mazda-3s with larger engines, the calculated error is only 1.46 percent. The magnitude of error of this size can be explained by the lags between exports and sales. From this matching, we can justifiably assume that Yamaguchi exports of the size 4 category include only the Mazda-3 with smaller engines, and those of the size 5 category are, in fact, Mazda-3s with larger engines.

Table A1. Yamaguchi export to the US in 2007

2007	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Model	Engine size sold in US	Production in US	Sales in US	Estimated imports (b-c)	Size 4 (1,500 – 2,000)	Size 5 (2,000 – 3,000)	error [d-(e+f)]/d
Mazda-3	4 & 5	0	120,291	120,291	72,298	49,748	-1.46%
Mazda-6	4 & 5	54,321	57,575	3,254	0	0	0%

**Table A2. Mazda distribution system for the California market**

Manufacturer: MAZDA

Distributor: MAZDA MOTOR OF AMERICA, INC. (MAZDA USA)

Local Dealer (California state):

- BROWNING MAZDA OF ALHAMBRA (ALHAMBRA)
- BAKERSFIELD MAZDA (BAKERSFIELD)
- MAZDA BURLINGAME (BURLINGAME)
- SANTA CRUZ MAZDA (CAPITOLA)
- BOB BAKER MAZDA (CARLSBAD)
- PALM SPRINGS MAZDA (CATHEDRAL CITY)
- BROWNING MAZDA (CERRITOS)
- MAZDA OF PUENTE HILLS (CITY OF INDUSTRY)
- CONCORD MAZDA (CONCORD)
- CULVER CITY MAZDA (CULVER CITY)
- DUBLIN MAZDA (DUBLIN)
- EL CAJON MAZDA (EL CAJON)
- MAZDA OF ELK GROVE (ELK GROVE)
- MAZDA OF ESCONDIDO (ESCONDIDO)
- LITHIA MAZDA OF FRESNO (FRESNO)
- STAR MAZDA (GLENDALE)
- HUNTINGTON BEACH MAZDA (HUNTINGTON BEACH)
- TUTTLE-CLICK MAZDA (IRVINE)
- PHILLIPS MAZDA (LAGUNA HILLS)
- ANTELOPE VALLEY MAZDA (LANCASTER)
- RAZZARI MAZDA (MERCED)
- SIERRA MAZDA OF MONROVIA (MONROVIA)
- WESTCOTT MAZDA (NATIONAL CITY)
- FREMONT MAZDA (NEWARK)
- ROMERO MAZDA (ONTARIO)
- MAZDA OF ORANGE (ORANGE)
- REDLANDS MAZDA (REDLANDS)
- TOWNE MAZDA (REDWOOD CITY)
- RIVERSIDE MAZDA (RIVERSIDE)
- AUTONATION MAZDA OF ROSEVILLE (ROSEVILLE)
- MAITA MAZDA (SACRAMENTO)

- CARDINALE MAZDA (SALINAS)
- JOHN HINE MAZDA (SAN DIEGO)
- MAZDA SAN FRANCISCO (SAN FRANCISCO)
- CAPITOL MAZDA (SAN JOSE)
- OAK TREE MAZDA (SAN JOSE)
- COLE MAZDA (SAN LUIS OBISPO)
- MARIN MAZDA (SAN RAFAEL)
- PERRY MAZDA (SANTA BARBARA)
- GALPIN MAZDA (SANTA CLARITA)
- SANTA MARIA MAZDA (SANTA MARIA)
- SANTA MONICA MAZDA (SANTA MONICA)
- HANSEL MAZDA (SANTA ROSA)
- CYPRESS COAST MAZDA (SEASIDE)
- SELMA MAZDA (SELMA)
- MAZDA OF STOCKTON (STOCKTON)
- JOHN HINE TEMECULA MAZDA (TEMECULA)
- NEFTIN WESTLAKE MAZDA (THOUSAND OAKS)
- SOUTH BAY MAZDA (TORRANCE)
- TRACY MAZDA (TRACY)
- TUSTIN MAZDA (TUSTIN)
- TEAM MAZDA (VALLEJO)
- GALPIN MAZDA (VAN NUYS)
- CJ WILSON MAZDA OF VENTURA (VENTURA)
- VICTORVILLE MAZDA (VICTORVILLE)
- WHEELER MAZDA (YUBA CITY)

Table A3. The number of observations for Mazda exports by engine size and destination countries

	Gasoline						Diesel		
	under 550	550-1000	1000-1500	1500-2000	2000-3000	3000 over	1500-2000	2000-2500	2500 over
China			6	81	68	3	1		
Hong Kong	1	1	131	145	135	2	5	39	3
Saudi Arabia			56	125	112	31			
Israel			65	132	92		4	4	
UAE			68	120	93	25	10	11	3
UK		2	137	197	127	2	106	40	2
Netherlands			136	196	134		166	74	1
Belgium		1	151	195	127	2	178	81	
France			144	193	113		166	86	
Germany		4	156	198	184	5	180	100	2
Switzerland			134	196	154	1	104	55	
Spain			83	186	96	1	111	43	
Italy		2	96	175	64		97	42	
Austria			144	194	143	1	187	51	
Canada		1	33	151	155	26		1	
US	1	4	71	176	179	57	4	9	4
Puerto Rico			53	128	116	25		1	
Chile			61	109	79	22	37	27	15
Australia		3	144	166	168	61	34	53	11
New Zealand	2	5	129	152	134	36	40	51	38
Total	4	23	1,998	3,215	2,473	300	1,430	768	79

Note: The total observations is 200 (2 ports times 100 quarters) for each cell.

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Figure 1. The multilayer distribution system

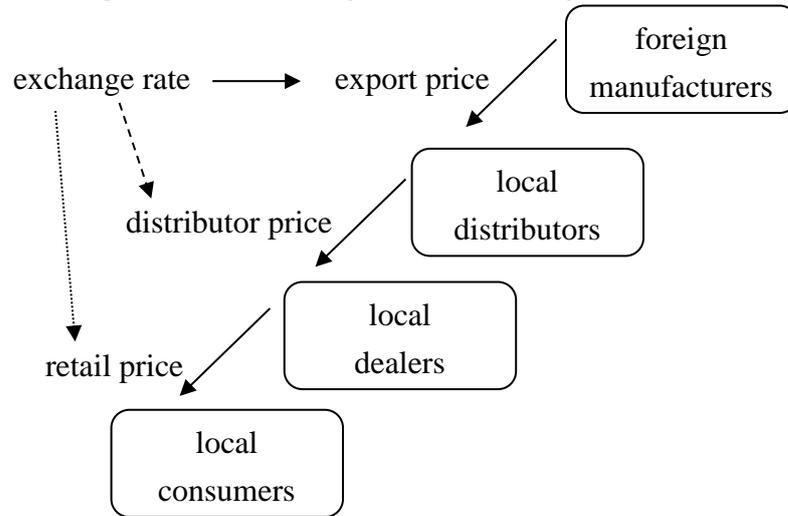
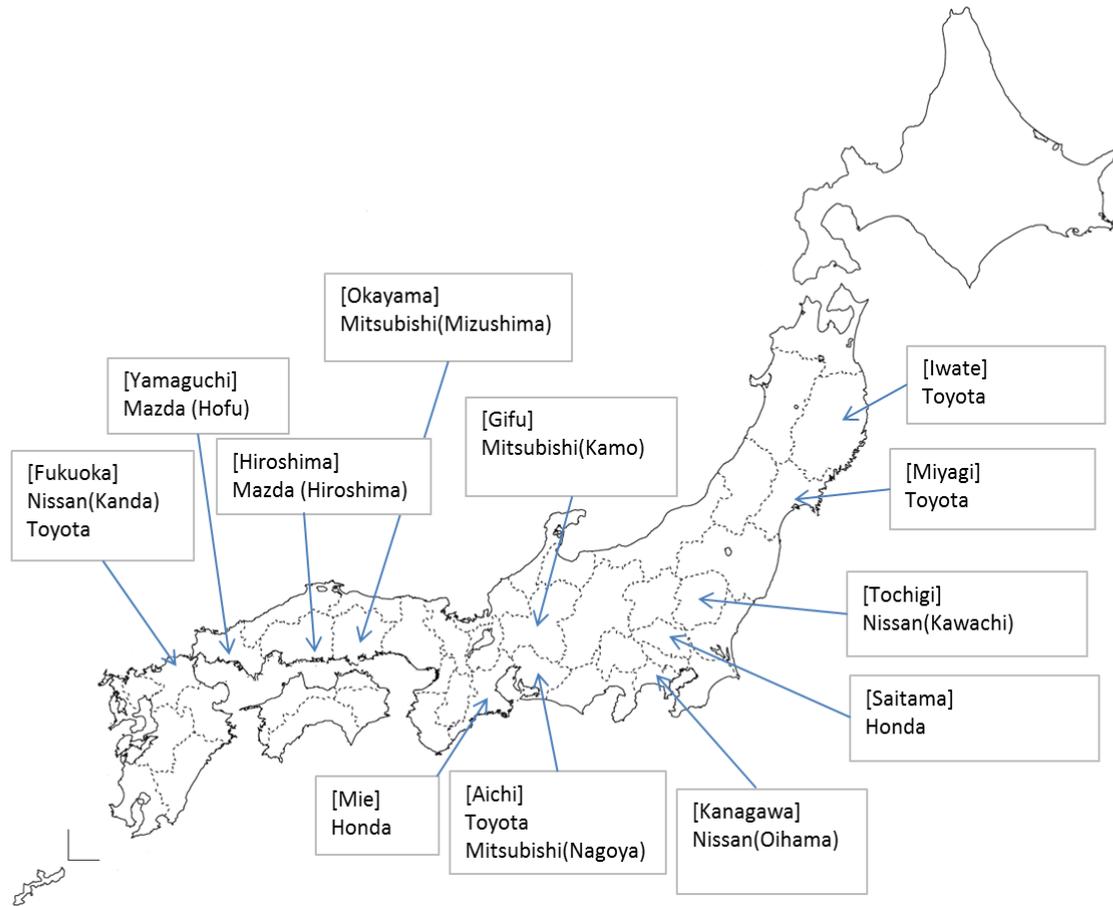
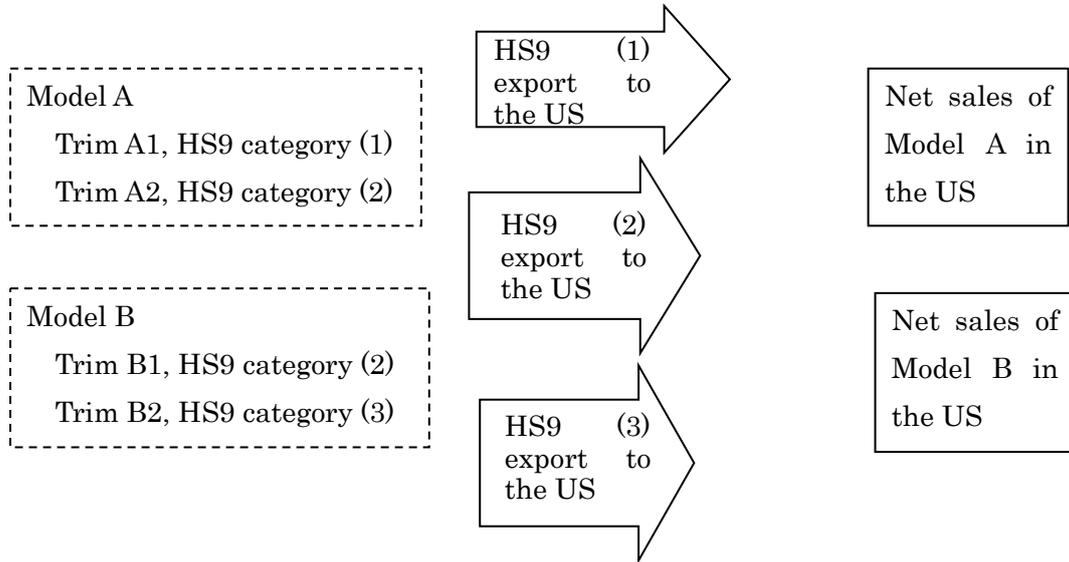


Figure 2. Geography of Automobile Production Plants in Japan



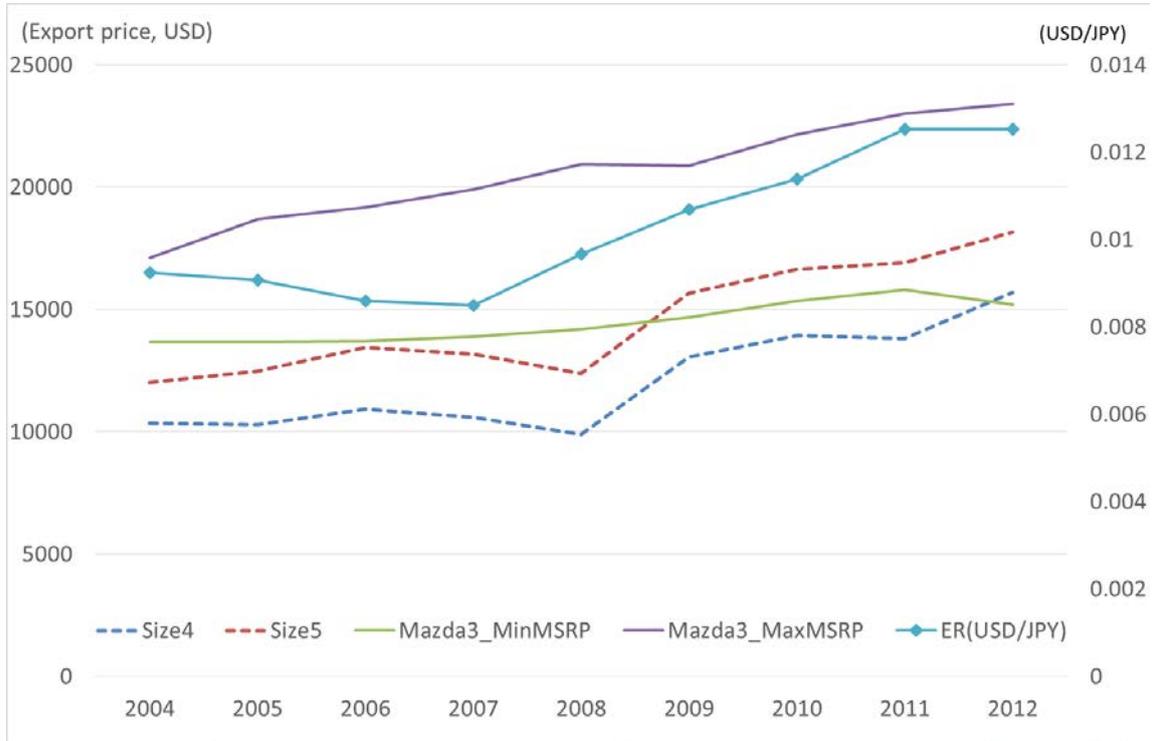
Note: The locations of automobile production plants (not exhaustive) are depicted on the geographical map of Japan, each district representing one of 47 prefectures. The box includes the prefecture names (in square brackets) and the automobile manufacturers' names.

Figure 3. An example of matching different databases



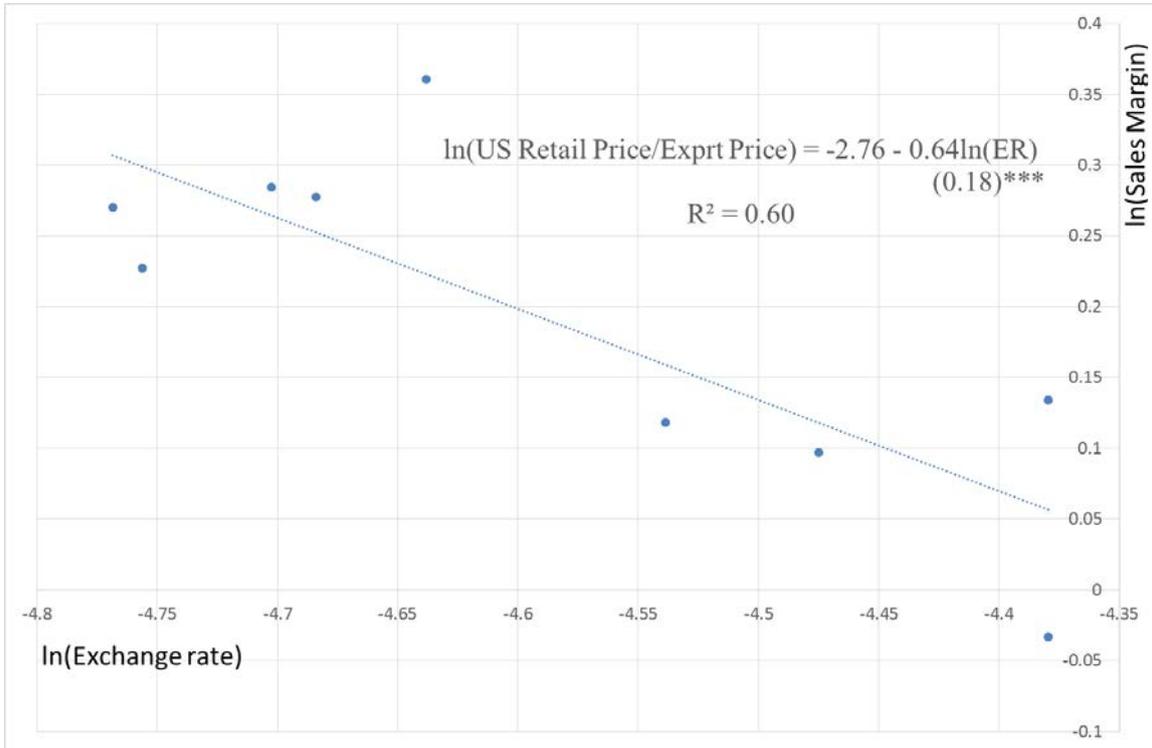
Note: Two trims of the Model A are categorized in two different HS9 categories, (1) and (2). Two trims of Model B are in categories (2) and (3). In this example, HS9 categories (1) and (3) have a one-to-one correspondence with a model-trim product. It should be noted that this matching is only made possible because of the use of port-level exports. HS9 category (2) is associated with two model-trims; therefore, within-category heterogeneity exists. However, the sales data in the destination market may reveal that HS9 category (2) corresponds with only one model-trim if, for example, the other model-trim is sold only in the European market.

Figure 4. US dollar export unit prices and retail prices



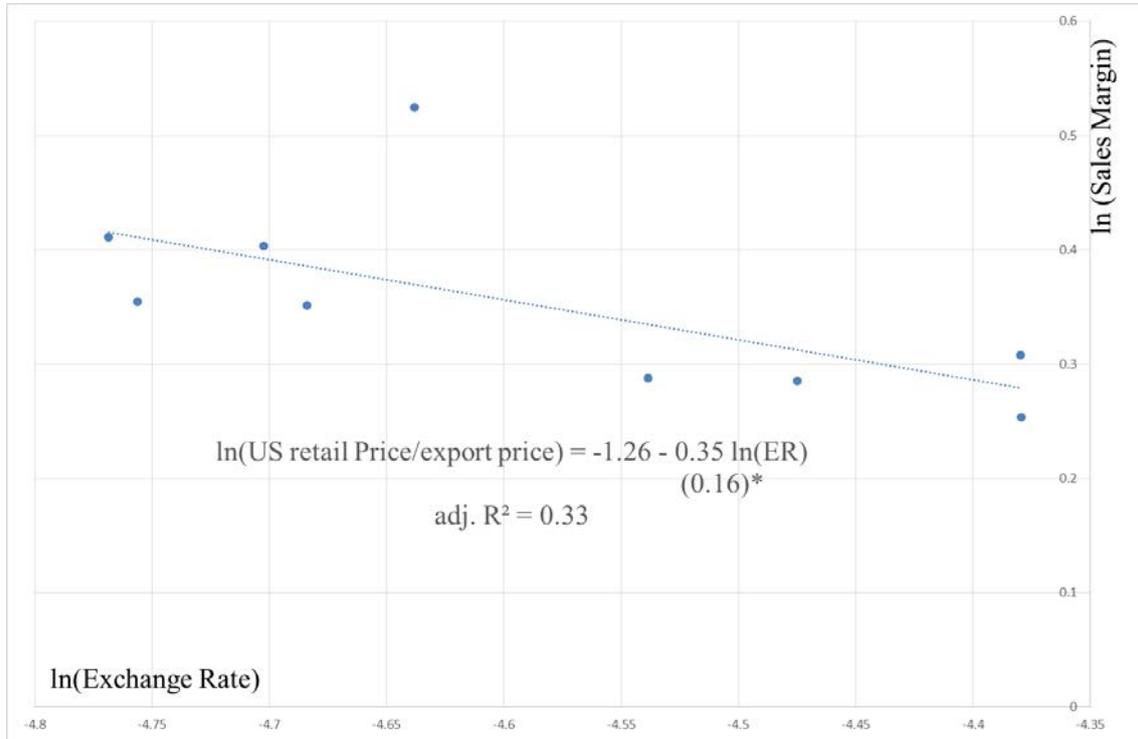
Note: The two solid lines represent the lowest and highest US manufacturer's suggested retail prices for the Mazda-3. The two dotted lines represent the US dollar export price for HS9 category 870323919 and 870323929 from the Yamaguchi port to the US. The exchange rate is defined as the dollar price of the Japanese yen currency.

Figure 5. Sales margin of Mazda-3 (1,500 - 2,000 cc engine) versus exchange rate



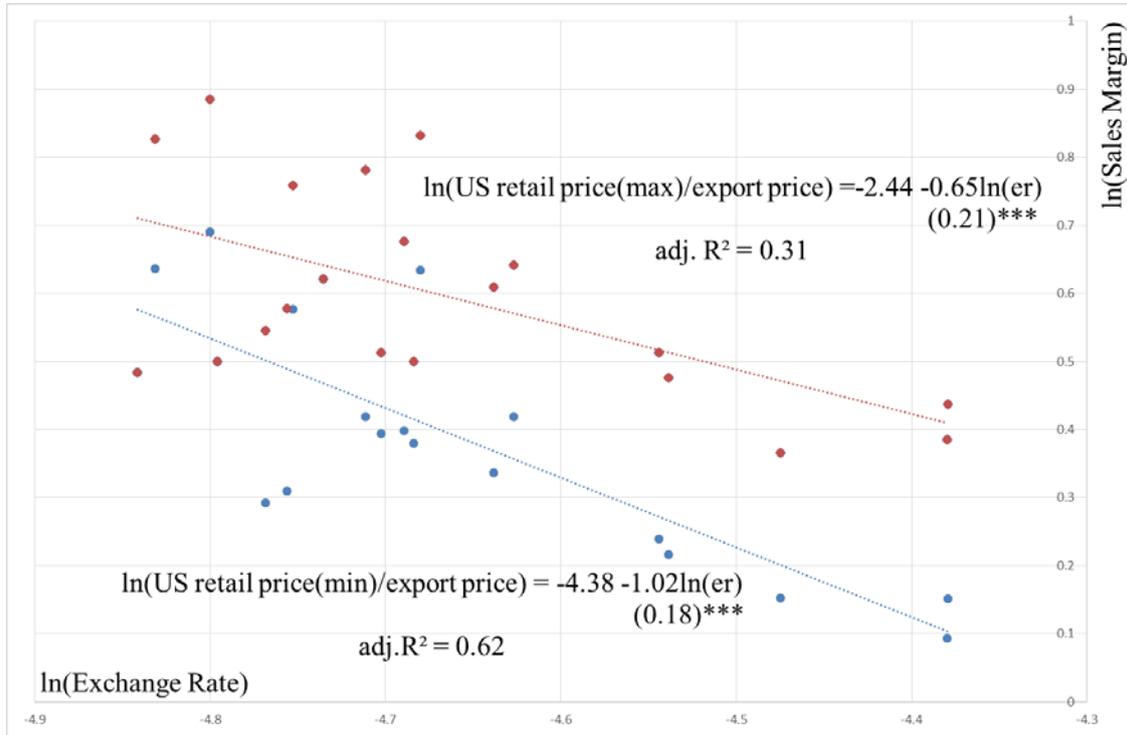
Note: The US sales margin, defined as the natural log of the ratio of the manufacturer's suggested retail price (MSRP) to the export price, is plotted against the natural log of the exchange rate. The US retail price is the lowest MSRP for Mazda-3s with a smaller engine. The export price is the unit price of HS9 category 870323919 from the Yamaguchi port to the US. The annual sample is from 2004 to 2012.

Figure 6. Sales margin of Mazda-3 (2,000 - 3,000 cc engine) versus exchange rate



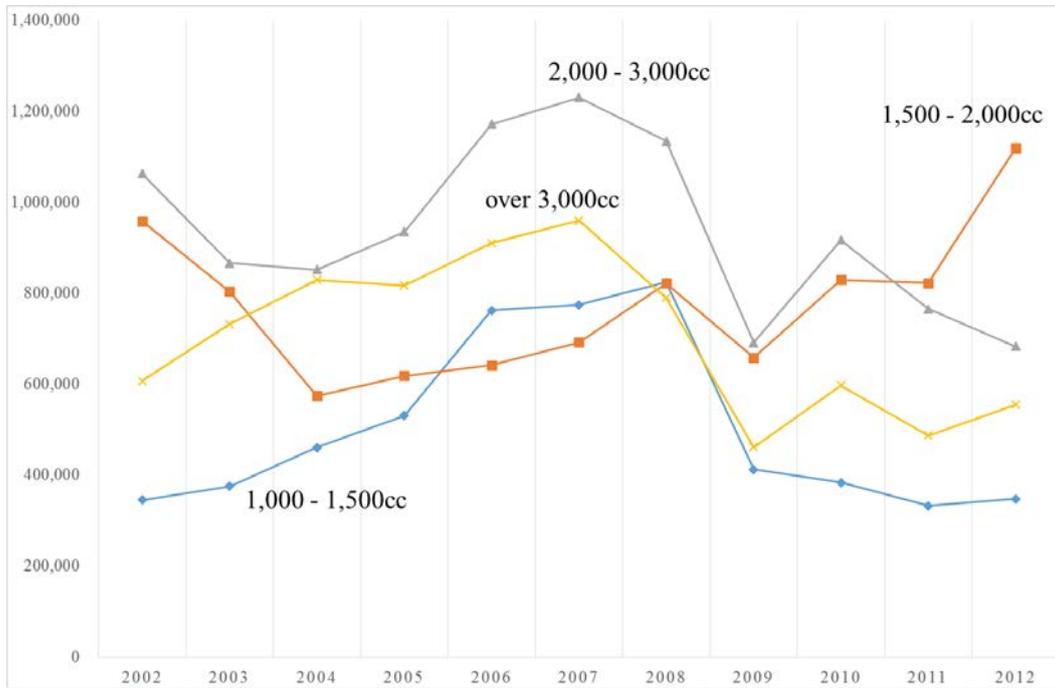
Note: The US sales margin, defined as the natural log of the ratio of the manufacturer's suggested retail price (MSRP) to the export price, is plotted against the natural log of the exchange rate. The US retail price is the highest MSRP for the Mazda-3s with a larger engine. The export price is the unit price of HS9 category 870323929 from the Yamaguchi port to the US. The annual sample is from 2004 to 2012.

Figure 7. Sales margin of MX-5 model versus exchange rates



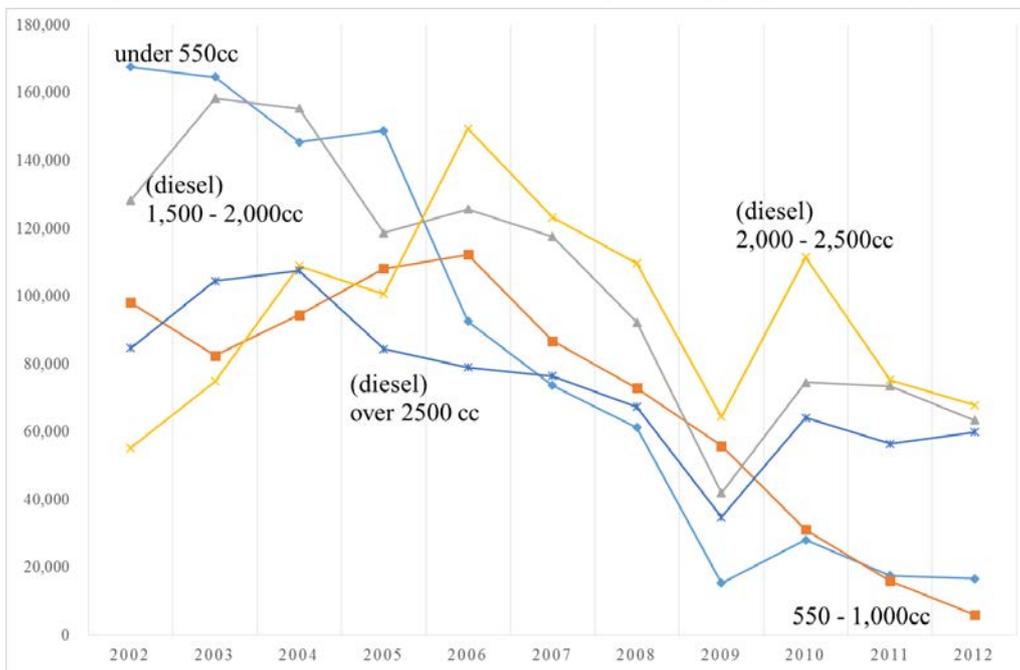
Note: The US sales margin, defined as the natural log of the ratio of manufacturer's suggested retail price (MSRP) to the export price, is plotted against the natural log of the exchange rate. The highest MSRP and the lowest MSRP for MX-5 are used for the US retail price. The export price is the unit price of HS9 category 870323919 from the Hiroshima port to the US. The annual sample is from 1992 to 2012, lacking 1998. The MSRP data source is Cars.Com.

Figure 8a. The volume of automobile exports, aggregated for Japan



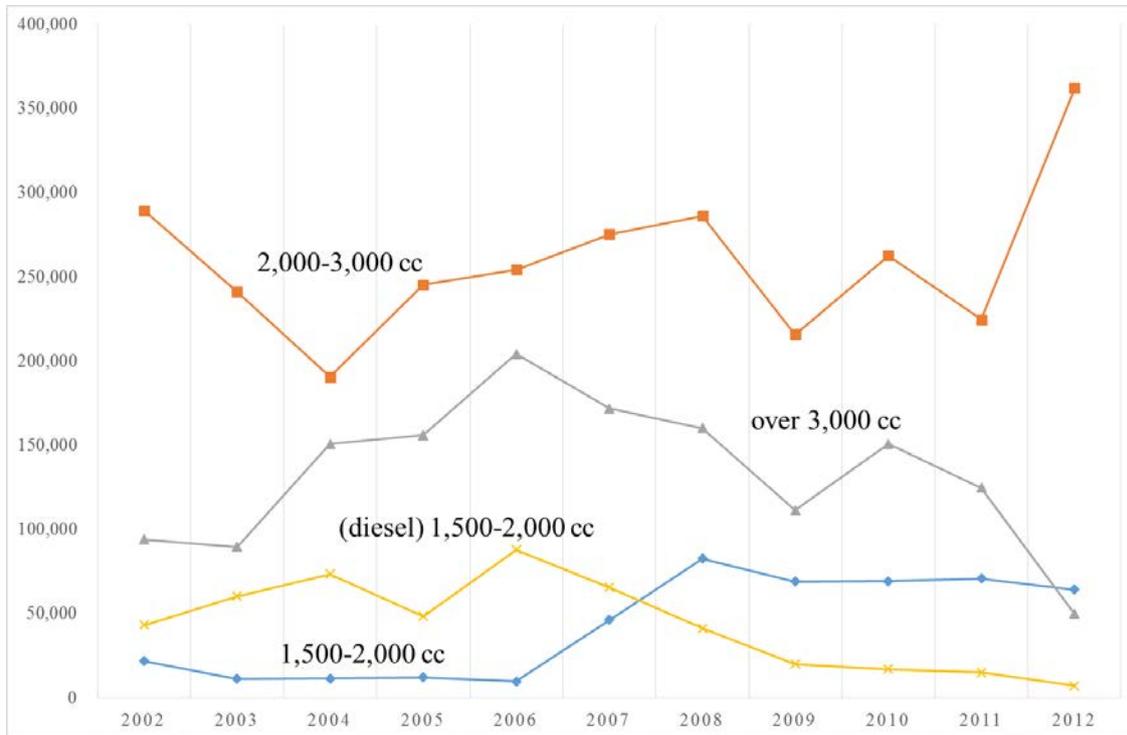
Note: The units of automobile exports from Japan, i.e., the sum of all ports, to all destination countries.

Figure 8b. The volume of automobile exports, aggregated for Japan



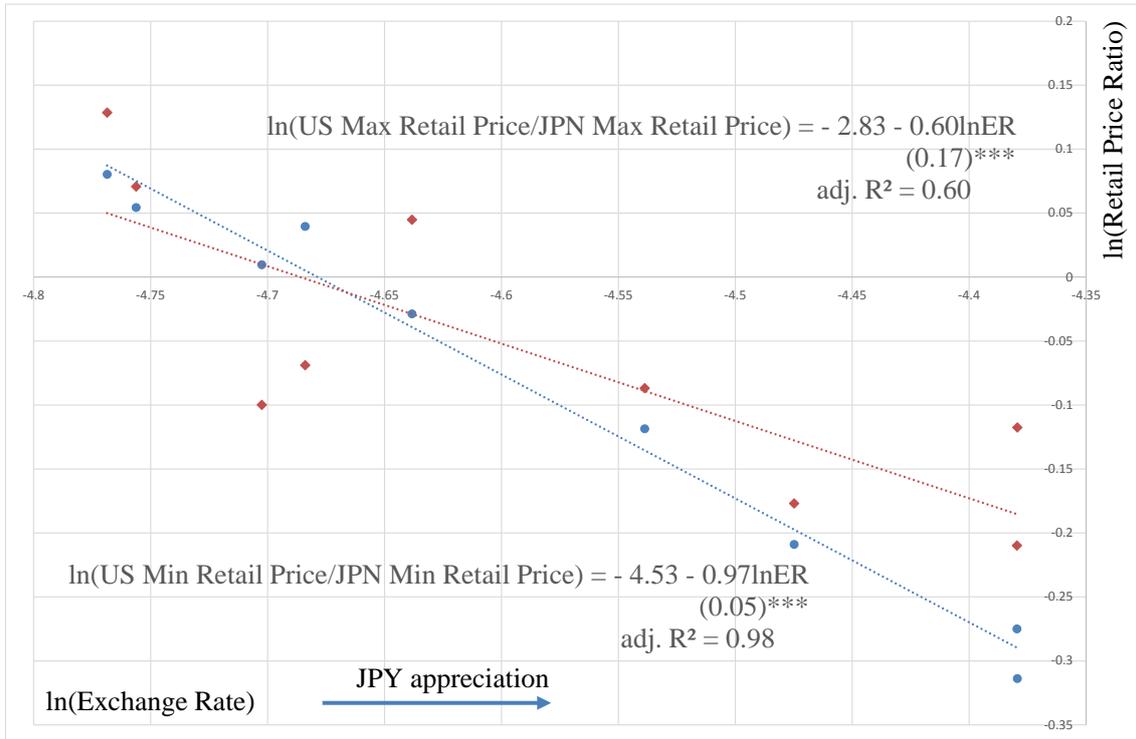
Note: The units of automobile exports from Japan, i.e., the sum of all ports, to all destination countries.

Figure 9. The volume of Mazda automobile exports



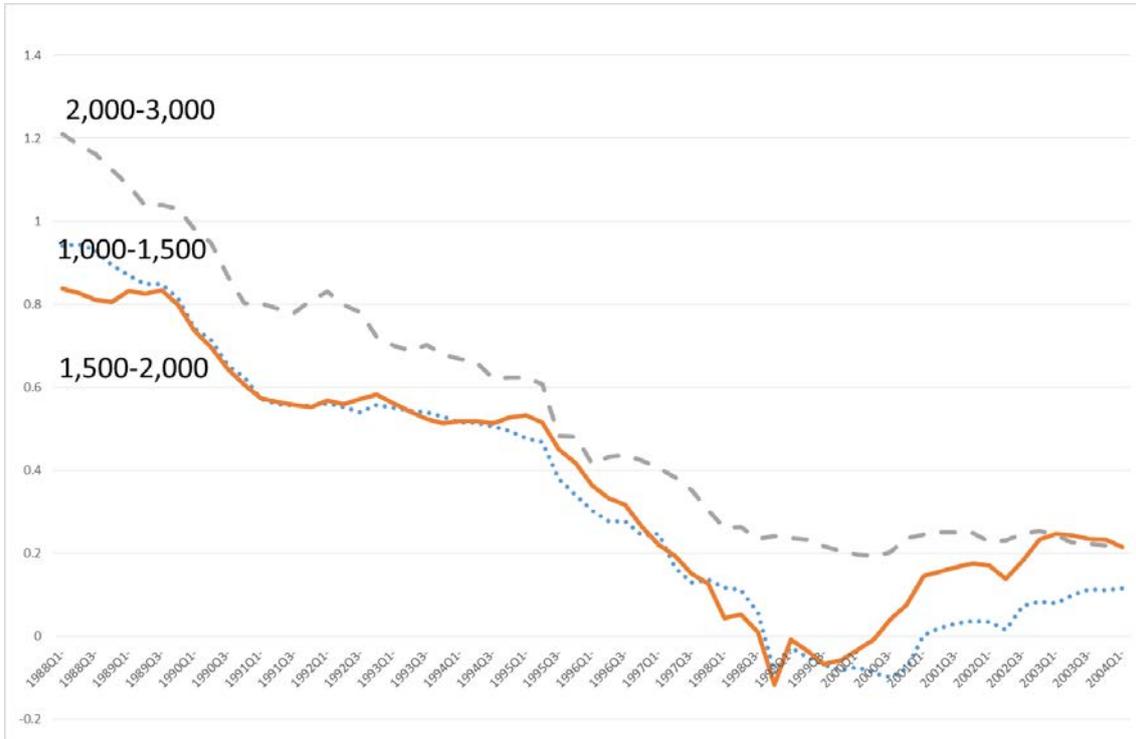
Note: The units of automobile exports from Yamaguchi and Hiroshima ports combined to all destination countries.

Figure 10. The retail price ratio versus the exchange rate



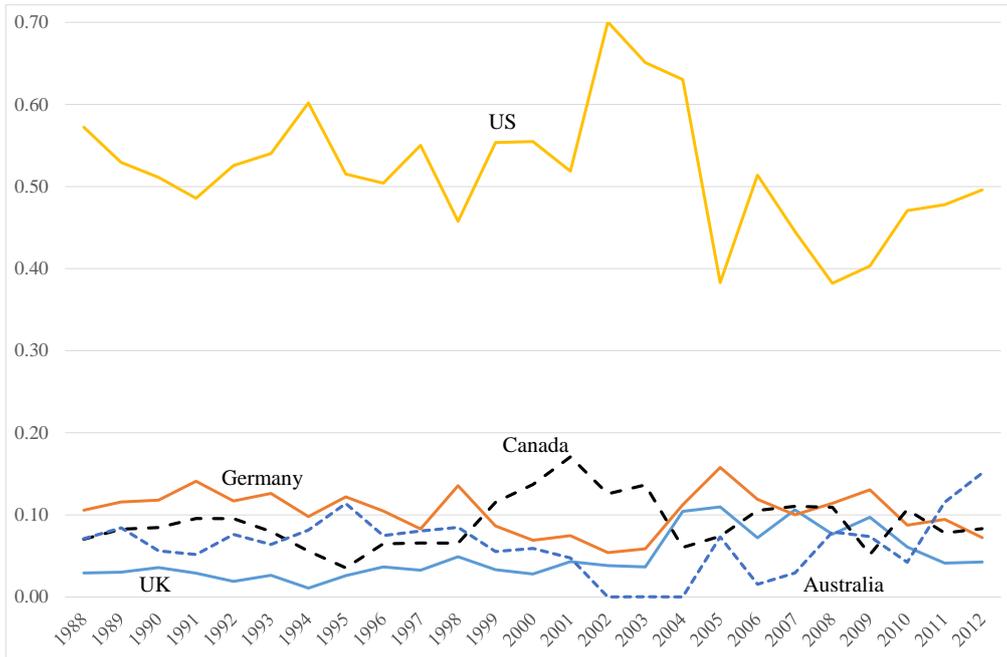
Note: The natural log of the ratio of the US highest (lowest) manufacturer's suggested retail price (MSRP) to the highest (lowest) Japanese retail price in terms of US dollars is plotted against the natural log of the exchange rate, the US dollar value for one unit of Japanese yen. Both US and Japanese retail prices are the MSRP for Mazda-3. The annual sample is from 2004 to 2012.

Figure 11. ERPT elasticity with a rolling window of 40 observations



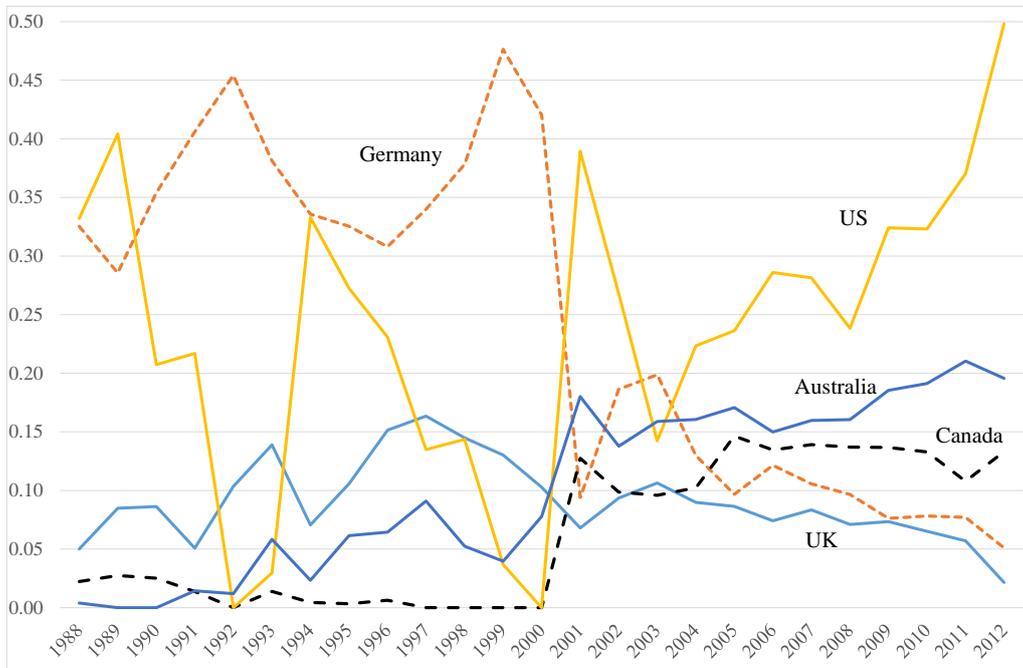
Note: The three lines represent the time-varying exchange rate pass-through of gasoline engine automobiles. The horizontal axis indicates the first quarter of the subsample. The ERPT elasticities are estimated by AR(2) regression with a rolling window of 40 quarterly observations for the combined exports from Hiroshima and Yamaguchi to 20 destination countries.

Figure 12. Shares of destination countries in Hiroshima automobile exports



Note: The five lines represent the shares of the top five destination countries in gasoline engine automobile exports from the Hiroshima port. The annual data are calculated by aggregating the quarterly data.

Figure 13. Shares of destination countries in Yamaguchi automobile exports



Note: See notes for Figure 12.

Table 1. Exports of Mazda from two ports by model and year

Model	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Mazda-2	32,920	21,938	13,883	4,879	8,896	9,117	732	56,753	139,200	92,418	89,872	91,010	76,996
Mazda-3				75,701	284,256	338,013	30,805	397,953	384,724	295,594	356,611	284,561	290,723
Mazda-5	30,061	25,711	27,772	22,952	18,788	50,777	10,169	79,845	85,285	44,823	54,825	59,015	38,483
Mazda-6			87,389	151,460	125,201	122,652	10,079	105,335	136,304	42,095	68,457	53,298	42,759
Mazda-8	53,729	36,973	62,787	44,162	38,201	22,582	0	353	406	179	678	938	1,311
Mazda CX-5												3,486	164,003
Mazda CX-7							5,173	69,052	60,168	34,597	87,635	98,507	6,058
Mazda CX-9							4,608	41,201	45,422	28,761	49,685	45,173	36,157
Mazda MX-5	41,674	35,460	37,586	29,054	23,153	25,245	3,884	33,870	21,625	17,185	19,146	14,327	13,943
Mazda RX-8				42,428	41,577	19,408	1,241	10,050	5,317	1,454	1,845	262	54
Mazda Tribute			16,459	21,659	16,313	8,215		300	440	1,180	400	0	0
Mazda Biante													1,303
Mazda 626	60,539	30,471											
Mazda Millenia	16,241	22,363											
Mazda 323	214,652	271,829	243,017	152,687	10,912	6,680							
Others	3,782	20,337	26,376	3,059	2,302	1,460	720	4,180	0	0	0	0	0
Total	453,598	465,082	515,269	548,041	569,599	604,149	67,411	798,892	878,891	558,286	729,154	650,577	671,790

Note: The number of units exported is taken from various monthly reports from Mazda.

Table 2. ERPT estimates for Mazda, 20 destinations

Type-Size ID Engine size		Gasoline Engine				Diesel Engine	
		G3 <u>1000-1500</u>	G4 <u>1500-2000</u>	G5 <u>2000-3000</u>	G6 <u>over 3000</u>	D1 <u>1500-2000</u>	D2 <u>2000-2500</u>
Entire Sample (1988Q1-2013Q4)	ERPT elasticity	0.38 (0.05)***+++	0.38 (0.04)***+++	0.50 (0.05)***+++	0.25 (0.15)*+++	0.06 (0.06)+++	0.20 (0.10)*+++
	adj. R2	0.996	0.997	0.995	0.992	0.997	0.997
	DW	1.84	2.01	1.71	2.57	1.80	1.77
	NOB	1,597	2,828	1,915	217	1,209	617
First ten years (1988Q1-1997Q4)	ERPT elasticity	0.94 (0.07)***	0.84 (0.06)***++	1.21 (0.08)***++		0.96 (0.11)***	1.08 (0.15)***
	adj. R2	0.996	0.997	0.992		0.993	0.994
	DW	1.97	2.05	1.69		1.45	1.58
	NOB	610	941	619		297	193
Middle ten years (1996Q1-2005Q4)	ERPT elasticity	0.30 (0.09)***+++	0.36 (0.05)***+++	0.41 (0.11)***+++		-0.06 (0.15)+++	0.27 (0.26)+++
	adj. R2	0.995	0.998	0.995		0.996	0.994
	DW	1.79	2.00	1.93		1.77	1.93
	NOB	670	1054	684		446	125
Last ten years (2004Q1-2013Q4)	ERPT elasticity	0.11 (0.06)*+++	0.21 (0.05)***+++	0.22 (0.05)***+++		-0.17 (0.04)***+++	-0.19 (0.06)***+++
	adj. R2	0.997	0.998	0.997		0.999	0.999
	DW	1.75	1.88	1.70		1.96	1.92
	NOB	593	1285	936		635	356

Note: Panel regression results for the exchange rate effects on automobile export prices. Exporting ports are restricted to only two ports (Hiroshima and Yamaguchi) for 20 destination countries for each engine type-size regression. Figures in parentheses are standard deviations. \*\*\*, \*\*, \* indicate that the ERPT coefficients are statistically greater than zero at the one, five, and ten percent significance level, respectively. +++, ++, + indicate that the ERPT coefficients are statistically less than one at the one, five, and ten percent significance levels, respectively.

Table 3. ERPT elasticity of automobiles from the Hiroshima port

Type-Size ID Engine size		Gasoline Engine				Diesel Engine	
		G3 <u>1000-1500</u>	G4 <u>1500-2000</u>	G5 <u>2000-3000</u>	G6 <u>over 3000</u>	D1 <u>1500-2000</u>	D2 <u>2000-2500</u>
Entire Sample (1988Q1-2013Q4)	ERPT elasticity	0.41 (0.07)***+++	0.37 (0.07)***+++	0.56 (0.08)***+++	0.20 (0.21)+++	0.04 (0.11)+++	0.48 (0.13)***+++
	adj. R2	0.994	0.997	0.991	0.934	0.996	0.996
	DW	1.81	2.02	1.64	2.52	1.75	1.71
	NOB	1,075	1,509	862	161	574	431
First ten years (1988Q1-1997Q4)	ERPT elasticity	0.93 (0.08)***	0.80 (0.07)***+++	1.17 (0.11)***		0.93 (0.16)***	1.08 (0.15)***
	adj. R2	0.995	0.997	0.990		0.991	0.994
	DW	1.92	2.06	1.55		1.40	1.57
	NOB	488	629	370		154	192
Middle ten years (1996Q1-2005Q4)	ERPT elasticity	0.29 (0.15)*+++	0.43 (0.08)***+++	0.38 (0.19)*+++		0.06 (0.28)+++	0.27 (0.26)+++
	adj. R2	0.990	0.997	0.988		0.992	0.994
	DW	1.75	1.98	1.89		1.81	1.93
	NOB	359	533	291		191	125
Last ten years (2004Q1-2013Q4)	ERPT elasticity	0.13 (0.07)*+++	0.22 (0.07)***+++	0.24 (0.07)***+++		-0.13 (0.06)*+++	-0.06 (0.09)+++
	adj. R2	0.997	0.997	0.993		0.999	0.999
	DW	1.68	1.80	1.71		1.91	1.55
	NOB	364	563	325		305	171

Note: Panel regression results for the exchange rate effects on automobile export prices. Regressions are estimated for 20 destination countries for each engine type-size and port regression. The figures in parentheses are standard deviations. \*\*\*, \*\*, \* indicate that ERPT coefficients are statistically greater than zero at the one, five, and ten percent significance level, respectively. +++, ++, + indicate that ERPT coefficients are statistically less than one at the one, five, and ten percent significance levels, respectively.

Table 4. ERPT elasticity of automobiles from Yamaguchi port

Type-Size ID Engine size		Gasoline Engine				Diesel Engine	
		G3 <u>1000-1500</u>	G4 <u>1500-2000</u>	G5 <u>2000-3000</u>	G6 <u>over 3000</u>	D1 <u>1500-2000</u>	D2 <u>2000-2500</u>
Entire Sample (1988Q1-2013Q4)	ERPT elasticity	0.25 (0.08)***+++	0.38 (0.04)***+++	0.45 (0.06)***+++	0.40 (0.18)**+++	0.07 (0.06)+++	-0.37 (0.10)***+++
	adj. R2	0.998	0.998	0.998	0.999	0.999	0.999
	DW	1.90	2.01	1.94	2.36	2.02	2.02
	NOB	522	1,319	1,053	56	635	186
First ten years (1988Q1-1997Q4)	ERPT elasticity	1.03 (0.14)***	0.92 (0.10)***	1.29 (0.11)***++		1.01 (0.14)***	
	adj. R2	0.998	0.998	0.994		0.997	
	DW	2.21	1.99	1.98		2.00	
	NOB	122	312	249		143	
Middle ten years (1996Q1-2005Q4)	ERPT elasticity	0.33 (0.09)***+++	0.16 (0.05)***+++	0.47 (0.10)***+++		-0.26 (0.08)***+++	
	adj. R2	0.998	0.999	0.997		0.999	
	DW	1.82	2.06	2.05		2.05	
	NOB	311	521	393		255	
Last ten years (2004Q1-2013Q4)	ERPT elasticity	0.10 (0.11)+++	0.22 (0.06)***+++	0.18 (0.06)***+++		-0.20 (0.06)***+++	-0.35 (0.10)***+++
	adj. R2	0.999	0.999	0.999		0.999	0.999
	DW	1.95	2.02	1.82		2.05	2.07
	NOB	229	722	611		330	185

Note: Panel regression results for the exchange rate effects on automobile export prices. Regressions are estimated for 20 destination countries for each engine type-size and port regression. Figures in parentheses are standard deviations. \*\*\*, \*\*, \* indicate that ERPT coefficients are statistically greater than zero at the one, five, and ten percent significance levels, respectively. +++, ++, + indicate that ERPT coefficients are statistically less than one at the one, five, and ten percent significance levels, respectively.

Table 5. The manufacturer's suggested retail prices for the Mazda-3

	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	
	No. of trims	3	5	8	8	8	8	7	7	17	16	
Manufacturer's suggested retail price (US dollars)	MSRP(min)	13,680	13,680	13,710	13,895	14,195	14,690	15,345	15,800	15,200	16,700	
	MSRP(max)	17,105	18,685	19,165	19,895	20,495	20,895	22,145	23,010	23,400	25,650	
Trim	hp@ 6500rpm	engine size										
i 4D	148	2.0	13,680	13,680	13,710							
s4D	160	2.3	16,615	16,615	16,880							
s5D	160	2.3	17,105	17,105	17,370							
SP23 5D	160	2.3			18,685							
SP23 4D	160	2.3			18,685							
iSport 4D	148	2.0				13,895	14,195	14,690				
iTouring 4D	148	2.0				15,990	16,255	16,795	17,095			
sSport 4D	156	2.3				17,190	17,735	18,135				
sSport 5D	156	2.3				17,680	18,225	18,625				
sTouring 4D	156	2.3			17,615	18,425	18,725	19,125				
sTouring 5D	156	2.3			17,615	18,425	18,725	19,125				
sGrand Touring 4D	156	2.3			19,165	19,895	20,495	20,895				
sGrand Touring 5D	156	2.3			19,165	19,895	20,495	20,895				
iSV 4D	148	2.0							15,345	15,800		
iSport 4D	148	2.0							16,255	16,705		
iTouring 4D	148	2.0							17,925	18,100		
sSport 4D	167	2.5							19,185	19,545		
sSport 5D	167	2.5							19,685	20,045		
sGrand Touring 4D	167	2.5							21,645	22,510		
sGrand Touring 5D	167	2.5							22,145	23,010		
iSV MT 4D	148	2.0									15,200	16,700
iSV AT 4D	148	2.0										17,550
iSport MT 4D	155	2.0									16,845	18,375
iSport AT 4D	155	2.0									16,845	19,225
iTouring MT 4D	155	2.0									18,700	19,500
iTouring MT 5D	155	2.0									19,300	20,000
iTouring AT 4D	155	2.0									18,700	20,350
iTouring AT 5D	155	2.0									19,300	20,850
sTouring MT 4D	167	2.5									21,300	
sTouring MT 5D	167	2.5									21,800	
sTouring AT 4D	167	2.5									21,300	
sTouring AT 5D	167	2.5									21,800	
iGrand Touring MT 4D	155	2.0										22,800
iGrand Touring MT 5D	155	2.0										23,300
iGrand Touring AT 4D	155	2.0									22,550	23,650
iGrand Touring AT 5D	155	2.0									23,150	24,150
sGrand Touring MT 4D	167	2.5									22,900	24,350
sGrand Touring MT 5D	167	2.5									23,400	24,850
sGrand Touring AT 4D	167	2.5									22,990	25,150
sGrand Touring AT 5D	167	2.5									23,400	25,650

Note: This table was compiled by the authors with the data available from the MSN AUTOS homepage.

Table 6. US ERPT elasticity

		Yamaguchi		Hiroshima
		G4 <u>1500-2000</u>	G5 <u>2000-3000</u>	G4 <u>1500-2000</u>
Type-Size ID	Engine size			
Entire Sample (1988Q1-2013Q4)	ERPT elasticity	0.38 (0.04)***+++	0.46 (0.06)***+++	0.36 (0.07)***+++
	US_D ERPT elas.	-0.01 (0.27)	-0.12 (0.16)	0.20 (0.20)
	adj. R2	0.998	0.998	0.997
	DW	2.01	1.94	2.02
	NOB	1319	1053	1509
First ten years (1988Q1-1997Q4)	ERPT elasticity	0.94 (0.09)***	1.33 (0.12)***+++	0.80 (0.07)***++
	US_D ERPT elas.	-0.49 (0.96)	-0.50 (0.29)*	0.07 (0.18)
	adj. R2	0.998	0.994	0.997
	DW	1.99	1.97	2.06
	NOB	312	249	629
Middle ten years (1996Q1-2005Q4)	ERPT elasticity	0.18 (0.05)***+++	0.52 (0.10)***+++	0.43 (0.08)***+++
	US_D ERPT elas.	-0.89 (0.42)**	-1.47 (0.23)***	0.10 (0.49)
	adj. R2	0.999	0.997	0.997
	DW	2.06	2.04	1.98
	NOB	521	393	533
Last ten years (2004Q1-2013Q4)	ERPT elasticity	0.21 (0.06)***+++	0.17 (0.06)***+++	0.19 (0.07)**+++
	US_D ERPT elas.	0.42 (0.19)**	0.31 (0.18)*	0.62 (0.16)***
	adj. R2	0.999	0.999	0.997
	DW	2.01	1.82	1.80
	NOB	722	611	563

Note: Panel regression results for the exchange rate effects on automobile export prices. Regressions are estimated for 20 destination countries for each engine type-size and port regression. Figures in parentheses are standard deviations. \*\*\*, \*\*, \* indicate that the ERPT coefficients are statistically greater than zero at the one, five, and ten percent significance levels, respectively. +++, ++, + indicate that ERPT coefficients are statistically less than one at the one, five, and ten percent significance levels, respectively.