An Examination of Exchange Rate Pass-Through to U.S. Motor Vehicle Products and Auto-Parts Import Prices

Kemal Turkcan*   Aysegul Ates†

*Department of Economics, Akdeniz University
†Department of Economics, Akdeniz University

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Abstract

A distinctive feature of present globalization is the development of international production sharing activities, i.e. production fragmentation. The recent developments in transportation and communication technologies led to a surge in intermediate goods trade. However, intermediate goods trade is often neglected in the empirical studies of the exchange rate pass-through (ERPT). Using import unit values of 79 motor vehicle products and 245 auto-part, which are classified by the 10-digit level of Harmonized Tariff Schedule (HTS), this study examines the pass-through of exchange rate changes from 5 major trading partners for the period of 1998.01 to 2006.12 by using panel data cointegration techniques. Secondly, this study aims to compare the ERPT for the motor vehicle products (final goods) to the ERPT for the auto-parts (intermediate goods) in the U.S. The results suggest that import prices do not respond proportionately to the exchange rates and the degree of estimated pass through into import prices differs for motor vehicle products and auto parts.

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Kemal TÜRKCAN* and Ayşegül ATEŞ**

ABSTRACT

A distinctive feature of present globalization is the development of international production sharing activities (i.e. production fragmentation). The recent developments in transportation and communication technologies led to a surge in intermediate goods trade. However, intermediate goods trade is often neglected in the empirical studies of the exchange rate pass-through (ERPT). Using import unit values of 79 motor vehicle products and 245 auto-part products, which are classified by the 10-digit level of Harmonized Tariff Schedule (HTS), this study examines the pass-through of exchange rate changes into the U.S. auto-industry import prices from 5 major trading partners for the period of 1998.01 to 2006.12. Nonstationary panel data estimation techniques and tests for cointegration are employed in this study. Secondly, this study aims to compare the ERPT for the motor vehicle products (final goods) to the ERPT for the auto-parts (intermediate goods) in the US. The results suggest that import prices do not respond proportionately to the exchange rates and the estimated pass-through elasticities for motor vehicle products are lower than that for auto-parts.

Key words: Exchange rate pass-through, U.S. auto-industry, Fragmentation

JEL classification: F40, L62, C33

* Kemal Türkcan, Akdeniz University, Department of Economics, Dumulupınar Bulvarı Kampüs, 07058, Antalya, Turkey; Tel: (242)-3106427; Fax: 242-2274454; Email: kturkcan@akdeniz.edu.tr.
** Ayşegül Ateş, Akdeniz University, Department of Economics, Dumulupınar Bulvarı Kampüs, 07058, Antalya, Turkey; Tel: (242)-3101860; Fax: 242-2274454; Email: aates@akdeniz.edu.tr.

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1. INTRODUCTION

One of the important issues in international economics is the relationship between exchange rates and traded good prices. Exchange rate pass-through (ERPT) is defined as the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing country.

ERPT studies abound the literature. To the best of our knowledge, with the exception of Athukorala and Menon (1994), Campa and Goldberg (1995), and Campa and Minquez (2002), intermediate goods trade is often neglected in both theoretical and empirical studies of the ERPT into import prices. However, trade of intermediate goods as well as final goods increased substantially in recent years due to increase in production sharing activities. As the world markets have become increasingly integrated in the last few decades due to developments in transportation and communication technologies, the degree of product fragmentation (i.e. production sharing) increased across countries.1 Increase in production sharing activities led to an increase in trade of final goods as well as intermediate goods required to produce them.2 Despite the increase in intermediate goods trade, empirical evidence on ERPT to intermediate goods import prices remains sparse. In this study we try to fill this gap by studying the sensitivity of import prices to exchange rate changes (i.e. ERPT) for intermediate as well as final goods in auto-

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1 Product fragmentation can be defined as division of production process into different locations across different countries.
2 A number of studies recorded the growing importance of trade in intermediate goods despite the fact that these studies all used different data sources and methods to measure the degree of fragmentation. See Feenstra (1998), Campa and Goldberg (1997), Hummels et al. (1998), Yeats (2001), Türkcan (2003), and Chen et al. (2005).
industry, where the importance of trade based on production sharing (i.e. fragmentation) is growing, thus both final and intermediate goods trade is increasing.

The US auto-industry is selected for several reasons: Firstly, the auto-industry is often regarded as one of the most fragmented industries. Due to the fragmentation, the import levels of auto-parts have continued to increase in the US in recent years. The nominal value of imported auto-parts more than doubled from $37 billion in 1995 to $77 billion in 2004 in the US (Klier and Rubenstein, 2006). Secondly, the US auto-industry trade has non-negligible share on the US trade deficit. The US automotive trade deficit has grown from less than $10 billion in 1979 to $150 billion in 2004 despite high level of inward investment by foreign manufacturers, and a decline in imports relative to vehicles built at transplant assembly facilities (Cooney and Yacobucci, 2005). Since auto-industry has a large share on the US trade deficit, its degree of ERPT would affect exchange rate based adjustments in US trade balance.

Most of the empirical ERPT studies on auto-industry have focused on pass-through to import prices of motor vehicle products (i.e. final goods) in the US (Feenstra, 1989; Goldberg, 1995; Gross and Schmitt, 2000; Banik and Biswas, 2007). In general, empirical studies for motor vehicle products have found incomplete degree of ERPT to import prices. The studies focused exclusively on the automobile industry (Feenstra et al., 1996; Gross and Schmitt, 2000; Gron and Swenson, 1996), have revealed that ERPT

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3 Expansion of production locations around the world for auto-industry is a good example of fragmentation. In auto-industry, global production networks involve intra industry trades in both at levels of final products and intermediate goods. Trade in parts and components can be used to measure the extent of production sharing. Diehl (2001) stated that during the period 1980-1995, world trade in automobile parts accounted for about one third of total world trade in automobile products.

4 The response of import prices to exchange rate changes has a large influence on trade balance dynamics depending on the degree of ERPT. If the degree of ERPT is low, the effect of depreciation on a trade balance may be limited. This is important on the debate concerning how adjustments of the current US trade deficit may be resolved.
differs depending on the source country, and the class of the product within the industry.\textsuperscript{5} The related literature on pricing to market (PTM) is primarily interested in investigating how export prices can differ across destination markets.\textsuperscript{6} PTM studies also found that PTM behavior varies across source countries and different product categories in automobiles have different degrees of PTM (Gagnon and Knetter, 1995; Gil-Pareja 2001, and 2003).

This paper extends the existing empirical research in the US auto-industry in two respects. First, this paper contributes the literature by studying the ERPT in the auto-parts as well as motor vehicle products. Previous studies have not look at ERPT in auto-parts industry to best of our knowledge. ERPT into US import prices of both auto-parts as well as motor vehicle products are analyzed by using an extensive data set of 79 motor vehicle products and 245 auto-part products, which are classified by the 10-digit level of HTS from 1998.01 to 2006.12. Second, ERPT for US auto-industry is analyzed by using nonstationary panel estimation techniques and tests for cointegration.\textsuperscript{7} We found that the US’s import pass-through in auto-industry is incomplete across both motor vehicle products and auto-parts. In addition, the results indicate that auto-part products have relatively higher pass-through rates than motor vehicle products.

The article is organized as follows. In Section 2, theoretical model is explained. The data set and econometric procedure are described in Section 3 and the empirical

\textsuperscript{5} For example Banik and Biswas (2007) found the ERPT value for the Japanese automobile manufacturers varied from 13% to 39% depending on automobile class size.

\textsuperscript{6} In the literature, the phenomenon of foreign firms stabilizing their import prices in the local currency is defined as pricing to market (PTM) by Krugman (1986).

\textsuperscript{7} Due to recent developments in time-series econometrics, several of the latest studies of ERPT explicitly recognize the fact that exchange rate and price series are often nonstationary and may be cointegrated (Athukorala and Menon, 1994; Feenstra et al. 1996; Gross and Schmitt 1996).
results are presented and discussed in Section 4 and Section 5 summarizes main findings of the study.

2. MODEL

This study follows Campa and Goldberg's (2002) approach, where a markup model is used to estimate pass-through effects. It is assumed that the representative firm sets its export to country \( j \) in its own currency \( (PX^j_t) \) as a markup \( (\pi_t^j) \) over its marginal cost of production \( (C^*_t) \):

\[
PX^j_t = \pi_t^j C^*_t
\]  

where the asterisk refers to the variable measured in foreign currency. To obtain the import price in the importing currency \( (PM^i_t) \), equation (1) is multiplied by the local currency price of foreign exchange, \( E^i_t \) (defined in terms of domestic currency per units of foreign currency). Hence, domestic currency import price is given by:

\[
PM^i_t = (PX^j_t)E^i_t = (\pi_t^j)E^i_t C^*_t
\]  

Markup rates \( (\pi_t^j) \) vary if the ERPT is less than complete. Markup rates depend on competitive pressure in the importing country, demand pressure for exporting country and the exchange rate. The price of import-competing products provides a measure of competitive pressure. The demand pressure, on the other hand, would be captured by the exporting country's industrial production index. The exchange rate can be an important
cost factor in the representative foreign firm's cost function if this representative firm heavily relies on the imported intermediate goods. The profit markup is thus modeled as:

\[ \pi_i^* = \left( \frac{P_i^j}{E_i^j C_i^*} \right)^{\alpha} (Y_i^*)^\beta \] (3)

where \( Y_i^* \) is demand pressure and \( P_i^j \) is competitive pressure. Substituting equation (3) into equation (2), we obtain:

\[ PM_i^j = \left( E_i^j C_i^* \right)^{1-\alpha} \left( P_i^j \right)^\beta (Y_i^*)^\beta \] (4)

After taking the logarithms of the variables we have:

\[ pm_i = (1-\alpha)e_i + (1-\alpha)c_i^* + \alpha p_i + \beta y_i^* \] (5)

where lowercase letters denote the logarithmic values of the variables.

In equation (5), the ERPT is defined as the elasticity of foreign currency with respect to the exchange rate (i.e., \( 1-\alpha \)). The import price is thus specified as a function of exchange rate \( e_i \), foreign exporter's marginal cost \( c_i^* \), competitive pressure \( p_i \), and the demand pressure \( y_i^* \). This model permits ERPT to depend on the structure of competition in the industry. Pass-through is said to be complete when \( \alpha = 0 \), whereas it is incomplete

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8 From now, we drop the country index \( j \) for simplicity reason.
when $\alpha$ is between 0 and 1. In sum, the model sets that the elasticity of the ERPT is positive and less than one. Moreover, the coefficients for the exporter's cost, the competitive pressure, and the demand pressure variables are expected to be positive.

One weakness of equation (5) is that the pass-through of exchange rate and foreign cost into import prices are the same. This restriction does not necessarily hold in practice.\(^9\) Therefore, in estimation, these restrictions are relaxed and following equation is considered:

$$pm_i = \alpha + \beta_1 e_i + \beta_2 c_i^* + \beta_3 p_i + \beta_4 y_i^* + \epsilon_i$$

This equation is considered for three groupings; motor vehicle products (final goods), auto-parts (intermediate goods), and auto-industry (total).

3. DATA AND ECONOMETRIC PROCEDURE

3.1. Data Sources and Proxy Description

This study examines ERPT into the US motor vehicle products and auto-part import prices from 5 major trading countries for the period 1998.01 to 2006.12. The key dependent variable used in this paper is monthly import unit values of automotive products in current US dollars between the US and its 5 trading partners. In this study import prices are approximated by import unit values. Bilateral trade flows used in this paper are obtained from the US International Trade Commission’s (USITC) web site: http://www.usitc.gov. The USITC database provides detailed monthly bilateral trade data for product imports in values and quantities (in thousands of $ US at currency prices) at

\(^9\) Athukorola and Menon (1994) argued that due to the incompatibility of price proxies the coefficient restrictions may not hold.
the 10-digit level of the HTS. These data are used to construct import unit value indexes for each trading partner. For this study, the top 5 trading partners are chosen.\textsuperscript{10} The purpose of this choice is to minimize the number of missing observations considering the fact that the construction of the import unit values at the ten-digit level of HTS requires not only import values but also quantity information. In this study, 79 items are selected as motor vehicle products and 245 items are considered as auto-parts from the ten-digit product level of HTS.\textsuperscript{11} For this study, import unit values are calculated for three categories (total auto-industry imports, motor vehicle products imports and auto-parts imports) and for five countries. Once, the motor vehicle products and auto-parts are selected for our study, the unit value for each product is constructed as the value of imports of the product divided by the quantity imported. To obtain the unit values at the country level, the calculated unit values are weighted by their value share in each country’s auto-industry product export to the US. These weighted unit values are then summed to yield monthly unit values for each country. Then, the process is repeated for other categories.

The data on bilateral exchange rates are obtained from the International Financial Statistics (IFS) CD-ROM. The prices for the US substitute goods, $p_t$, and the foreign exporter's marginal cost, $c^*_t$, are proxied by the producer price indexes (PPI) and obtained from the International Financial Statistics (IFS) CD-ROM. As the proxy for demand

\textsuperscript{10}The countries included in this study are Canada, Germany, Japan, Korea, and Mexico. These countries account for roughly 90\% of the US automotive imports in 2005. US auto-parts imports from China has grown significantly in recent years (5\% of US auto-parts imports came from China in 2004), however its motor vehicle exports to US is negligible. Therefore, China is excluded from the analysis.

\textsuperscript{11} To select the automotive final products and automotive parts from the trade data, we employ the list provided by the Office of Aerospace and Automotive Industries’ Automotive Team, part of the U.S Department of Commerce’s International Trade Administration. That team’s definition of automotive final goods and parts can be found at http://www.ita.doc.gov/td/auto.html.
pressure, $y^*_t$, the foreign industrial production index (IPI) is used. IPI data are also from the IFS CD-ROM.

### 3.2. Panel Unit Root Tests

As a pre-test for cointegration analysis, first panel nonstationarity of the variables is investigated. Four types of panel unit root tests, Levin, Lin, and Chu (2002) (LLC), Im, Peseran, and Shin (2003) (IPS), Breitung (2000) and Hadri (2000) unit root tests, are employed in this paper.

With the exception of IPS test, all of the aforementioned tests assume there is a common unit root process across the relevant cross sections.\(^{12}\) LLC and Breitung tests assume that the variable $y$ is determined by following stochastic process:

$$y_{i,t} = \rho_i y_{i,t-1} + \gamma_i z_{i,t} + \xi_{i,t} \quad i = 1,\ldots,N \quad \text{and} \quad t = 1,\ldots,T$$

(7)

where $\rho_i$ is an autoregressive (AR) coefficient, $z_{i,t}$ is the deterministic component and $\xi_{i,t}$ is the error term. The deterministic component, $z_{i,t}$, could be zero, one, units and/or time effects. It is assumed that each AR coefficient is the same for all units, $\rho_i = \rho$, that the error term $\xi_{i,t}$ is stationary process. By contrast, the less restrictive IPS test allows for individual unit root process; i.e. $\rho_i$ may vary across cross-sections.\(^{13}\) LLC, Breitung and IPS tests have null hypothesis of unit root (i.e. $H_0$: nonstationary) against alternative hypothesis that all individual series in the panel data are stationary.

\(^{12}\) In the literature, this is referred to as pooling the residuals along the within-dimension.

\(^{13}\) In the literature, this is referred to as pooling the residuals along the between-dimension.
Hadri (2000) proposes a Lagrange multiplier test (LM) based on residuals. Similar to the Kwiatkowski et al. (1992) unit root test the Hadri test assumes that each time series is stationary around a deterministic level or around a unit specific deterministic trend against the alternative hypothesis of a unit root in panel data (i.e. H₁: nonstationary).

Table 1 reports panel unit root tests on the relevant variables. As can be seen, with very few exceptions all unit root test results suggest that series in question are not stationary and OLS estimation will result in biased and inconsistent estimates. After first differencing, all series become stationary.

3.3. Testing for Panel Cointegration

Having confirmed that variables are nonstationary and exhibit unit roots, next step is to determine whether variables are cointegrated. In order to test cointegration relationship, the methodology proposed by Pedroni (1999) is employed.

Pedroni (1999) has developed seven tests based on the residuals from the cointegrating panel regression under the null hypothesis of nonstationarity.

The method utilizes the residuals from the panel cointegration regression given by:

\[
y_{i,t} = \alpha_i + \delta_i t + \gamma_{it} + X'_{it} \beta_t + e_{it} \quad i = 1, \ldots, N \quad t = 1, \ldots, T
\]

\[
\hat{e}_{it} = \rho \hat{e}_{i,t-1} + \xi_{it}
\]

First four tests are based on pooling along the within-dimension and the remaining three are based on pooling along the between-dimensions. Within-dimension
Based statistics are known as panel cointegration statistics, which are a variance ratio test (v-statistic), a panel version of Phillips-Perron (1988) (PP) \( \rho \)-statistic and t-statistic, and ADF t-statistic. The null hypothesis is \( \rho_j = 1 \) against \( \rho_j = \rho < 1 \). Between-dimension based statistics are known as group-mean panel cointegration statistics. Group panel statistics are Phillips-Perron (1988) (PP) \( \rho \)-statistic and t-statistic and ADF t-statistic. The null hypothesis is \( \rho_j = 1 \) against \( \rho_j < 1 \).

As shown in Table 2, out of all different tests only one, the panel v statistics, cannot reject the null of no cointegration. Theory also supports cointegration among considered variables. Thus, it can be concluded that there is a cointegrating relationship among variables.

3.4. ERPT Estimations by DOLS

The presence of cointegration and unit roots considerably affects the asymptotic distributions in time series as well as in panel analysis. However, cointegration equations have attractive properties: as the number of observations increase in T and N, the OLS estimation of the cointegrated variables converges in the long-run equilibrium to the true value. However, for moderate sample size, the estimation bias may remain substantial. Kao and Chiang (2000) suggest that dynamic (D) OLS estimator performs better in estimating the panel equations than does the OLS estimator with bias correction or the FM-OLS estimator. As a result, they suggest using the DOLS estimator when dealing with cointegration. Therefore, DOLS estimation procedure is employed in this paper. The DOLS regression adds to the leads and lags of the differences of the independent variables. The equation estimated by DOLS is:
\[ pm_i = \alpha + \beta x_i + \sum_{k=\eta_i}^{\eta_i} \gamma_k \Delta x_{i+k} + v_i \]  
(10)

where \( pm_i \) is the import price, \( x_i = [e, c_i', p, y_i'] \), and \( \beta = [\beta_1, \beta_2, \beta_3, \beta_4] \).

4. EMPIRICAL RESULTS

The DOLS results for each of the product groupings (total auto-industry imports, motor vehicle products imports, and auto-part imports) are reported in Table 3, respectively. For the goal of the study, we will focus only on the pass-through elasticities for motor vehicle products and auto-parts.\(^{14}\) Beginning with the final goods (motor vehicle products), the pass-through elasticity of the DOLS regression is positive and statistically significant, consistent with the model specified in the study. The estimated magnitude of the pass-through elasticity in motor vehicle products, consistent with earlier studies, is also found to be incomplete (Feenstra, 1989; Feenstra et al., 1996; Gross and Schmitt, 2000; Gil-Pareja, 2001 and 2003; and Banik and Biswas, 2007).\(^{15}\) The incomplete ERPT values might be a result of price interdependence among the rival firms since the US automobile market structure is oligopolistic in nature. As suggested by Gross and Schmitt (2000), the low degree of ERPT for motor vehicle products indicates that foreign exporters face a relatively elastic demand schedule in the US auto-industry. Besides if a foreign firm exports goods in an industry in which domestic firms have considerable market power, the foreign firm may be more reluctant to increase prices when domestic currency depreciates. As a result, foreign firm adjusts its mark-up downward to maintain market

\(^{14}\) The estimated coefficients for other explanatory variables are generally positive and in line with the theory described in the previous sections.

\(^{15}\) Banik and Biswas (2007) examined the ERPT in US automobile market and found incomplete pass-through changing from 13 % to 77 % depending on product class and the source country for the period 1991.07 to 1999.12.
In addition, the large size of US market also induces firms to price to market (Gil-Pareja, 2001; Campa and Goldberg, 2002).

Our results show however, that the degree of pass-through is relatively low compared to earlier findings. However more recent studies such as Hellerstein et al. (2006) and Marazzi and Sheets (2006) found that ERPT in automobile industry declined in 1990s. Our finding of low ERPT (25%) in motor vehicle products is consistent with their results. This lower ERPT in motor vehicle products than earlier studies might be attributed to competitive pressures within the US market and ongoing structural changes in international patterns of production due technological advances, reduced transportation costs, and declining trade barriers. As a result of rising offshoring and other vertically fragmented global production processes in auto-industry, US imports of motor vehicle products are very likely to have a higher share of US made and dollar denominated inputs. This could also translate to lower ERPT. In addition, increased cross-border production, which implies exporters’ cost may be incurred in several currencies, may be another reason for low pass-through rate (Gron and Swenson, 2000, Bodnar, Dumas and Marston, 2002). Olivei (2002) hypothesized that the observed low pass-through rates may reflect an increasing share of intra-firm transfer prices in import prices indexes and argued that in certain industries, such as automotive and computer etc., an increase in the

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16 Hellerstein et al. (2006) provides empirical evidence that industries with low foreign market power relative to domestic market power such as road vehicles exhibit low pass-through rates.

17 Hellerstein et al. (2006) showed that the transmission of exchange rates to road vehicle import prices declined from 48% in 1985-1994 period to 14% in 1995-2005 period in US. Marazzi and Sheets (2006) also found a decline in pass-through rates in motor vehicle import prices after 90s. Their rolling regression results indicate that pass-through went down from 50% in 1995 to 10% in 2004.

18 For example, Chen et al. (2005) reported that US content of US imports from Canada and Mexico’s motor vehicle industry increased over time from one sixth of total US imports from these two countries in 1990 to more than one-quarter of total US imports from these countries in 2000.

19 Athukorala and Menon (1994) suggest that pass-through is lower when the impact of exchange rate changes on imported intermediate goods costs is considered in empirical analysis.
share of imports based on intra-firm trade would translate into a decline in the ERPT due to transfer pricing between multinational corporations’ headquarters and its affiliates in foreign countries.\textsuperscript{20} In other words, decline in pass-through in motor vehicle industry may also be due to an increased prevalence of intra-firm transfer pricing practice.\textsuperscript{21}

Turning now to intermediate goods, the coefficient estimate is 0.48 and statistically significant. This result also confirms the general claim of incomplete pass-through in the ERPT literature. The incomplete pass-through into auto-part import prices might be due to high substitutability of auto-part products in general. When products are highly substitutable, a price increase is likely to induce consumers to switch to the alternate. Thus, the foreign firm will be more likely to keep its price in line with the domestic price and absorb exchange rate shock rather than reflect them on to the prices.\textsuperscript{22}

Also it is worth noting that the pass-through rate to imported intermediate goods prices is higher than to final goods prices.\textsuperscript{23} The increase in foreign transplant company shares in US and their preference to obtain intermediate goods from their source country may explain relatively higher pass-through rates into auto-part import prices. US domestic vehicle manufacturers continued to lose market share to U.S.-affiliates of

\textsuperscript{20} Aksoy and Riyanto (2000) show that ERPT is lower when the industry is vertically integrated.

\textsuperscript{21} As Menon (1993) suggested pass-through relates to the important role played by MNCs in international trade. MNCs might have more leverage than independent firms in responding exchange rate movements due to their world-wide networks. MNCs can shield themselves against unfavorable exchange rate shocks by employing different strategies. These are the use of intra-corporate exchange rates, the ability of manipulate the prices charged on intra-firm transfers, the timing of payments on those transfers and the decision to invoice contracts in selected currencies in order to minimize the effect of exchange rate changes.

\textsuperscript{22} Substitutability is increased in auto-part sector due to sectoral shifts. For example, Detroit 3 started to purchase more foreign based supplier component. (US Auto-parts Industry Annual Assessment, 2006)

\textsuperscript{23} Campa and Minez (2002) estimated the pass-through elasticities to Consumer Price Index (CPI) and the costs of intermediate goods consumption for 12 European Union countries’ (EU) trade with 12 non-EU countries. Their empirical results indicate that calculated pass-through elasticities for final goods consumption are significantly lower than that for intermediate goods consumption.
foreign-based manufacturers (transplant) in the last two decades.\textsuperscript{24} As pointed out by Klier and Rubenstein (2006), these transplants have established a strong relationships with homemarket (foreign) suppliers.\textsuperscript{25} As a result of these well established relationships, foreign auto-parts producers would not need to adjust their price in the US auto-parts industry to protect their market shares. In other words, the PTM incentives for foreign auto-parts producers are much more willing to undertake price adjustments not to lose their market shares.

5. CONCLUDING REMARKS

This study has focused on the pass-through of exchange rate changes into both motor vehicle products and auto-part import prices in the US. Following Campa and Goldberg (2002), pass-through rates are estimated using monthly data from 1998.01 to 2005.12. Using the DOLS method, our econometric results lead to following conclusions. First, empirically, the US’s import pass-through in auto-industry is incomplete across both motor vehicle products and auto-parts. The low pass-through values require large devaluation of the dollar to narrow the US auto trade deficit. This result is important since auto-industry has significant share in US imports. The second importing finding of this paper is that auto-parts (intermediate goods) have relatively higher pass-through rates than motor vehicle products (final goods). This finding could be due to the transfer pricing between foreign auto firms and their affiliates in the US. Intrafirm prices may be less sensitive to exchange rate movements than non-intrafirm prices.\textsuperscript{26} Further research is

\textsuperscript{24} Foreign transplants have increased their share of North American motor vehicle production from virtually nothing to more than a quarter of the total in 25 years. (Cooney and Yacobucci, 2005 p.25)

\textsuperscript{25} For example, the results in Blonigen (2001) show a strong positive relationship between Japanese automobile production in the US and imported Japanese automobile parts.

\textsuperscript{26} Rangan and Lawrence (1999) argue that intrafirm trade may respond differently to exchange rate changes than does trade between firms.
needed to assess the effect of transfer pricing on the degree of ERPT. To understand underlying dynamics, integrated production activities should also be examined more closely.
### TABLE 1: Panel Unit Root Tests

<table>
<thead>
<tr>
<th>Variable (level)</th>
<th>LLC</th>
<th>IPS</th>
<th>Breitung</th>
<th>Hadri</th>
</tr>
</thead>
<tbody>
<tr>
<td>( pmt_t ) (Total)</td>
<td>-4.039* (0.000)</td>
<td>-2.832 (0.002)</td>
<td>1.002 (0.842)</td>
<td>4.089* (0.000)</td>
</tr>
<tr>
<td>( pmt_t ) (Motor Vehicles)</td>
<td>-0.199 (0.421)</td>
<td>0.404 (0.657)</td>
<td>1.224 (0.889)</td>
<td>5.239* (0.000)</td>
</tr>
<tr>
<td>( pmt_t ) (Auto-parts)</td>
<td>-1.603*** (0.055)</td>
<td>-3.188* (0.001)</td>
<td>1.366 (0.914)</td>
<td>4.543* (0.000)</td>
</tr>
<tr>
<td>( e_t )</td>
<td>-0.671 (0.251)</td>
<td>-0.114 (0.455)</td>
<td>-1.181 (0.119)</td>
<td>6.992* (0.000)</td>
</tr>
<tr>
<td>( c_t )</td>
<td>0.554 (0.710)</td>
<td>1.193 (0.884)</td>
<td>2.772 (0.997)</td>
<td>7.883* (0.000)</td>
</tr>
<tr>
<td>( y_t )</td>
<td>7.135 (1.000)</td>
<td>-0.654 (0.257)</td>
<td>0.759 (0.776)</td>
<td>5.553* (0.000)</td>
</tr>
<tr>
<td>( p_t ) †</td>
<td>0.858 (0.675)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable (difference)</th>
<th>LLC</th>
<th>IPS</th>
<th>Breitung</th>
<th>Hadri</th>
</tr>
</thead>
<tbody>
<tr>
<td>( pmt_t ) (Total)</td>
<td>-24.720* (0.000)</td>
<td>-25.387* (0.000)</td>
<td>-6.975* (0.000)</td>
<td>5.386* (0.000)</td>
</tr>
<tr>
<td>( pmt_t ) (Motor Vehicles)</td>
<td>-21.863 (0.000)</td>
<td>-24.048 (0.000)</td>
<td>-11.502* (0.000)</td>
<td>5.462* (0.000)</td>
</tr>
<tr>
<td>( pmt_t ) (Auto-parts)</td>
<td>-25.011* (0.000)</td>
<td>-27.071* (0.000)</td>
<td>-9.379* (0.000)</td>
<td>0.327 (0.372)</td>
</tr>
<tr>
<td>( e_t )</td>
<td>-26.382 (0.000)</td>
<td>-22.683 (0.000)</td>
<td>-13.561* (0.000)</td>
<td>0.831 (0.203)</td>
</tr>
<tr>
<td>( c_t )</td>
<td>-20.454* (0.000)</td>
<td>-16.179* (0.000)</td>
<td>-7.231* (0.000)</td>
<td>0.893 (0.186)</td>
</tr>
<tr>
<td>( y_t )</td>
<td>-140.866 (1.000)</td>
<td>-1.106 (0.134)</td>
<td>-0.147 (0.4416)</td>
<td>-0.114 (0.545)</td>
</tr>
<tr>
<td>( p_t ) †</td>
<td>-4.258 (0.003)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Notes:** LLC, IPS and Breitung use the null hypothesis of unit root while the Hadri test uses null of no unit root. The choice of lag length is based on the modified SIC. The choice of lag length is based on the modified SIC. The p-values are given in parentheses. *, **, *** indicate statistical significance at 1, 5, and 10 % levels respectively. † \( p \) variable does not vary across each unit thus ADF unit root test is applied.

### TABLE 2: Pedroni Cointegration Test Results

<table>
<thead>
<tr>
<th>Constant</th>
<th>Total auto-industry imports</th>
<th>Motor vehicle products imports</th>
<th>Auto-part products imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel v-stat</td>
<td>1.565 (0.117)</td>
<td>0.788 (0.755)</td>
<td>0.881 (0.271)</td>
</tr>
<tr>
<td>Panel ρ-stat</td>
<td>-9.105* (0.000)</td>
<td>-4.644* (0.000)</td>
<td>-13.710* (0.000)</td>
</tr>
<tr>
<td>Panel pp t-stat</td>
<td>-8.143* (0.000)</td>
<td>-4.932* (0.000)</td>
<td>-11.808* (0.000)</td>
</tr>
<tr>
<td>Panel adf t-stat</td>
<td>-7.274* (0.000)</td>
<td>-2.739* (0.001)</td>
<td>-11.356* (0.000)</td>
</tr>
<tr>
<td>Group ρ-stat</td>
<td>-9.538* (0.000)</td>
<td>-6.624* (0.000)</td>
<td>-11.990* (0.000)</td>
</tr>
<tr>
<td>Group pp t-stat</td>
<td>-9.246* (0.000)</td>
<td>-7.176* (0.000)</td>
<td>-10.797* (0.000)</td>
</tr>
<tr>
<td>Group adf t-stat</td>
<td>-7.598* (0.000)</td>
<td>-4.734* (0.000)</td>
<td>-8.869* (0.000)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constant with trend</th>
<th>Total auto-industry imports</th>
<th>Motor vehicle products imports</th>
<th>Auto-part products imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel v-stat</td>
<td>1.746*** (0.087)</td>
<td>2.126* (0.042)</td>
<td>-0.191 (0.392)</td>
</tr>
<tr>
<td>Panel ρ-stat</td>
<td>-10.655* (0.000)</td>
<td>-9.433* (0.000)</td>
<td>-13.284* (0.000)</td>
</tr>
<tr>
<td>Panel pp t-stat</td>
<td>-9.847* (0.000)</td>
<td>-9.007* (0.000)</td>
<td>-12.967* (0.000)</td>
</tr>
<tr>
<td>Panel adf t-stat</td>
<td>-9.451* (0.000)</td>
<td>-6.719* (0.000)</td>
<td>-12.602* (0.000)</td>
</tr>
<tr>
<td>Group ρ-stat</td>
<td>-10.382* (0.000)</td>
<td>-9.031* (0.000)</td>
<td>-11.064* (0.000)</td>
</tr>
<tr>
<td>Group pp t-stat</td>
<td>-10.784* (0.000)</td>
<td>-9.252* (0.000)</td>
<td>-11.030* (0.000)</td>
</tr>
<tr>
<td>Group adf t-stat</td>
<td>-10.410* (0.000)</td>
<td>-7.968* (0.000)</td>
<td>-9.069* (0.000)</td>
</tr>
</tbody>
</table>

**Notes:** The null hypothesis is no cointegration. The p-values are given in parentheses. *, **, *** indicate statistical significance at 1, 5, and 10 % levels respectively.

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<table>
<thead>
<tr>
<th>DOLS</th>
<th>Total auto-industry imports</th>
<th>Motor vehicle products imports</th>
<th>Auto-part products imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_t$</td>
<td>0.236*</td>
<td>0.251*</td>
<td>0.475*</td>
</tr>
<tr>
<td></td>
<td>(3.52)</td>
<td>(4.55)</td>
<td>(2.14)</td>
</tr>
<tr>
<td>$c_t^*$</td>
<td>0.281*</td>
<td>0.396*</td>
<td>0.553***</td>
</tr>
<tr>
<td></td>
<td>(2.84)</td>
<td>(4.84)</td>
<td>(1.68)</td>
</tr>
<tr>
<td>$p_t$</td>
<td>-0.322*</td>
<td>0.027</td>
<td>2.581*</td>
</tr>
<tr>
<td></td>
<td>(-2.95)</td>
<td>(0.30)</td>
<td>(7.12)</td>
</tr>
<tr>
<td>$y_t^*$</td>
<td>0.715*</td>
<td>0.398*</td>
<td>-1.631*</td>
</tr>
<tr>
<td></td>
<td>(11.35)</td>
<td>(7.66)</td>
<td>(-7.81)</td>
</tr>
<tr>
<td>Constant</td>
<td>7.081*</td>
<td>6.770*</td>
<td>0.199</td>
</tr>
<tr>
<td></td>
<td>(17.42)</td>
<td>(20.18)</td>
<td>(0.15)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.337</td>
<td>0.415</td>
<td>0.263</td>
</tr>
<tr>
<td>F Test</td>
<td>21.53*</td>
<td>30.14*</td>
<td>15.16*</td>
</tr>
<tr>
<td>Chow Test</td>
<td>380.50*</td>
<td>195.86*</td>
<td>139.65*</td>
</tr>
<tr>
<td>Sample Size</td>
<td>525</td>
<td>525</td>
<td>525</td>
</tr>
</tbody>
</table>

**Notes:** t-values, given in parentheses, are based on White’s method.
* , ** , *** indicate statistical significance at 1%, 5 %, and 10 % levels respectively.
Assumptions for DOLS: 1 lag and 1 lead. The coefficients for lag and lead are not reported.
References


www.ncseonline.org/NLE/CRSreports/05apr/RL32883.pdf.


