Asymmetric Price Differential between Medium and Small Class Cars across Countries: A Case Study - Korea and the U.S.

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This paper examines how a Korean automobile firm price-discriminates between the Korean and the U.S. markets. We argue that a Korean automobile firm's pricing behavior depends on the differences in price elasticity over the segmented markets between the countries. Our findings are that differences in price elasticity may help explain why a medium-class car's price is higher in Korea than that in the U.S. while a small-sized car's price is higher in the U.S. than in Korea, which implies that a Korean automobile firm 3rd degree price-discriminates on the same or similar products between Korea and the U.S. This type of 3rd degree price discrimination differs from a typical home-bias effect (charging higher prices to domestic consumers) because a small-sized car which is produced domestically sells at higher price abroad. This finding can be added as a source that violates the law of one price.

Keywords: International price discrimination, Law of one price, Pricing to market, Automobile industry
JEL Classification: D12, D22, F14, L11, L13, L62

I. Introduction

The Press and media often criticize that Hyundai Motors, the firm with approximately 50 percent of the market share in the Korean automobile industry, charges domestic consumers much higher prices with its monopoly power than American consumers.[1,2] However, it is not evident because among the cars

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[1] Source for the market share: Korea Automobile Manufacturers Association (2005, 2011).

[2] There have been many articles on this issue in press and media. An article written in English

domestically manufactured by Hyundai Motors, a small-sized car is more expensive in the U.S although a medium-class car sells at higher price in Korea.

For example, Hyundai Motors sold both *Sonata LX 3.3 DOHC* (a medium-class) and *Accent GLS 4 door I4* (a small-sized) in the U.S. and Korea in 2005.[3] Here, the year 2005 is the critical threshold because of the fact that *Sonata LX 3.3 DOCH*, *Accent GLS 4 door I4*, and some other models had almost the same specifications, especially including engine size, in both countries until 2005.[4] In addition, Hyundai Motors began to produce Sonata in the U.S. from 2005, which implies that Sonata sold in Korea and the U.S. cannot easily be compared in that the same model is manufactured and sells in Korea and the U.S., respectively.[5] The pre-tax price of the *Sonata* was approximately $20,400 in the U.S. while it was about $27,600 in Korea. The differential was over $7,000. However, the price of *Accent* was $11,044 in the U.S. but it was about $8,680 in Korea. The differential was roughly $3,000.[6] When another small-sized car, *Elantra GT 4 door*, is compared, there is no much difference in the prices between the countries: the price of *Elantra* was $15,655 in Korea and $15,394 in the U.S. Hyundai Motors charged a higher price on a medium-class car in Korea than in the U.S. but a lower or the same price on small-sized cars in Korea. When *XG 350 4 door V6*, another medium-sized car, produced and sold by Hyundai Motors in both countries, is introduced, the above price inequality of medium-sized car does not change.

The above observations are summarized as the inequalities that $P_{medium}^{Korea} > P_{small}^{US}$ and $P_{small}^{Korea} \leq P_{small}^{US}$ or $P_{medium}^{Korea} / P_{medium}^{US} > 1$ and $P_{small}^{Korea} / P_{small}^{US} \leq 1$.[7]

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is shown at http://english.chosun.com/site/data/html_dir/2007/12/05/2007120561015.html : "In January, lawyer Choi Gyu-ho filed a complaint with the Fair Trade Commission accusing Hyundai Motor and Kia Motors of abusing their near-monopoly power in pricing their cars."

[3] Sources for the prices: Car Life (2005) for Korea and the U.S. Automotive News (2005) for the U.S. The U.S. prices include transportation costs and import taxes but do not include sales tax but Korean prices include sales tax (value-added). Hence pre-tax prices of the cars sold in Korea are compared to the prices in the U.S.

[4] Difference in options between Korea and the U.S. is also critical issue that causes difference in the prices of cars between the countries. For this, the authors selected the car models with almost the same options in each country in this section.

[5] Hyundai started producing Sonata at Hyundai Motor Manufacturing Alabama LLC in Alabama (a State in the U.S.) from May 2005.

[6] Exchange rate: $1 = 1044 Korean Won, October 15, 2005 (Bank of Korea Economic Statistics System, http://ecos.bok.or.kr/)

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These observations can also be summarized as:

$$P^{Korea}_{medium} \Big/ P^{US}_{medium} \quad \geq \quad P^{Korea}_{small} \Big/ P^{US}_{small} \tag{1}$$

These inequalities indicate that the price of a medium-class car is higher in Korea but the price of a small-sized car is higher in the U.S. or relative price of medium-class car is higher than that of small-sized car between Korea and the U.S. We define (1) as "*Asymmetric Price Differential*" between the countries (*APD*, hereafter). We also define the behavior of *APD* by a multinational automobile firm as "Asymmetric Pricing", meaning that a multinational firm charges a higher price on a product of one type (e.g. small-sized cars) in one country than that in the other country but vice versa on a product of the other type.

Price differences for the same or similar goods across countries are not an uncommon phenomenon and international price differences for several traded goods have been extensively studied in economic literature. (e.g. Aw 1993, Gil-Pareja 2002, Haskel and Wolf 2001, Verboven 1996). Most studies have explained international price differences in terms of pricing-to-market (PTM), law of one price (LOOP) or industry-specific restrictions (import quota and tariff) in several countries (e.g. Goldberg [1995], Knetter [1993], Goldberg and Verboven [2001]), but none of these works explains *APD* because these studies focus on a single product or a bundle of similar products. The case of *APD* seems similar to the home-bias effect in the European car markets (Vervoven 1996), which indicates that domestic consumers are less sensitive to changes in domestic products' prices so that domestic firms can make higher markups in their home countries. However, *APD* is different from the home-bias effect because Hyundai Motors produced both small-sized and medium-class cars domestically but charged lower prices to domestic consumers on small-sized cars while higher prices abroad on medium-class cars.

In this paper, we explore possible sources of *APD* such as production costs, opportunity costs, market powers, and demand elasticities. Especially to calculate the elasticities, we adopt a random-coefficients logit model as in Berry (1994), Berry, Levinsohn and Pakes (1995), and Nevo (2000). For each country, we

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[7] P^{Korea}_{medium} represents price of medium-class cars sold in Korea. P stands for price, the subscript for a car size and the superscript for a country.

estimate demand parameters and use them to calculate their own price elasticities of demands for the products in the segments of interest.

All other sources except differences in relative elasticity do not show the corresponding pattern of *APD*. Relative elasticity for a medium-class car is lower than that for a small-sized car between Korea and the U.S., which is described as $\varepsilon_{medium}^{Korea}/\varepsilon_{medium}^{US} \leq \varepsilon_{small}^{Korea}/\varepsilon_{small}^{US}$.

This finding is consistent with *APD* in that Hyundai Motors charges higher (lower) prices on the domestic consumers than Americans when it sold medium-class (small-sized) cars because Korean consumers are less (more) elastic to medium-class (small-sized) cars than the U.S. consumers. This asymmetric pricing scheme can be considered as a 3rd degree price discrimination that takes advantage of relative elasticity differences across different markets. Hence a Korean automobile firm not only 2nd degree price-discriminates across consumers by product differentiation within one country but also 3rd degree price-discriminates, using relative elasticity differences, on the same or similar products between the Korean and American markets.[8,9] More importantly, the phenomenon of *APD* can be seen as a source to explain why sometimes differences in the prices of the same or similar goods across countries cannot fully reflect transportation cost, import tax, or level of competition, i.e., why LOOP is violated.

The rest of the paper is organized as follows. Section 2 provides a brief description of the Korean and the U.S. automobile industries and identification strategy to compare two different markets. Section 3 delineates the sources of *APD* and shows the findings why other sources except the relative elasticity differences do not explain *APD*. Sections 4 and 5 outline the economic model and econometric specification, Sections 6 and 7 report data description and empirical results, and Section 8 concludes this paper.

## II. A First Look at the Car Markets in Korea and the U.S.

It is obvious that the Korean and the U.S. automobile markets are different. Each country's consumers have different choice of alternatives, different consumer preferences, dissimilar market structures and so on. Table 1 provides

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[8] See Figure 1.

[9] The assumption of the 2nd degree price discrimination in the automobile industry is a common assumption in the literature (see, for example, Berry, Levinson and Pakes 1995).

a brief summary of the Korean and the U.S. markets in the early 21st century. The number of vehicles sold in the U.S. was sixteen times as many as that in Korea. The number of alternatives available to American consumers was significantly higher than the number to Koreans (102 vs. 255). The Korean market was more monopolistic, being dominated by domestic firms (see *CR* ratios, *HHI* and the domestic market share in Table 1). Tax rates are also different between the countries. The value added tax is included in the car prices in Korea while sales taxes are not included in the MSRP (Manufacturer's Suggested Retail Price) in the U.S., and these taxes vary across regions.[10] Since these two markets are very different, it is not easy to compare the two markets in order to draw general findings like a study of European car markets (Verbovan

Figure 1. A Korean automobile firm's price discriminating behavior between Korea and the U.S.
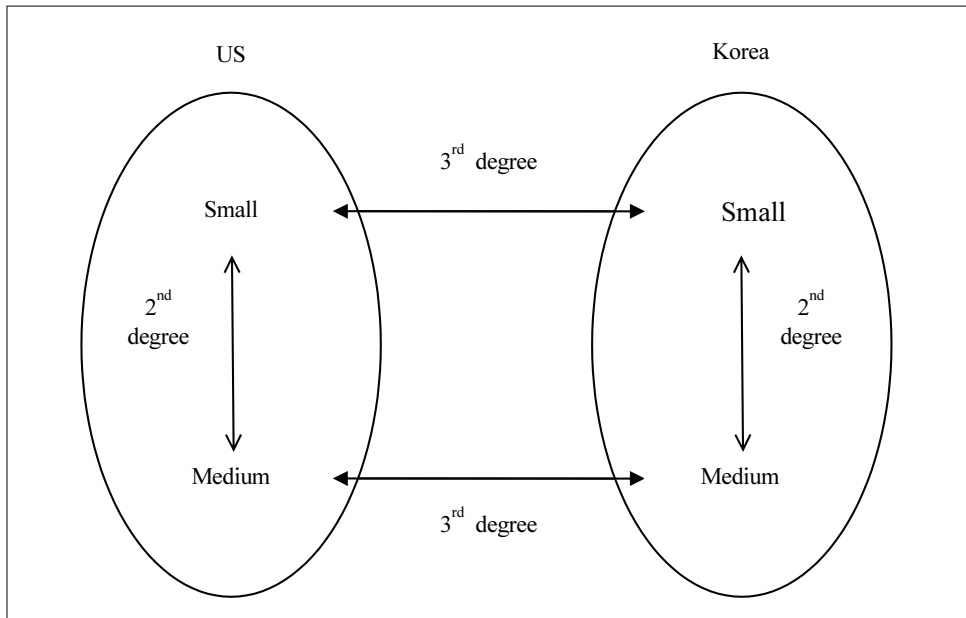
Note:
- The 2nd price discrimination by product differentiation through product differentiation in each country is a common assumption in the literature (e.g., Berry, Levinson and Pakes 1995).
- The 3rd price discrimination based on different (relative) elasticities of demand between Korea and the U.S. is the argument tested in this paper.

[10] http://www.taxadmin.org/fta/rate/tax_stru.html, Federation of Tax Administrators (August 2, 2011).

1996). Therefore, we focus on the models that were produced only in Korea
but sold in both Korea and the U.S.

 Considering the differences between the countries, our strategy to compare
the Korean and the U.S. markets is as follows: first we find similar market
classes between the countries. For the classification, we use general market
segmentation rules in each country. For example, *Hyundai Sonata* belongs to
medium in Korea and *mid-range, lower* in the U.S. Second, we compare
properties between *medium* and *mid-range, lower* to examine possible sources
of *APD*. Our assumption is that *Hyundai Sonata* competes with other models
in *medium* in Korea and in *mid-range, lower* in the U.S. Although overall
attributes are a little different between *medium* and *mid-range, lower*, the

Table 1. Characteristics of the Korean and the U.S. Automobile Markets (2000 - 2004)

	Korea	U.S.
Quantity sold	1045844	16954190
Price	$13,570.5	$26,083.0
Number of alternatives	102	255
Domestic market share (%)	93.50	63.35
Light truck market share (%)	46.17	54.26
Import tax[c]	8%[d]	2.5% , 25%[e]
CR1 (%)[a]	42.9	17.7
CR4	86.7	48.3
CR7	97.4	61.1
HHI[b]	2646	798.5

Sources: Car Life (various issues), Korea Automotive Research Institute (2005, 2006), the U.S.
         Automotive News (various issues)
Notes:
- All variables except import tax are the 5 year (2000 to 2004) averages.
- [a] *CR1*, *CR4*, and *CR7* are concentration ratios: the measurement of the market share of the single
  largest, the four largest, and the seven largest firms.
- [b] the Hirschmann-Herfindahl Index (*HHI*), the sum of squared market shares, is a concentration
  index, describing competition level in a market. The *HHI* puts more weight on the larger size
  firms to reflect the variation in size.
- [c] based on CIF price; [d] since 1995; [e] car (2.5%), truck (25%)
- Market shares to compute *CR* and *HHI* are price-weighted.

attributes of the models sold by Hyundai and other Korean manufacturers (Kia Motors and Daewoo) were almost the same in both countries.[11] We adopt the market segmentations that are provided by the Korea Automobile Manufacturers Association for Korea and the U.S. Automotive News for the U.S.[12] Market class is "*the segment of the market in which a vehicle competes. Automotive News market classifications are determined by vehicle size, price and market intent*" (the U.S. Automotive News, 2005).

In this paper, our main interest is the cars in the group of small-sized (*small* and *small-medium* in Korea and *budget* and *economy* in the U.S.) and medium-class segments (*medium* and *large* in Korea and *mid-range, lower* and *mid-range, standard* in the U.S.). The reason is that the cars that were manufactured by Korean firms and sold in Korea and the U.S. belong to these classes only in the period of this paper's data set. Table 2 summarizes our identification strategy to compare cars between the countries. We exclude SUVs and minivans because basic specifications of the same models sold by Korean firms in both countries were too distinct, especially engine size (the authors' observation on the data set). For instance, *Santa Fe*'s (a SUV of Hyundai Motors) displacement in Korea was 2.0 (liters) while starting displacement of this model in the U.S. was 2.4 or higher.

Lastly, we do not extend the data set to the year 2005 or further. The reason is that Hyundai Motors started manufacturing *Sonata* at Hyundai Motor Manufacturing Alabama LLC in the U.S. from May 20, 2005. This means that

Table 2. Corresponding Market Classes between Korea and the U.S.

	Korea	US
Small-size	Small	Budget
	Small-Medium	Economy
Medium-class	Medium	Mid-range, lower
	Large	Mid-range, standard

Sources: The Korea Automotive Research Institute (2005), the U.S. Automotive News (2005).

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[11] Daewoo stopped exporting its products to the U.S. in 2003 after being merged with GM. Daewoo was famous for an OEM provider of GM before it produced its own models and later became a subsidy of GM.

[12] We use the market classes that are listed in "Korea Automobile Industry" published by Korea Automobile Manufacturers Association (2005) and "Market Data Book" and "Automotive Yearly Data Book" by the U.S. Automotive News (2005).

some of the cars sold by Hyundai Motors in the U.S. are not produced in Korea. In our analysis, we focus on the cars domestically manufactured and sold in Korea and the U.S. by Korean automobile firms in order to explore the phenomenon, *APD*, shown in Equation (1). Therefore, for the data set in this paper, all Korean cars sold in the U.S. were manufactured in Korea (see the U.S. Automotive News 2001 - 2005).

III. Sources of Price Difference

We assume that the market structure of the automobile industry is an oligopoly with Bertrand competition through product differentiation. This assumption is commonly used in the literature (e.g., Bresnahan [1987], Berry [1994], Berry, Levinsohn and Pakes [1995], Verboven [1996], Goldberg and Verboven [2001], Pertin [2002]) and we follow this conventional wisdom. We then analyze the possible sources of price difference that may cause *APD*, shown in Equation (1). The sources are driven by either cost or markup differences, because a profit-maximizing firm's behavior under oligopolistic competition is generally summarized as:

$$Price_j = (marginal)\ \mathrm{cost}_j + markups_j \qquad (2)$$

where *j* is a particular car model. Functional forms for costs and markups are subject to be various under different assumptions and model specifications, but in most cases, a firm's profit maximizing behavior is summarized in this way.

1. Cost Differences

Observing cost differences is hard for economists because of the lack of data on production costs. Further, it is difficult because the relevant cost differences depend not only on production costs but also opportunity costs. Despite these difficulties, we argue that production-cost differences do not explain *APD,* for the costs of both small-sized and medium-class cars sold by Korean automobile firms in the U.S. are likely to be higher than the costs in Korea due to transaction costs such as import tax and transportation cost, which violates Equation (1).[13] In addition, Hyundai Motors provided a longer and higher-mile warranty to

[13] For the data set in this paper, all Korean cars sold in the U.S. were produced in Korea (see the U.S. Automotive News, 2001-2005).

American consumers than Korean. In the case of the power-train protection, the warranty of Hyundai Motors was 10-year or 100,000 miles on all products in the U.S., but in Korea the warranty for *Accent* was 3-year / 60,000 km (37282.2 miles) and the warranty for *Elantra*, *Sonata*, and *XG* was 5-year or 100,000 km (62,137 miles).[14] It is obvious that the costs of the warranty in the U.S. were much higher than those in Korea for all the products sold by Hyundai Motors. Thus, cost differences do not help explain *APD*.

If *APD* were driven by local costs such as local distribution costs, then relative prices of similar products should be equal between the countries (Haskel and Wolf 2001). For illustration, we compare the relative prices of similar products sold by Hyundai Motors in both countries. In 2005, the relative price of *Elantra* with respect to *Accent*, both are small-sized care, in Korea is approximately 1.8, whereas the relative price for these small-sized care in the U.S. is about 1.4. The relative price of *XG* in terms of *Sonata*, both are medium-class care, in Korea is 1.1, but this relative price is 1.3 in the U.S.[15] This indicates that *APD* may not be explained by differences in local costs between the countries.

Opportunity costs may contribute to *APD*. One possibility is when there is a difference in the number of cars exported to the U.S. between small-sized and medium-class cars. If the quantities exported to the U.S. are significantly different between small-sized and medium-class cars, then there would be differences in opportunity cost due to the capacity constraints of selling products in the U.S. Unfortunately, these data are not available to us. Instead, we provide sales data of Hyundai Motors in the U.S. market in 2004, which could be a clue for the quantity of products exported to U.S. by Korean firms, shown in Table 3. We cannot find any pattern in favor of *APD*. Assuming that the number

Table 3. Car Sales of the selected segments in U.S. by Hyundai Motors

segment	model	2004
small-sized	Accent	43,258
	Elantra	112,892
medium-class	Sonata	107,189
	XG	16,630

Sources: The U.S. Automotive News (2005).

[14] Sources: for the U.S., http://www.hyundaiusa.com/global/warranty/warranty.aspx and for Korea, http://www.hyundai-motor.com/index.html.

[15] Sources: Car Life (2005) for Korea and the U.S. Automotive News (2005) for the U.S.

of sales is a good proxy for capacity constraints, a much higher number of Elantra than that of Accent (similar cars) could suggest why Accent in the U.S. is more expensive than in Korea. However, the quantities of *Elantra* and *Sonata* (small-sized vs. medium-class) are not significantly different, which means that differences in capacity constraints between the segments cannot explain *APD*.

2. Markup differences

Markups can help explain *APD* if (3) holds:

$$
markup_{medium}^{Korea} \Big/ markup_{medium}^{US} \geq markup_{small}^{Korea} \Big/ markup_{small}^{US}
$$

$$(3)$$

Markups can be different between Korea and the U.S. depending on the demand elasticities or levels of competition. Other sources can be import restrictions such as import quota, but there was no import quota in the countries during the time of the data set, i.e., from 2000 to 2004.[16]

First, we compare levels of competition between the countries. Table 4 provides measures of the competition in the car markets. As it was mentioned in Section 2, we focus on the car markets only. The stylized facts of the entire automobile market, the Korean market was more concentrated and domestic-firm dominated, are consistent with the car markets (see *CR*s and *HHI* in Tables

Table 4. Car Market Concentration (2000-2004)

	Korea	U.S.
# of cars sold for 5 years	3136257	41495968
Market share by domestic cars (%)	98 (94)	47 (63)
CR1 (%)	50	9.1
CR4	86.4	33.4
CR7	96.4	47.7
HHI	3011	487.8

Notes:
- Car market does not include light trucks (SUVs and minivans).
- Market shares in the parenthesis are price-adjusted.

[16] Markups can also be different due to collusion among firms, but t it is unlikely because levels of competition were very low in Korea. (See Tables 1 and 4).

1 and 4). Next, we narrow down the range of our analysis to the small-sized and medium-class segments but the main stylized facts do not change, as shown Table 5. A noticeable point in the U.S. market's case is that *CR1* and *HHI* in small-sized and medium-class were much higher than the entire car market (see the U.S. *CR1* and *HHI* in Tables 4 and 5), meaning that these two segments were more concentrated than other classes of cars.

We compare the relative values of market concentration using *CR1* and *HHI* to examine whether the level of competition helps explain *APD*. In HHI's case, Equation (4) must hold:

$$ HHI^{Korea}_{medium} \Big/ HHI^{US}_{medium} \geq HHI^{Korea}_{small} \Big/ HHI^{US}_{small} \qquad (4) $$

The intuition in Equation (5) is that as a market (or a segment of the market) is more competitive (less concentrated), prices tend to be lower. Table 6 presents that the relative *CR1* and *HHI* of medium-class and small-sized cars. It is obvious that the results in Table 6 are not consistent with Equation (4). Not only relative *HHI* of medium-class between the countries but also relative *HHI* of small-sized cars are greater than 1 and this cannot explain *APD*.

Alternatively, a source of *APD* can be differences in the price elasticity of demand. For elasticity differences to explain *APD*, Equation (5) must hold:

$$ \left| \varepsilon^{Korea}_{medium} \Big/ \varepsilon^{US}_{medium} \right| \leq \left| \varepsilon^{Korea}_{small} \Big/ \varepsilon^{US}_{small} \right| \qquad (5) $$

If (5) is proven, then this can help explain APD between small-sized and

Table 5. CR1 and HHI by selected classes for Korea and the U.S. Markets

class 1	class 2	CR1		HHI	
		Korea	US	Korea	US
small-sized	Budget	56	35	4114	2669
	Economy	57	19	3939	1193
medium-class	Midrange-lower	44	19	3176	1204
	Midrange-standard	75	18	5973	1066

Note: Unit of CR1 is percentage.

Table 6. Relative Values of CR1 and HHI

	CR1	HHI
Budget	1.6	1.54
Economy	3	3.3
Midrange-lower	2.32	2.64
Midrange-standard	4.17	5.43

Note:
- Budget and Economy are small-sized and Midrange-lower and Midrange-standard are medium-class cars.
- When relative values are compared, please see $CR1^{Korea}_{medium}/CR1^{US}_{medium} \geq CR1^{Korea}_{small}/CR1^{US}_{small}$ and $HHI^{Korea}_{medium}/HHI^{US}_{medium} \geq CHHI^{Korea}_{small}/HHI^{US}_{small}$.
- $CR1^{Korea}_{medium}$, for example, represents CR1 of medium-class cars in Korea.

medium-class cars. (5) implies that Korean firms exercise price discrimination based on relative elasticities of Koreans with respect to the U.S. consumers such that they charge higher (lower) prices on medium-class (small-sized) cars in Korea because the demand elasticity for the consumers purchasing medium-class (small-sized) car is lower (higher) in Korea than in the U.S. This is typical 3rd price discrimination because the firms charge different prices in different markets for the same or similar products by taking advantage of the different price elasticities across the U.S. and Korean markets. The following sections investigate this issue.

IV. Economic Model

We adopt a random-coefficients logit model as in Berry, Levinsohn and Pakes (1995) (hereafter referred to as BLP) to derive the demand system of automobile industry. Suppose we have $t = 1,\cdots, T$ markets and each with $i = 1,\cdots, I_t$ consumers.[17] In each market, there are aggregate quantities (market shares), average prices, and product characteristics for $j = 1,\cdots, J_t$ products. The conditional indirect utility of consumer i who purchases product j at market t can be defined as

$$u_{ijt} = x_{jt}\beta_i + \alpha_i p_{jt} + \xi_{jt} + \varepsilon_{ijt}, \ i=1, ... , I, j=1, ..., J, t=1, ..., T \quad (6)$$

[17] Following Berry, Levinsohn and Pakes (1995), a year is defined as a market. In this paper, time frequency is a year and its range is from 2000 to 2004, which means that there are 5 markets in each country.

where x_{jt} is observable product characteristics, p_{jt} is the price of product j in market t, ξ_{jt} is the unobserved product characteristics, ε_{ijt} is a mean-zero stochastic error term of consumers' heterogeneity, and (α_i, β_i) are individual-specific coefficients.

The distribution of consumers' taste parameters is modeled as follows.

$$
\begin{pmatrix} \alpha_i \\ \beta_i \end{pmatrix} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} + \Pi\, D_i + \Sigma v_i
$$

$$
= \begin{pmatrix} \alpha \\ \beta \end{pmatrix} + \begin{pmatrix} \Pi_\alpha \\ \Pi_\beta \end{pmatrix} D_i + \begin{pmatrix} \Sigma_\alpha \\ \Sigma_\beta \end{pmatrix} (v_{i\alpha}, v_{i\beta}),\ D_i \sim P_D^*(D), v_i \sim P_v^*(v) \tag{7}
$$

where D_i is consumer i's observable demographic characteristics, v_i is a random variable capturing the additional effect of consumer i's unobservable characteristics on his (α_i, β_i); Π is coefficients that measure how parameters depend on consumer observables, and Σ is measures on how parameters depend on the unobservables.

Since the consumers can decide not to purchase any of the products, we assume the existence of an outside good, $j = 0$, to account for zero consumption.[18],[19] The indirect utility from the outside good is

$$
u_{i0t} = \xi_{0t} + \pi_0 D_i + \sigma_0 v_i + \varepsilon_{i0t} \tag{8}
$$

where the mean utility from the outside good, ξ_{0t} is normalized to zero.

Let $\theta = (\theta_1, \theta_2)$ be a vector of all parameters: $\theta_1 = (\alpha, \beta)$, $\theta_2 = (vec(\Pi), vec(\Sigma))$.

[18] Without the outside good, consumers are forced to purchase one of the inside goods and demand depends only on differences in prices. A general price increase for all products will not decrease the quantities purchased. However, if all prices increase, then some consumers would not buy any product at all. Thus we need the outside good to account for zero consumption.

[19] In general, a market share of outside option can be defined as the total market size minus the inside products' market shares (Nevo [2000], p.527). We started using as the market share the number of households in each country as the market size, respectively. Of course, we checked various cases of the market share such as 10, 20, 25, 50, 60, 70 or 75 percent of the number of households but there was not significant distinction in parameter estimates. However, more rigorous way to choose the market size is that it is also estimated. In this paper, we assume that the market size is observed.

By combining equations (7) and (8), we have the final indirect utility equation:

$$u_{ijt} = \delta_{jt}(x_{jt}, p_{jt}, \xi_{jt}; \theta_1) + \mu_{ijt}(x_{jt}, p_{jt}, D_i, v_i; \theta_2) + \varepsilon_{ijt},$$
$$\delta_{jt} = x_{jt}\beta - \alpha p_{jt} + \xi_{jt}, \mu_{ijt} = [-p_{jt}, x_{jt}](\Pi D_i + \Sigma v_i) \qquad (9)$$

Assuming ε_{ijt} are distributed according to the i.i.d. Type I extreme value distributions, the probability of individual i purchasing product j in market t is

$$s_{ijt} = \frac{\exp(\delta_{jt} + \mu_{ijt})}{1 + \Sigma_{k=1}^{J}\exp(\delta_{kt} + \mu_{ikt})} \qquad (10)$$

We can also obtain the overall market share of product j in market t by integrating the probabilities picked by each consumer in Equation (10) across the individual types and weighting each type with its probability in the population, as shown in Equation (11):

$$s_{jt} = \int_v \int_D s_{ijt}\, dP_D^*(D)dP_v^*(v)$$
$$= \int_v \int_D \left[\frac{\exp(\delta_{jt} + \mu_{ijt})}{1 + \Sigma_{k=1}^{J}\exp(\delta_{kt} + \mu_{ikt})}\right] dP_D^*(D)dP_v^*(v) \qquad (11)$$

The price elasticities of the market share of product j with respect to the price of product k are

$$\eta_{jkt} = \frac{\partial s_{jt}}{\partial p_{kt}} \cdot \frac{p_{kt}}{s_{jt}}$$
$$= \left\{ \begin{array}{l} -\dfrac{p_{jt}}{s_{jt}} \displaystyle\int_v \int_D \alpha_i s_{ijt}(1 - s_{ijt})dP_D^*(D)dP_v^*(v)\, if\, j = k \\[12pt] \dfrac{p_{kt}}{s_{jt}} \displaystyle\int_v \int_D \alpha_i s_{ijt} s_{ikt}\, dP_D^*(D)dP_v^*(v)\, otherwise \end{array} \right\} \qquad (12)$$

The reason we only consider the demand side in the regression analysis is that the focus is the price elasticity of demand. In Bertrand oligopoly model with differentiated products, markups are inversely related to both own-price and cross-price elasticities. Thus once we obtain the estimates for elasticities,

then markups can also be inferred. The higher the own-price elasticity, the lower the markup, that is consumers are more sensitive to changes in price. The higher cross-price elasticity, the lower the markup and this means the higher the levels of competition.

V. Econometric Model

Our estimation follows Berry (1994), BLP (1995) and Nevo (2000). Given an appropriate set of instruments, $Z = [Z_1, ..., Z_M]$, the GMM estimate is

$$\hat{\theta} = \mathrm{argmin}_\theta \; \omega(\theta)' Z \Phi^{-1} Z' \omega(\theta) \tag{13}$$

where the weight matrix, Φ is a consistent estimate of $\mathrm{E}[Z'\omega\omega Z]$, and the structural error terms, ω, are defined as the unobserved product characteristics, ξ_{jt}. These unobserved characteristics can be computed through the following procedures. For a given θ_2, there exists a vector of mean utilities, δ_t, that equates predicted market shares with observed market shares. In other words, we can obtain the mean utility that solves the following equations for each market.

$$s_{.t}(x_{.t}, p_{.t}, \delta_{.t}; \theta_2) = S_{.t} \tag{14}$$

where s_t are the predicted market shares given θ_2 and S_t are the observed market shares from the data. The mean utility δ_t can be computed by the inversion of J equations in (14). Berry (1994) proves the existence of a unique mean utility level, $\delta(S)$, by holding that the mean utility of outside good equals zero.

$$\delta_{.t}(x_{.t}, p_{.t}, S_{.t}; \theta_2) = s_{.t}^{-1}(S_{.t}) \tag{15}$$

The structural error term can also be defined as

$$\xi_{jt} = \delta_{jt}(x_{.t}, p_{.t}, S_{.t}; \theta_2) - (x_{jt}\beta + a p_{jt}) \tag{16}$$

For the simple logit model, we can obtain analytical expression for δ_{jt} and the solution is equal to $\ln(S_{jt}) - \ln(S_{0t})$, but for the random-coefficients logit model, the inversion should be performed numerically due to the nonlinear nature of Equations (15) and (16).

Market shares depend on prices and disturbance terms, but prices will also depend on the disturbance terms in Equation (16), which means that prices are correlated with the unobserved product characteristics. Without isolating this correlation, the estimates can be inconsistent. This calls for some instrumental variables for the endogenous prices. Berry's (1994) suggestion is to use the observed product characteristics (excluding endogenous price) and the averages of the values of the same characteristics of other vehicles offered by that firm as instruments that some variable correlated with price but not with anything else in the demand system as in Equation (16).[20]

We will use Berry's idea to construct instrumental variables in the regression analysis.[21]

VI. Data

The main data set consists of prices, sales, and some attributes of new vehicles sold in Korea and the U.S., dating from 2000 to 2004 (5 years). The U.S. data are collected from *"The U.S. Automotive News Market Data Book"* from 2000 to 2005. The Korean data are obtained from various sources. Domestic sales data are collected from "*2005 Automotive Market*" published by the Korea Automotive Research Institute and the accuracy is confirmed by "*Korea Automotive Industry 2005*" by Korea Automobile Manufacturers Association.[22] We collect the data for domestic prices and vehicles' characteristics from "*Car Life*", a leading automobile magazine in Korea, and we obtain the data for the imported automobiles from the Korea Automobile Importers and Distributors Association.[23] Following BLP (1995), we assume that the market size in each country is exogenously given to be the number of households of each country.[24]

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[20] In 2SLS case, "price" is regressed on the instruments that listed above and the explanatory variables in the first stage. Same logic is applied when a random coefficient logit model is performed.

[21] BLP (1995) and Nevo (2000) adopt Berry's (1994) to construct instrumental variables.

[22] In "*2005 Automotive Market*", consumers' sales are separated from business sales. However, we cannot take advantage of using this to compare Korea and U.S. markets since there is no distinction between consumers and business uses in "U.S. Automotive Yearly Data Book".

[23] http://www.kaida.co.kr/dbase/DatabaseMain.jsp (a membership is required to access data).

[24] The number of households for US is easily collected from "*Statistical Abstract of the United States*", http://www.census.gov/statab/www/house.html and for Korea from "*Korea Statistical Yearbook, 2004*", Korea national Statistical Office. My assumption here is that one fourth or one third of the households in a country are potential buyers for new vehicles and three fourth (two third) of the households are subject to purchase used vehicles. This idea comes from Verboven

To make Korean data comparable to the U.S. data, we deflate the prices in the Korea data set by 10% because MSRPs (Manufacturer's Suggested Retail Prices) published in Korea include 10 percent of the value-added taxes. Since units of measurement are different between the countries, conversions of the measurement for the Korean data are performed on the product characteristics: cm to inch, kg to lbs, and Korean Won to US dollar.

The descriptive statistics for the U.S. and Korean automobile markets are provided in Table 7. On average, prices in the U.S. were twice as high as those in Korea. Size (measures as the product of length and width) and height of auto vehicles were larger in the U.S. than those in Korea. The ratio of horse power to weight (HP/Weight, a measure of engine performance) was higher in the U.S. These patterns persist even we decompose the auto vehicles into cars and light trucks except height in cars' and HP/Weight in light trucks' cases. Height of cars in Korea was higher than that in the U.S. by approximately 0.5 inch and HP/Weight of light trucks in both countries were almost the same. These exceptions might indicate that American consumers preferred higher light trucks as well as larger size and higher engine performance for cars.

Table 7. Descriptive Statistics (5 year average, 2000-2004)

Attribute	All Vehicles		Cars		Light Trucks	
	Korea	US	Korea	US	Korea	US
Price	13570.54	26083.00	12801.24	23994.34	14723.30	28085.59
	(9147.61)	(9733.00)	(11072.79)	(11729.59)	(4809.41)	(6741.97)
Size	12571.25	14217.92	12260.82	13007.96	13021.80	15374.88
	(1548.47)	(2322.85)	(1791.78)	(1553.38)	(935.62)	(2348.40)
Height	61.15	63.80	56.53	56.05	67.86	71.21
	(6.04)	(8.34)	(1.39)	(2.05)	(3.27)	(4.45)
HP/Weight	0.041	0.046	0.044	0.057	0.035	0.035
	(0.008)	(0.014)	(0.007)	(0.010)	(0.006)	(0.006)

Notes:
- Standard deviations are given in the parentheses; Prices in Korea are converted into the U.S. dollars using average exchange rate in each year.
- prices are nominal, not PPP adjusted and exchange rates for each year are annual averages taken from Bank of Korea Economic Statistics System, http://ecos.bok.or.kr/.

(1996). In 2004, the number of Korea new vehicle sales was 881,430 and that of used vehicles was 1,668,770 (Korea National Statistical Office (2005), Korea Automobile Manufacturers Association (2006)).

VII. Results

In Table 8, we report the results of OLS and 2SLS, using the instrumental variables discussed in Section 5, in the estimation of demand parameters.[25] These results are obtained from the regression of $\ln(S_{jt})$ - $\ln(S_{0t})$ on prices and product characteristics. That is, we run a regression of $\delta_j(S)$ on (x_j, p_j) to estimate β and α, treating ξ_j as an unobserved error term, relying on the following equation: $\delta_j(S) = \ln(S_{jt}) - \ln(S_{0t}) = x_j\beta - \alpha p_j + \xi_j$. In both cases, all the coefficients are of the expected sign except *HP/WT* in the OLS case. As noted previously, OLS estimates do not take into account the correlation between prices and the

Table 8. The Estimates of OLS and 2SLS for the Korea and the US Markets

Variable	Korea		US	
	OLS	2SLS[b]	OLS	2SLSb
Constant	-10.877	-13.272	-7.619	-9.689
	(1.513)	(1.975)	(0.659)	(0.199)
Price[a]	-2.671	-3.346	-0.442	-0.648
	(0.192)	(0.401)	(0.038)	(2.018)
Size	6.688	7.940	2.213	2.432
	(0.751)	(1.002)	(0.217)	(0.295)
Height	2.289	4.812	0.544	2.920
	(2.040)	(2.445)	(0.900)	(2.396)
HP/WT	-0.447	2.422	-0.067	1.805
	(1.173)	(1.913)	(0.469)	(1.793)

Notes:
- The dependent variable is $ln(S_j)$ - $ln(S_0)$
- Number of observations = 455 for Korea and 1019 for the US, respectively.
- Asymptotically robust standard errors are given in parentheses.
- [a] This variable is *ln(price)* for Korea and price for the US
- [b] Instruments: Size, Height and HP/WT for each vehicle; the average of Sizes of the firm's other vehicles, the average of Heights of the firm's other vehicles, and the average of HP/WTs for the firm's other vehicles.
- For Korea, weak-identification test *F*-statistic = 45.715 (p = 0.000), Over-identification x^2= 5.393 (p = 0.067).
- For the U.S., Weak-identification test *F*-statistic = 10.571 (p = 0.000), Over-identification x^2= 0.135 (p = 0.713).

[25] To check whether estimates for the parameters between the Korean and the U.S. markets, we performed the Chow and the likelihood ratio tests. The estimates between the countries are significantly different at 1% level of significance.

unobserved product characteristics, and therefore they are inconsistent. The use of the instrumental variable generates some changes in coefficient estimates. With the instrument, the absolute values of coefficients in the observed product characteristics increase and the estimates for *HP/WT* turns into positive values in both countries, as expected. More importantly, the coefficient of price increases in absolute value, which may correct downward bias of OLS estimates. This finding indicates that products with more desirable characteristics that are unobservable sell at higher prices.

In Tables 9 and 10, the estimation results from the random-coefficient logit model are reported. The estimates are based on equation (9) and computed using the procedure described in Section 5. Compared to the 2SLS logit case, the marginal (mean) utility of individual product characteristics and price varies across consumers so that we estimate a mean and a variance for each of them. The first columns display the means of the taste parameters, α (for price) and β's (other product attributes). The estimates for prices in both countries are negative and statistically significant. The next two columns in Tables 9 and 10 present the estimates for the parameters that measure heterogeneity around these means. By taking into account this heterogeneity, we can obtain more realistic substitution patterns across products. An important finding is that

Table 9. The Estimates of Random-Coefficients Logit Model for the Korea Market

Variable	means	interaction with demographic variables	standard deviations
	(α / β's)	*ln(income)* , *(π's)*	(σ's)
constant	-20.790	0.547	0.459
	(2.956)	(0.709)	(15.025)
price [a]	-5.271	0.315	0.521
	(0.398)	(0.063)	(0.396)
Size	7.101	0.587	0.545
	(1.125)	(0.349)	(3.523)
Height	10.636	0.587	0.577
	(3.420)	(0.623)	(10.439)
HP/WT	3.099	0.587	0.587
	(2.002)	(0.054)	(3.031)

Notes:
- Parameters are GMM estimates. Number of observations: 455. *ns* = 60. Asymptotically robust standard errors are given in parentheses; [a] This variable is *ln(price)*.

Korean consumers are more sensitive to changes in prices (see the estimates for α, -5.271 in Table 9 and -2.808 in Table 10). It is probably due to income effect. The proportion of car purchase expenses in Korean's income may be higher than the one in Americans. Besides, Koreans may have better outside options such taxes, buses, or subways. Sul and Chae (2007) show that Koreans have lower transportation costs than Americans not only in nominal costs but also in the relative indices considering the GDP difference between Korea and the U.S.

Table 11 presents the estimated relative values of price elasticities for small and medium class cars sold by Hyundai Motors. First, own price elasticities are calculated from (12) and these estimates are used to compute these relative elasticities. Table 12 shows the five year average of relative elasticities for small and medium classes.

The results in Tables 11 and 12 are consistent with *APD* as shown in (1) and (5). When focusing on the cars manufactured by Hyundai Motors, relative elasticities of medium-class (*Sonata* or *XG*) cars between Korea and the U.S. are lower than 1 while relative elasticities of small-sized cars (*Accent* and *Elantra*) are greater than 1, which shows the same pattern as (5). This asymmetry does not change when the average elasticies for market classes are used in Table

Table 10. The Estimates of Random-Coefficients Logit Model for the U.S. Market

Variable	means	interaction with demographic variables	standard deviations
	(α / β's)	*ln(income)* , (π's)	(σ's)
Constant	-7.6381	0.8729	-0.4134
	(0.9394)	(0.1110)	(9.7071)
Price	-2.8070	1.2329	-0.0450
	(0.0812)	(0.0259)	(0.0326)
Size	3.8344	-0.8934	0.0890
	(0.2362)	(0.0592)	(3.5403)
Height	-0.7908	-0.1500	1.7207
	(1.1943)	(0.2093)	(1.0262)
HP/WT	-1.6095	0.3819	-0.8320
	(0.7496)	(0.1167)	(0.6176)

Note:
- Parameters are GMM estimates. Number of observations: 1,019. *ns* = 60. Asymptotically robust standard errors are given in parentheses

12. Our finding indicates that medium-class cars are more elastic but small-sized care are less elastic in the U.S., which supports *APD*, shown in (1). Therefore, relative elasticity differences can be a source of price differences between Korea and the U.S., which could explain *APD*.

Hyundai Motors charges different prices on the same or similar products between Korea and the U.S. by taking advantage of relative elasticity differences. This pricing scheme of Hyundai Motors can be seen as a 3rd degree price discrimination across countries with relative elasticity differences and this can be considered as a source of international price differences. Of course, charging higher prices with relative elasticity differences is possible because Korean firms have much stronger market powers over all the segments in Korea (see *CR*

Table 11. Estimated Relative Elasticities for Hyundai Motors' cars in the Selected Classes.

	year		
	5 year average	2004	2003
Accent	2.464	2.208	2.314
Elantra	1.892	1.706	1.807
Sonata	0.973	0.987	0.956
XG	0.945	0.965	0.916

Notes:
- *Accent* and *Elantra* are small-sized cars. In the small-sized, *Accent* belongs to Budget-sized and *Elantra* to Economy-sized.
- *Sonata* and *XG* are medium-class cars. In the medium-class, *Sonata* is in Midrange-lower and *XG* is in Midrange-standard.
- When relative elasticities are compared, please use $\varepsilon_{medium}^{Korea}/\varepsilon_{medium}^{US} \leq \varepsilon_{small}^{Korea}/\varepsilon_{small}^{US}$.
- $\varepsilon_{medium}^{Korea}$ for example, represents the elasticity of medium-class cars in Korea.

Table 12. Average Relative Elasticities of Medium Cars with respect to Small Cars

Segment		Relative elasticity
small-sized	Budget	2.307
	Economy	1.784
medium-class	midrange-lower	0.950
	midrange-standard	0.931

Note:
- When relative elasticities are compared, please use $\varepsilon_{medium}^{Korea}/\varepsilon_{medium}^{US} \leq \varepsilon_{small}^{Korea}/\varepsilon_{small}^{US}$.
- $\varepsilon_{medium}^{Korea}$ for example, represents the elasticity of medium-class cars in Korea.

and *HHI* in Tables 1 and 5). This asymmetric pricing scheme is distinct from home-bias effect (Vervoben 1996) in the sense that firms take advantage of home-bias effect that domestic consumers are less sensitive to changes in domestic products' prices so that domestic firms can make higher markups in their home countries. In the phenomenon of *APD*, Hyundai Motors produced both small-sized and medium-class cars domestically, but charged lower prices to domestic consumers on small-sized cars but higher prices on medium-class cars. To the extent, this type of international price discrimination can be seen as a source to violate the law of one price (LOOP).

VIII. Conclusion

The phenomenon of asymmetric price differential (*APD*) across different-sized cars between Korea and the U.S. is unclear. We found the evidence that supports *APD*, with Korean automobile firms 3rd degree price discriminating on the same or similar products in different countries through differences in relative elasticity. Although 3rd degree price discrimination is a common phenomena across countries, it is not clear that multinational firms 3rd degree price discriminate with *APD* across countries. Although we present a case study, it can be inferred that there is complicated pricing behavior by multinational firms that sell the same or similar goods in different countries. This pricing scheme by Korean multinational firms such as Hyundai Motors can also contribute to the literature on pricing to market (PTM) and the law of one price (LOOP) as an additional source.

Unlike most automobile industry's studies in economics have focused on the U.S. and European markets, this paper examined the Korean automobile industry. We will do further research with the data collected for Korea. Related to this paper, we will explore why small-sized cars, especially budget size, are much cheaper in Korea than in the U.S. Of course, consumers for small-sized cars are likely to be more sensitive to price changes and outside options, thus prices for these cars are cheaper. This, however, does not fully explain significantly cheaper small-sized cars in Korea than in the U.S. Unlike in the American market, there exist cheaper and smaller cars, extra-small cars, that only sold in Korea. There could be a certain degree of competition between the segments of small-sized and extra-small cars in Korea, which further bring down the prices of small-sized cars in Korea. This research is now underway.

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