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OTA, Rui
Yokohama City University

ZHANG, Lili
Nissan Trading China Co., Ltd

RIETI
Research Institute of Economy, Trade & Industry, IAA

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Declining Demand and Product Quality: An Empirical Study of the Japanese PC Monitor Market[1]

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Yokohama City University
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Abstract

As evinced by the dumping phenomenon caused by the rapid economic growth of developing countries, many markets in advanced economies have rapidly declined. In such declining markets, however, the price of domestic products has been increasing instead of decreasing. To understand price increases in a declining market due to the rush in imports of new products, this paper empirically investigates changes in product quality using POS data on PC monitors sold at major mass retailers in Japan (January 2009--December 2011). The paper utilizes the hedonic approach to estimate the impact of product features on price. As a result of calculating the Quality Index developed by Feenstra (1988) with the estimates, this paper demonstrates that the quality of Japanese PC monitors increased by 6.6% in 2010 (compared to the previous year) and 8.5% in 2011. The result shows that the price increase in a declining market can be explained by increasing product quality.

Keywords: declining markets, price increase, product quality
JEL classification: L11, L15, O33

[1]This study is conducted as a part of the Project “Evidence-based policy study on the law and economics of market quality” undertaken at the Research Institute of Economy, Trade and Industry (RIETI). This paper is based on Zhang's master thesis submitted to Yokohama City University Zhang (2019). We appreciate the beneficial comments from Fumio Dei, Yuichi Furukawa, Takakazu Honryo, Mitsuhide Hoshino, Arata Ito, Yoshiyuki Nakazono, Sayuri Shiraishi, Makoto Yano and the participants of The 2019 International Academic Consortium for Sustainable Cities. Ota gratefully acknowledges the financial support from Kyoto University and the Grant-in-Aid for Scientific Research (KAKENHI ¥#16K03635).

1 Introduction

As we have seen it as a result of the dumping phenomenon caused by rapid economic growth of developing countries, several markets in the advanced economy have rapidly declined. Unintuitively, however, there are some declining markets where the domestic price has been increasing instead of decreasing. Although existing literature such as Yano, Dei, and Ota (2012, 2017) provide models to explain price rises in declining markets, studies do not mention another simple alternative: upgrading quality of products. It is easy to imagine that firms, which face declining demand, would upgrade quality to their products in order to differentiate from cheaper foreign products. By using a micro dataset the paper investigates the relationship between price and product quality in a declining market.

To this end, the paper utilizes the hedonic approach to estimate the impact of the product's features on the price of monitors for personal computers (hereafter, PC monitors). As demonstrated in the following section, Japanese PC monitors are a good example of a declining market: sales of Japanese products have declined, while those of Korean and Taiwanese products have increased. We estimated a hedonic regression by using POS data on PC monitors sold at major mass retailers in Japan (January 2009–December 2011) and calculated the quality index developed by Feenstra (1988). This paper demonstrates that the quality of Japanese PC monitors increased by 6.6% in 2010 (compared to the previous year) and 8.5% in 2011, and that the price of Japanese PC monitors rose during these periods. The results show that price increase in a declining market can be explained from the perspective of product quality.

The results imply that heterogeneous consumers' preferences play an important role while studying a declining market. Some consumers demand high quality and high price, while others demand low quality and low price. From our example of the Japanese PC monitor market, we observe that Japanese firms improve their products and some consumers select products even if they are expensive, while others select cheaper products.[1]

According to the recent theory of market quality (Yano, 2009), the quality of products is a primary factor in determining market quality.[2] From this aspect of market quality theory, we

[1] Although it does not mention product quality, Ota (2011, 2019) investigates price dynamics in a declining market with several distributions of consumers' preferences.

[2] Yano (2009) points out that "quality of competition", "quality of information", and "quality of products" are the primary factors.

could say that the quality of the Japanese PC monitor market *improves* because the quality of products has increased even though its demand declines. This raises the question of what a declining market means. So far, declining markets have been defined as those where profits of firms or quantities traded in markets decline (Ghemawat and Nalebuff, 1985; Fudenberg and Tirole, 1986). In this context, this paper provides a new aspect, or quality, to define and analyze a market. Although the paper does not conduct a welfare analysis, protecting a declining market from foreign competition is questionable if the quality of the market improves.

Studying the price increase in a declining market also has policy implications especially for trade policies. By facing the dumping phenomenon caused by developing countries, the advanced economies are likely to takes trade policies to protect their market to delay the speed of the declining (Caves, Frankel, and Jones, 2005). However, this protection policy might be inappropriate if the demand decline causes upgrading quality of products to differentiate from others. In addition to quantifying harms from price changes, doing benefits from quality changes would be an important aspect to evaluate a trade policy.

The rest of the paper proceeds as follows. In Section 2, we introduce existing literature on declining markets and emphasize that this study would be a pioneer in investigating the relationship between price and quality in a declining market. Section 3 explains certain features of the Japanese PC monitor market where Japanese firms are facing declining demand. In Section 4, we provide a hedonic approach and calculate the quality index, with estimates presented in Section 5. Finally, Section 6 concludes the study.

2 Existing Literature

Existing literature on declining markets has mainly focused on the optimal timing of exit. For example, Ghemawat and Nalebuff (1985, 1990) investigate the optimal timing of exit in a declining market where price is assumed to decline over time.[3] Although price setting is a fundamental strategy for firms, few studies investigate pricing behavior in declining demand.

Exceptions are Ota (2011, 2019) and Yano et al. (2017). The former studies price dynamics

[3]Other examples include, Reynolds (1988), Whinston (1988), Londregan (1990), and Fishman (1990). While Ghemawat and Nalebuff (1985, 1990) assume that each firm has complete information regarding the rival firm's cost, Fudenberg and Tirole (1986) analyze a case of incomplete information.

when firms face a decline in demand for their product due to the arrival of a new substitutable product. Those papers simulate price paths under an assumption that the demand curve for the old product becomes steeper as the new product replaces it, which is observed in an empirical study on the US photographic film market (Ota, 2020). Yano et al. (2017) reveals a mechanism of price increase in a declining market caused by a discrete demand shift from an existing home country's product to a new foreign product, demonstrating that the mechanism can empirically explain price increase in US-made Black and White TVs in its market during the 1960s.

While existing studies on pricing in a declining market have focused on theoretical mechanisms of price dynamics, no study investigates a relationship between price and product quality. As recent empirical industrial organization studies seriously consider endogeneity in the estimation of demand functions since Berry (1994) and Berry, Levinsohn, and Pakes (1995), the quality of products plays an important role in pricing.[4] Therefore, even though there are several reasons behind a demand decline, it is not difficult to imagine that both quality of products and their prices would interact with the decline. From this perspective, this paper investigates how the quality of products affect their price under a declining demand. To my best knowledge, this is the first study to investigate the relationship between price and quality in a declining market.

3 Japanese PC Monitor Market

This paper focuses on the Japanese PC monitor market where demand for PC monitors made by Japanese firms declines. Using sales data on a major electronics retailers as provided by GfK Japan, a marketing research company, we construct a POS panel data and use this data set to describe and analyze the Japanese PC monitor market. The data include monthly sales volumes and their values for individual products, and product-specific information for the period 2009–2011. Other channels are excluded. The coverage rate is unknown, but GfK covered approximately 30% of domestic/foreign desktop PCs sold during this sample periods.

With this data set, we first examine the market structure of Japanese PC monitors. Table 1 shows annual market shares between 2009 and 2011. Although many companies including overseas companies sell their products in Japan, the top 5 companies account for approximately

[4] Yano (2009) launch a new field of economics emphasizing the quality of markets. In market quality economics, market quality consists of qualities of products, information, and competition.

80% of the market share. Table 2 also shows annual market shares among only Japanese firms.[5] According to the Table 2, the top 3 companies occupy more than 80% market shares among all Japanese firms. Thus, our first observation is that the Japanese PC monitor market is oligopolistic.

Next, we examine changes in prices of PC monitors and their sales volume in the Japanese market. Figure 1 shows the annual total sales volume of Japanese products and foreign products mainly made by Korean and Taiwanese firms. As seen in the figure, sales volumes of Japanese products decline, and volumes of foreign products have overtaken Japanese products since 2010. While the sales volume of Japanese products is declining, their average prices are increasing. Figure 2 shows the paths of average prices of Japanese, Korean, and Taiwanese products, respectively. While the average prices of Korean and Taiwanese products has decreased, that of Japanese products has not, even though their demand declines as seen in Figure 1. The classical analysis under perfect competition cannot raise prices when the demand curve shifts to the lower left due to demand decline. Here, changes in quality come as potential identifiers to explain the price rise.[6]

In this regard, our study agrees with Yano et al. (2017), which analyzes an imperfectly comptitive model where price rises under declining demand. In contrast, this study focuses not only on prices but also on the quality of products by using micro data. Our data set contains product-specific information and can track changes in the quality of domestic products as well as changes in the quality of imported foreign products. There are many specifications that characterize PC monitors in addition to the manufacturer and price. Our empirical analysis uses variables listed in Table 3. Although we have other characteristics data, a hedonic regression with all data suggests that listed variables have statistically significant effects.[7] Then, by

[5]We define Japanese firms as those headquartered in Japan.

[6]With the same research question and motivation, Yano et al. (2017) provides a mechanism to explain price rise under declining demand. That paper demonstrates that a model with the following three characteristics can explain how an import surge raises the price of an existing home product: (1) a discrete demand shift from an existing home country's product to a new foreign product, (2) Cournot competition under free entry and exit in an importing country, and (3) a monopolistic exporter.

[7]Our data set contains the following variables: manufacturer, nationality, model number, release date, brand, display type, screen size, high-definition support, D terminal type, microphone presence, monitor wide type, brightness, USB presence, speaker presence, pixel count (vertical), dot pitch , touch panel, HDCP compatible, number of HDMI terminals (new), camera, safety standard (TCO), safety standard (MPR), PC connection, headphone terminal, RoHs standard, J-Moss compatible, international energy star program, plug and · Play, composite video terminal, S terminal, 3D, touch point type, LED type, safety standard (TCO) new.

following Shiratsuka and Kuroda (1995), we use only statistically significant variables for the hedonic analysis described below.

Although many characteristics are easy to understand, we may need an explanation about J-Moss. It is a Japanese standard on the restriction of the use of certain hazardous substances in electrical and electronic equipment. If a product satisfies the standard, an optional green mark can be displayed on it. According to Hayakawa (2018), putting on a J-Moss label is a regulation that obliges enterprises to collect and bear costs in order to promote the suppression, reuse, and recycling of electrical and electronic equipment waste. We may imagine that having a J-Moss label would increase product prices.

4 Empirical Analysis: Hedonic Approach

To investigate the relationship between a product's price and its quality, this paper utilizes the hedonic approach.[8] The hedonic approach is often used to control quality changes of products when governments create a consumer purchase index.[9] For example, the Statistic Bureau of Japan currently applies the approach to control quality changes in Personal Computers (Desktop and Laptop) and Cameras because manufacturers frequently renew these products. Applying the hedonic approach would be appropriate in this study as manufacturers of PC monitors often provide new models.

When we take the hedonic approach wherein we implicitly assume that the products' prices depend on their characteristics. Based on the theoretical background developed by Rosen (1974), this paper sets up the following hedonic price function in a semi-log liner form:

$$\ln p_{it} = \alpha + \sum_{j=1}^{J} \beta_j x_{ij} + \sum_{k=1}^{K} \delta_k n_{ik} + \sum_{t=1}^{T} \gamma_t d_{it} + \sum_{t=1}^{T} \eta z_t + \epsilon_{it} \tag{1}$$

where p_{it} is the real price of product i at time t deflated by Consumer Price Index and x_{ij} is a vector characteristics j of product i. As explained in the previous section, we chose ten characteristics listed in Table 3. The variable n_{ik} is a dummy for manufacturers' nationality

[8] According to Colwell and Dilmore (1999), Haas (1922b,a) is the first to produce a hedonic study.

[9] Recent developments of the Hedonic approach include Pakes (2003), Bajari and Benkard (2005), Benkard and Bajari (2005), Requena-Silvente and Walker (2006), and Erickson and Pakes (2011).

(k=Korea, Taiwan, China, the U.S.) and d_{it} is a dummy variable for months after release. Finally z_t is a time trend dummy.

The hedonic function to be estimated is a market equilibrium price curve in which the supply and demand of the characteristics of products meet. However, as Shiratsuka and Kuroda (1995) mentions, there is no a priori constraint there. A typical treatment for this problem is to apply the Box-Cox transformation to variables and find the minimum log-likelihood for each specification.[10] Table 4 shows comparisons of the log-likelihood of several specifications. As a result of comparing the fitting with other function forms using Box-Cox transformation, the semi-logarithmic linear, which is (1), shows the best fit to the data.

Our data are unbalanced panel data, that is, all PC monitors are not observed continuously during the observation period. This is because manufacturers frequently update their PC monitors. A concern of using unbalanced panel data is that the resulting sample selection problem causes biased estimators (Woolridge, 2009). Thus, we employ a Missing Completely At Random (MCAR) test developed by Li (2013). The test demonstrates that the unbalance of data used in this study occurs randomly. Therefore, there is no selection bias in the obtained estimation result.

Since the characteristics of each PC monitor are constant over time, we cannot estimate fixed effects. Thus, we employ a random effects model.[11] Table 5 shows the estimation results. The second column from left shows the estimation results by using all data including US and Chinese manufacturers in addition to Japanese, Taiwanese, and Korean manufacturers. In this regression, we include country dummy variables: UD stands for a dummy for US nanufacturers, KD, TD, CD are dummies for Korean, Taiwanese, and Chinese manufacturers, respectively. All country dummies except China demonstrate statistically significant and negative coefficients. This shows that Japanese products are more expensive than products of other countries.

Although many characteristics have positive effects on price, some have a negative influence, that is, lower price. In our regression, variables *Speaker*, *MPR*, and *PC* lower monitor prices. A possible reason is that these characteristics except *MPR* are almost defaulted func-

[10]Box-Cox transformation is given in the following equation: $y^{(\lambda)} = \frac{y^{\lambda}-1}{\lambda}$ where λ is a parameter. When $\lambda = 0$, the variable is in the log form.

[11]The results of analysis performed as pool data do not change significantly.

tions. Consumers would not place high values on defaulted functions because they cannot distinguish products by these features. As Table 3 shows, 58% of monitors have speakers, and 97% have PC connections. It is not statistically significant, *Wide Type* has a negative coefficient and its installation ratio is 63%. The variable *MPR* shows whether the product satisfies a certain level of regulation on low frequency electric and magnetic fields emitted from the monitor.[12] Although it seems that safer products would have higher values leading to higher prices, consumers may not consider this standard seriously as World Health Organization (WHO) mentions that "[a]ll reviews conducted so far have indicated that exposures below the limits recommended in the ICNIRP (1998) EMF guidelines [...] do not produce any known adverse health effect" where the limit of the ICNIRP guideline is 83μT and a desktop monitor emits up to 0.4 μT for a 30cm distance.[13] In conclusion, we could say that characteristics which have negative effects of price are not major factors when consumers decide products, because these functions are commonly equipped or consumers do not care.

The third to fifth columns show estimation results focusing on Japanese, Taiwanese, and Korean manufacturers, respectively. Although the signs and statistical significance of estimates are similar between Japanese and Taiwanese products, they differ between Japanese and Korean monitors.

Our results demonstrate that *USB*, *J-MOSS*, and *C-Video Termination* contribute to the price increase of Japanese products, while they do not have significant effects on Korean product prices. We could imagine that *USB* and *C-Video Termination* will make PC monitors more useful, but they are not fundamental features. This is because we can use USB through our computers and not monitors, and Composite Video Termination is basically used for watching movies recorded on video cameras and watching TV programs. If the main usage of PC monitors is to display computer applications, these functions are additional. Thus, raising price by incorporating these features may come from this quality improvement of the monitor. As aforementioned, *J-MOSS* is a Japanese standard on the restriction of the use of certain hazardous substances in electrical and electronic equipment. Our estimations indicate that qualifying the standard costs consumers buying Japanese products.

[12]MPR is the former name of Swedac, the Swedish Board for Technical Accreditation.

[13]See WHO homepage (accessed 2020/2/18). ICNIRP stands for International Commission on Non-Ionizing Radiation Protection.

Touch panel and *3D* contribute to the price increase of Korean products while they do not have significant effects on the prices of Japanese products. As with *USB* and *C-Video Termination*, while *Touch panel* and *3D* could render PC monitors more useful, they are not fundamental features. Although including these features makes Korean products expensive, their installation rate is quite low: the former is only 1.1% of Korean products, and the latter is only 5.2% according to Table 6. Therefore, we observe that there are no features to raise prices in Korean products in aggregate.

5 Quality Index

Our research question is to investigate the relationship between price and quality of products in a declining market. To this end, we calculate quality index according to Feenstra (1988) with the estimates. The quality index of each monitor is a theoretical price calculated by using estimated values. The estimates include only characteristics and exclude dummy variables. We calculate the weighted average using the sold quantity of each monitor as a weight by nationality every year. The index is interpreted as average quality in each country's product.

Table 7 shows the calculated quality indices of each country's product. The quality index for Japanese products has risen continuously from 2009 to 2011: the quality of Japanese PC monitors increased by 6.6% in 2010 (compared to the previous year), and by 8.5% in 2011. While the quality of Japanese products has risen, that for Korean products has declined by 0.6% from 2010 to 2011. A minor improvement (0.8%) was observed during the period of 2009–2010.

The result shows that the price increase in a declining market can be explained from the perspective of product quality. By facing harsh competition with foreign firms, Japanese firms may upgrade their products to survive in their markets. A similar case of the Japanese wooden furniture market was studied by Yano et al. (2012). Although the current paper does not have a theoretical framework as in Yano et al. (2012), this can empirically treat quality changes by using a hedonic approach. We could observe that the quality of products improves in a declining market, and the price rises.

6 Conclusion

In order to investigate a price rise in a declining market, this paper focuses on product quality. By taking the Japanese PC monitor market as an example, the paper demonstrates that the quality of Japanese products has been shown to increase by 6.6% in 2010 and 8.5% in 2011 even though the demand for them has declined during this period. The quality of Korean products, which are increasing in demand, has increased just by 0.8% in 2010 and decreased 0.6% in 2011, while the quality of Taiwanese products has changed by 12% in 2010 and 1.7% in 2011. The results empirically show that the price rise in a declining market can be explained by the rise in product quality.

This paper demonstrates that product quality would be changed, and consumers will respond to it in a declining market. This suggests that one would model heterogeneous consumers' preference when they study a declining market. While some consumers demand products with high quality and high price, others demand those with low quality and low price. In a declining market, which differs from a normal market, this heterogeneity plays a more important role to determine prices and for firms to survive. From our observation of the Japanese PC monitor market, we found that Japanese firms improve their products and some consumers select products even if they are expensive.

However, there are several aspects that this paper does not consider. First, we do not control unobservables in our regression. It is said that Large Scale Integration (LSI) determines the quality of images. Both Mitsubishi and LG have their own output programs, but they do not appear in the data. However, upon closer examination, the difference can be observed. It is not only prices and features, but also unobservable factors such as the appearance that are important factors that influence the purchase of PC monitors.

Second, we have not conducted a welfare analysis. We may wonder whether surplus has increased as a result of an environment where you can purchase cheaper foreign products even if Japanese products decline.

Although this paper mentions an example wherein Japanese firms may upgrade their products when facing harsh competition with foreign firms, the study does not offer any theoretical/empirical model as a verification. The final aspect to extend the paper is to build a model that endogenizes technological progress due to import pressure. Feenstra (1988) shows an

improvement in the quality of Japanese small passenger cars and trucks during the Japanese voluntary export restraint periods. A future study should examine whether an increase in imports from overseas has induced faster technological progress.

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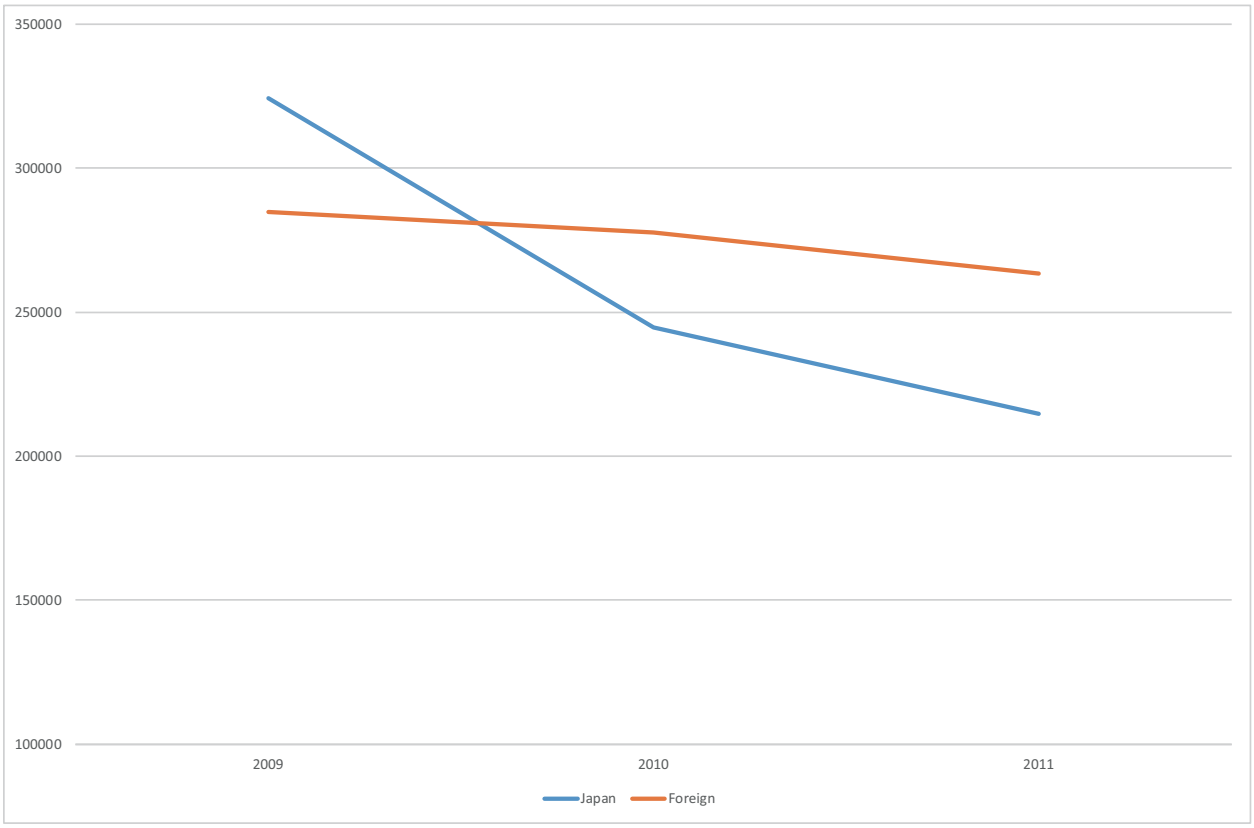

Figure 1: Quantity Sold

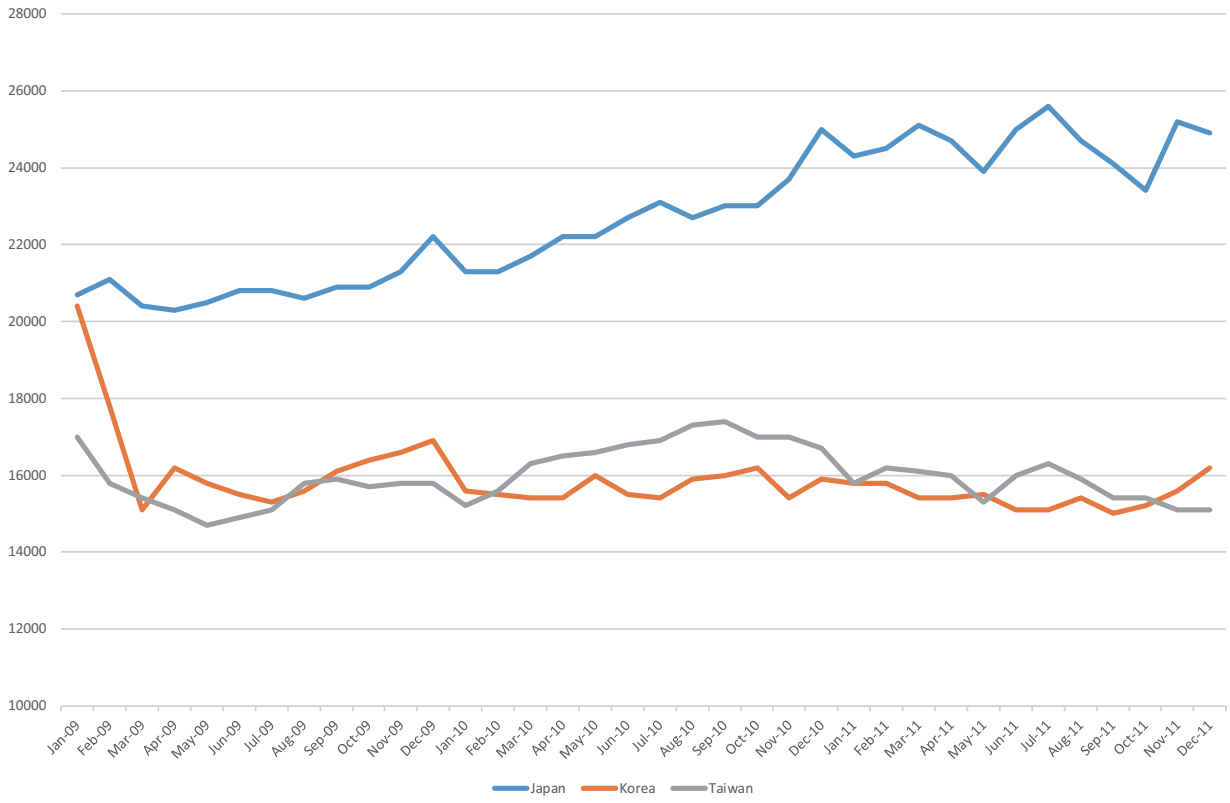

Figure 2: Real Price

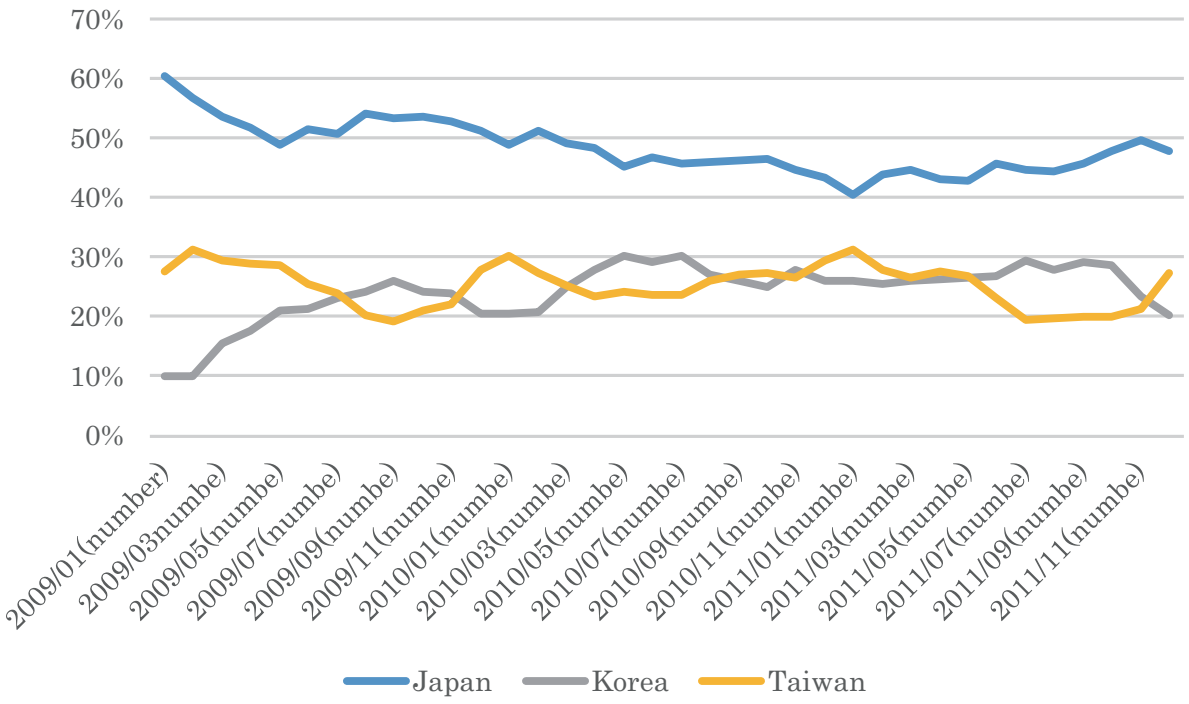

Figure 3: Market Share in Japan

Company	2009	2010	2011
Mitsubishi（Japan）	18%	22%	21%
LG ELECTRO（Korea）	14%	20%	21%
Acer（Taiwan）	20%	19%	13%
IO Data（Japan）	17%	13%	12%
Benq（Taiwan）	5%	7%	10%
Princeton（Japan）	7%	7%	5%
SAMSUNG（Korea）	3%	3%	3%
HYUNDAI IT（Korea）	2%	3%	2%
Nanao（Japan）	1%	1%	2%
Buffalo（Japan）	4%	0%	0%
Others	9%	5%	10%
Share 3	52%	60%	55%
Share 5	74%	80%	78%
Share 10	91%	95%	90%

Table 1: Market Share in Japan

Company	2009	2010	2011
Mitsubishi	34%	46%	47%
IO Data	33%	28%	28%
Princeton	13%	14%	12%
Nanao	3%	3%	4%
Buffalo	7%	0%	0%
DiON	4%	1%	0%
Century	2%	2%	2%
NEC	1%	1%	1%
Green House	1%	0%	1%
Twin Birds	0%	1%	1%
Others	3%	3%	4%
Share 3	79%	88%	86%
Share 5	90%	91%	91%
Share 10	97%	97%	96%

Table 2: Market Share among Japanese Companies

Variables	Observations	Mean	St. Dev.
Display Size	52,020	21.19	7.90
Wide Type	52,020	0.63	0.48
USB	47,700	0.17	0.37
Speaker	51,948	0.58	0.49
Touch Panel	43,164	0.05	0.22
MPR	51,624	0.17	0.37
PC Connection	51,768	0.97	0.18
J-Moss	51,660	0.57	0.50
C-Video Termination	52,020	0.11	0.31
3D	51,732	0.02	0.13

Table 3: Summary Statistics

	(Left) Parameter	(Right) Parameter	Log likelihood
B-C 1	0.046	0.046	-141656.26
B-C 2	0.063	1	-141225.4
B-C 3	0	2.464	-152478.12
Log Linear	0	0	-141729.41
Semi-Log Linear	0	1	-141356.22
Linear	1	1	-154312.85

Notes: We put the following restrictions: for the first Box-Cox Transformation (B-C1), we restrict that the transformation parameters on both sides are the same; we restrict the parameters on the right-hand side to be 1 for the second (B-C2), and to be 0 on the left-hand side for the third (B-C3) case.

Table 4: Log likelihood of each function form

	All	Japan	Taiwan	Korea
Screen Size	0.0738***	0.0710***	0.107***	0.0818***
	(0.00360)	(0.00423)	(0.00601)	(0.00902)
Wide Type	-0.0636	-0.139**	-0.170***	0.248
	(0.0523)	(0.0606)	(0.0419)	(0.246)
USB Type	0.454***	0.521***	0.106*	-0.219
	(0.0738)	(0.0720)	(0.0599)	(0.493)
Speaker	-0.233***	-0.396***	-0.0446	0.0709
	(0.0411)	(0.0721)	(0.0284)	(0.0730)
Touch panel	0.857***	0.784***	0.396***	1.536***
	(0.0896)	(0.0968)	(0.0579)	(0.265)
MPR	-0.0994**	-0.142***	-0.0872***	-0.880
	(0.0458)	(0.0528)	(0.0322)	(0.770)
PC	-0.815***	-0.756***		-1.830***
	(0.166)	(0.187)		(0.309)
J-Moss	0.163***	0.269***	0.110***	0.0897
	(0.0476)	(0.0751)	(0.0329)	(0.111)
C-Video Termination	0.680***	0.844***	0.375*	0.00230
	(0.0881)	(0.104)	(0.222)	(0.0960)
3D	0.830***	0.427***	0.682***	0.814***
	(0.143)	(0.0728)	(0.139)	(0.158)
UD	-0.184**			
	(0.0852)			
KD	-0.593***			
	(0.0760)			
TD	-0.428***			
	(0.0424)			
CD	-0.146			
	(0.125)			
Constant	9.476***	9.545***	7.543***	9.547***
	(0.151)	(0.163)	(0.121)	(0.173)
Observations	13,213	7,823	2,719	2,171
Number of ID	1,077	657	184	167

Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5: Estimation Results

	Japan	Taiwan	Korea
USB	18.8%	9.1%	7.8%
Touch Panel	7.9%	0.5%	1.1%
J-Moss	69.2%	39.3%	56.3%
Composite Video	14.2%	2.5%	8.3%
3D	0.8%	2.0%	5.2%

Table 6: Installation Rate of Characteristics

(yen)	2009	2010	2011
Japan	22320.14	23793.04	25803.84
		(6.6%)	(8.5%)
Korea	18013.84	18164.98	18060.62
		(0.8%)	(-0.6%)
Taiwan	15748.59	17636.81	17945.41
		(12%)	(1.7%)

The rates of change relative to the previous year are in parentheses.

Table 7: Quality index of each country's product