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Impact of R&D Activities on Pricing Behaviors with Product Turnover

Yasushi Hara

(Hitotsubashi University)
2018 FFJ/Michelin Fellow

Akiyuki Tonogi

(Toyo University)

Konomi Tonogi

(Rissho University)

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Fondation France-Japon de l'EHESS (FFJ)
54, boulevard Raspail 75006 Paris - ffj@ehess.fr

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Yasushi Hara, Akiyuki Tonogi & Konomi Tonogi

Abstract

This study empirically investigates the impact of research and development (R&D) activity on product turnover from Point-of-Sales (POS) data. When measuring the inflation rate in an economy, the effects of quantitative changes, volume changes, and quality changes from nominal sales changes must be removed. In order to examine the effect of R&D activities on price changes from sales data, we implement an empirical combining three datasets: weekly POS data, patent database (IIP Patent DB) data, and Survey of Research and Development data. We use regression analysis with pooling and panel regression. We observe that while the effect of price increases due to the new product introduction can be related to R&D behavior a negative effect on the price of the incumbent product is also observed. In addition, the relative prices of new and incumbent products tended to be higher for companies with active R&D expenditures. We suggest that continuous R&D is necessary to keep introducing high value products while prices are under pressure.

Keywords

POS Data, Unit Value Price, R&D, Patent Acquisition

JEL Classification: E31, O33, O34

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Contents

1. Introduction

1.1. Research Theme

This paper presents an empirical study of the impact of R&D activities on price setting behaviors and product turnover by manufacturers based on POS (Point-of-Sales) data. In recent years, the product turnover effect captured by means of transaction data has gained considerable attention in the literature on the measurement of inflation and the general price level. Large scale operation data from retailers enable us to observe product turnover in daily transactions and understand the importance of the price setting behavior along with product turnovers by product manufacturers and retail stores.

Based on a constant elasticity of substitution (CES) aggregator function, Feenstra (1994) and Feenstra and Shapiro (2003) derive a formula for a Cost of Living Index (COLI) that captures the welfare effects derived from variety expansion. Broda and Weinstein (2010), also using the CES aggregator function, find that new goods cause a significant "bias" in the price index. Variety expansion effects have become a topic of increasing interest in many fields of economics, including international trade, economic growth, and business cycle research. In the studies mentioned above, the emergence of new goods affects consumer welfare through a change in the total number of product varieties and not through price differentials between new and incumbent goods. Although the variety channel is certainly important, other effects, including the introduction of commodities with higher/lower prices or qualities, may have a major impact on consumer welfare and the general price level. For example, let us assume that a firm replaces its old product with a new product of the same quality but with a higher price. Abe, Inakura and Tonogi (2017) measure the contribution of the product turnover effect to the inflation rate by using the inflation rate decomposition of the unit value price index based on POS data. One important question raised by these works is the extent to which the quality change effect may influence the product turnover effect in the inflation rate.

In current innovation empirical study, scientific publication and patent data is used for the operationalization of emerging technologies, and scientometric method has focused mainly on the detection of emerging process of technology (Rotolo, Hicks and Martin 2015). And a meta-analysis survey of product innovation process indicates that there were a very few studies that using price of products for empirical analysis (Evanschitzky et al. 2012).

The purpose of this study is to examine the relationship between the R&D activities and the price of products taking into account product turnover. In previous studies focus on R&D activities by using patent and R&D expenditures, price of products was not covered due to the data availability (Ikeuchi et al. 2017) (Yamaguchi et al. 2018). Measuring the quality change in product turnover is difficult, however, as quality improvements are promoted by the R&D activities by maker firms. Hence, empirical research on the relationship between R&D activities and price settings with product turnover is undertaken in order to provide a framework measuring to measure the impact of quality changes on price changes.

In order to examine the effect of R&D activities on price changes in sales data, we implement empirical analysis on the data that are combined with three data sets: weekly POS data, patent database (IIP-DB), and Survey of Research and Development. This study provides a number of empirical facts associating price changes with product turnover and R&D, including patent acquisition. Using our novel dataset, we implement pooling and panel regressions. As a result of the analysis, we find that while the effect of the price increase due to the new product introduction results from R&D behavior, a negative effect on the price of the incumbent product is also observed. In addition, the relative prices of new products and continuing products tend to be high in companies with significant R&D expenditures. It is suggested that continued R&D activity is necessary to keep introducing high value products when prices are under pressure.

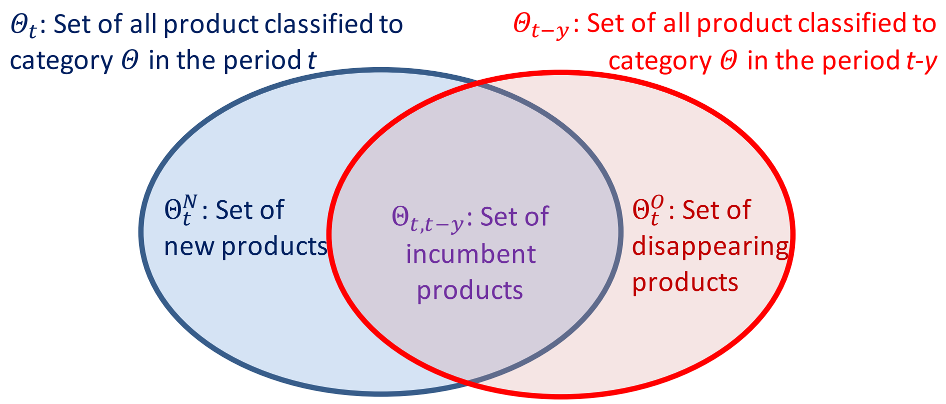
In section 2 we explain the dataset constructed for this study and address the concepts of prices of new, disappearing, and incumbent products. In section 3, the results of the regression analysis are explained. In section 4 we discuss the interpretation for results of regression analysis. Section 5 concludes.

2. Database Construction

2.1. POS Data

In our empirical analysis, we use Point-of-Sales (POS) data collected by register scanners at the time of consumer make retail purchases. We identify three different product categories, namely, new goods, incumbent goods, and disappearing goods by using the Universal Product Code (UPC) of the corresponding products along with the recorded sales date. Figure 1 shows the concept of new goods, incumbent goods, and disappearing goods in sales records.

Figure 1: Classification of New, Incumbent, and Disappearing Goods



In addition, we may identify the firms making the products based on the manufacturer code embedded in the UPC.

2.1.1. Summary of the SRI Database

POS data generated through sales at retail stores are collected by marketing research companies. Our POS data, namely, the SRI database, were collected by INTAGE Inc., Japan. The database includes data from approximately 4,000 Japanese retail stores. The representative sample of retail stores by area and store type is chosen by INTAGE. INTAGE has classified the retail stores into 11 types: (1) General Merchandising Store; (2) Supermarket L; (3) Supermarket S; (4) Convenience Store; (5) Drugstore; (6)-(11) Others. Recorded products are categorized as: (1) grains; (2) processed foods; (3) daily necessities; (4) cosmetics; (5) medicines. These categories represent 18% of total household expenditures according to Japan's "Household Survey." The average number of transaction records is approximately 5.5 million per week. The sales and quantities are aggregated on a weekly basis by item and by store in the SRI database. The remarkable advantage of the SRI database is the availability of product data with volume information in several units of measurement. For example, units of volume for a given product may include grams, milliliters, number of pieces, and number of uses.

2.1.2. Unit Value Price

To measure the price change rate of a new product, we need price information from new and disappearing products produced by a manufacturer. However, it is difficult to calculate price changes for each item separately. For this reason we adopt the unit value price of all products from a manufacturer to compare the prices between new and disappearing products.

We assume $\Theta_{j,t}$ that is the set of products of category Θ produced by manufacturer *j* in period *t*. Let us denote the quantity and price of product *i* sold in period *t* as q_t^i and p_t^i, respectively. The variable v^i denotes the volume of product *i*. The total unit value price for maker *j* and category Θ for period *t*, denoted by $P(\Theta_{j,t})$, may be expressed as:

$$P_t(\Theta_{j,t}) = \sum_{i\in\Theta_{j,t}} \left(\frac{v^i q_t^i}{\sum_{i\in\Theta_{j,t}} v^i q_t^i}\right)\left(\frac{p_t^i}{v_i}\right).$$

Let $\Theta_{j,t}^C$ be the set of incumbent products produced by maker *j* sold in period *t* and *t-y*. Then the set of incumbent products $\Theta_{j,t}^C$, the set of new products $\Theta_{j,t}^N$, and the set of disappearing products $\Theta_{j,t}^O$, in period *t* for manufacturer *j* satisfy the following set-theoretic relationships:

$$\Theta_{j,t}^C = \Theta_{j,t} \cap \Theta_{j,t-y},$$

$$\Theta_{j,t}^N = \Theta_{j,t} \cap \neg\Theta_{j,t-y},$$

$$\Theta_{j,t}^O = \Theta_{j,t-y} \cap \neg\Theta_{j,t}.$$

Following the definitions of set of incumbent, new, and disappearing products, we may express the unit value price $P_t(\Theta_{j,t})$ as the weighted sum of the unit value price of the new products and the incumbent products as:

$$P_t(\Theta_{j,t}) = W_t(\Theta_{j,t}^N)P_t(\Theta_{j,t}^N) + W_t(\Theta_{j,t}^C)P_t(\Theta_{j,t}^C),$$

where.

$$P_t(\Theta_{j,t}^N) = \sum_{i\in\Theta_{j,t}^N} \left(\frac{v^i q_t^i}{\sum_{i\in\Theta_{j,t}^N} v^i q_t^i}\right)\left(\frac{p_t^i}{v_i}\right) \text{ and } P_t(\Theta_{j,t}^C) = \sum_{i\in\Theta_{j,t}^C} \left(\frac{v^i q_t^i}{\sum_{i\in\Theta_{j,t}^C} v^i q_t^i}\right)\left(\frac{p_t^i}{v_i}\right),$$

$$W_t(\Theta_{j,t}^N) = \sum_{i\in\Theta_{j,t}^N} \left(\frac{v^i q_t^i}{\sum_{i\in\Theta_{j,t}} v^i q_t^i}\right) \text{ and } W_t(\Theta_{j,t}^C) = \sum_{i\in\Theta_{j,t}^C} \left(\frac{v^i q_t^i}{\sum_{i\in\Theta_{j,t}} v^i q_t^i}\right).$$

Similarly, we may express the unit value price $P_{t-y}(\Theta_{j,t-y})$ as the weighted sum of the unit value price of the disappearing and incumbent products as:

$$P_{t-y}(\Theta_{j,t-y}) = W_{t-y}(\Theta_{j,t}^{O})P_{t-y}(\Theta_{j,t}^{O}) + W_{t-y}(\Theta_{j,t}^{C})P_{t-y}(\Theta_{j,t}^{C}),$$

where,

$$P_{t-y}(\Theta_{j,t}^{O}) = \sum_{i\in\Theta_{j,t}^{O}} \left(\frac{v^i q_{t-y}^i}{\sum_{i\in\Theta_{j,t}^{O}} v^i q_{t-y}^i}\right)\left(\frac{p_{t-y}^i}{v_i}\right),$$

$$P_{t-y}(\Theta_{j,t}^{C}) = \sum_{i\in\Theta_{j,t}^{C}} \left(\frac{v^i q_{t-y}^i}{\sum_{i\in\Theta_{j,t}^{C}} v^i q_{t-y}^i}\right)\left(\frac{p_{t-y}^i}{v_i}\right),$$

$$W_{t-y}(\Theta_{j,t}^{O}) = \sum_{i\in\Theta_{j,t}^{O}} \left(\frac{v^i q_{t-y}^i}{\sum_{i\in\Theta_{j,t}} v^i q_{t-y}^i}\right),$$

$$and$$

$$W_{t-y}(\Theta_{j,t}^{C}) = \sum_{i\in\Theta_{j,t}^{C}} \left(\frac{v^i q_{t-y}^i}{\sum_{i\in\Theta_{j,t-y}} v^i q_{t-y}^i}\right).$$

2.1.3. Price Change Rates

Using the unit value prices, we may now, for a given manufacturer, calculate the price change rates for: (1) all products; (2) new products against disappearing products; (3) incumbent goods. The corresponding expressions are:

$$\text{Price Change Rate (All Products)} = \frac{P_t(\Theta_{j,t}) - P_{t-y}(\Theta_{j,t-y})}{P_{t-y}(\Theta_{j,t-y})},$$

$$\text{Price Change Rate (New to Disappearing products)} = \frac{P_t(\Theta_{j,t}^{N}) - P_{t-y}(\Theta_{j,t}^{O})}{P_{t-y}(\Theta_{j,t}^{O})}$$

$$\text{Price Change Rate (Incumbent products)} = \frac{P_t(\Theta_{j,t}^{C}) - P_{t-y}(\Theta_{j,t}^{C})}{P_{t-y}(\Theta_{j,t}^{C})}$$

We compute unit value prices on a monthly basis while change rates are compared to the same month of the previous year. These price change rates are used to examine the impact of R&D activities on price setting by product manufacturers.

2.1.4. Relative Prices

Next, we compute the relative price of a given manufacturer against the general price for the product category. Suppose that the set of products made by manufacturer *j*, $\Theta_{j,t}$, is a subset of Θ_t for category Θ. We can then calculate the aggregate unit value price of category Θ in period *t* as follows:

$$P_t(\Theta_t) = \sum_{i\in\Theta_t} \left(\frac{v^i q_t^i}{\sum_{i\in\Theta_t} v^i q_t^i}\right)\left(\frac{p_t^i}{v_i}\right).$$

The corresponding relative prices for all products, new products, and incumbent products of category made by maker j in period t are given by:

$$\text{Relative Price (All Products)} = \frac{P_t(\Theta_{j,t})}{P_t(\Theta_t)}$$

$$\text{Relative Price (New Products)} = \frac{P_t(\Theta_{j,t}^N)}{P_t(\Theta_t)}$$

$$\text{Relative Price (Incumbent Products)} = \frac{P_t(\Theta_{j,t}^C)}{P_t(\Theta_t)}$$

These relative prices are also used to examine the impact of R&D activities on the price setting behavior of product manufacturers.

2.2. Patent Data

The Intellectual Property Patent Database (IIP-DB) was developed by the Institute of Intellectual Property from the Japan Patent Office (JPO) standardized database (Seiri Hyojunka data, in Japanese), which includes patent process information disclosed by the JPO. We use patent ratio data, namely, the ratio of the number of patent applications to number of researchers, as a proxy for R&D activity by a given product maker:

$$\text{Patent Ratio} = \frac{\text{number of patents}}{\text{number of researchers}}.$$

2.3. R&D Data

We use the data on Research and Development (R&D) Expenditures from the Survey of Research and Development (SRD) conducted by Japan's Bureau of Statistics and the Japanese Ministry of Internal affairs and Communications. We construct the R&D ratio, that is, the ratio of Internal R&D Expenditures to Sales, as another proxy for R&D activity by a product manufacturer:

$$\text{R\&D Ratio} = \frac{\text{R\&D Expenditure}}{\text{Sales}}.$$

2.4. Merging the Data

We merged datasets in following procedure. Firstly, harmonized Japanese firm name was obtained from the NISTEP corporate name dictionary. The dictionary includes disambiguated firms' names, firm identification code, corporate financial code, and changes of name. And the dictionary also provides a matching table between firm code and firm's patent application number. We matched corporate names in the Survey of Research and Development to firm names in the NISTEP corporate name dictionary. We then used the firm identification code to tie the firm to the relevant patenting data. Finally, we made exact match between firm name in SRI data and corporate name in NISTEP corporate name dictionary by financial corporate code, JICFS code of UPC. Under this procedure, we merge the SRI data, IIP Patent Database, and SRD to identify the relation between price setting behaviors and R&D activities by makers. Subsequently, price change rates and relative prices in the SRI are converted into yearly averages.

2.4.1. Summary Statistics

Table 1 shows the summary of statistics for the merged panel data. The data cover the period from 2002 to 2007. The number of price change rate observations for all products is about 49,000, the number of makers is about 12,000, and the average time range for makers is approximately 4 years. The number of observations of price change rates for new products to disappearing products is about 19,000, with approximately 6,000 product manufacturers, and an average time range for manufacturers of about 3 years. Patent ratio and R&D ratio include approximately 36,000 observations. Table 2 summarizes the number of observations, averages, and standard deviations of the variables by year.

Table 1: Panel Summary of the Dataset

Variable		Mean	Std. Dev.	Min	Max	Observations		
UVPI chg rate	overall	0.0023	0.0740	-0.3440	0.4512	N	=	49,317
	between		0.0584	-0.3440	0.4356	n	=	12,222
	within		0.0603	-0.3708	0.4208	T-bar	=	4.0351
UVPI chg rate (new on old)	overall	0.1386	0.4898	-0.8066	4.6532	N	=	18,690
	between		0.3850	-0.7873	4.2441	n	=	6,100
	within		0.3689	-2.3325	3.8582	T-bar	=	3.0639
UVPI chg rate (incumbent)	overall	-0.0023	0.0513	-0.3951	0.4540	N	=	48,441
	between		0.0478	-0.3438	0.4033	n	=	12,049
	within		0.0392	-0.3371	0.3961	T-bar	=	4.0203
UVPI relative price	overall	0.2356	0.6644	-4.7111	7.0132	N	=	49,317
	between		0.6864	-3.8519	6.6454	n	=	12,222
	within		0.1797	-3.6331	4.2568	T-bar	=	4.0351
UVPI relative price (new)	overall	-0.0893	0.9209	-5.0878	6.9282	N	=	26,482
	between		0.8528	-4.7111	6.9282	n	=	8,017
	within		0.5273	-5.2168	4.4748	T-bar	=	3.3032
UVPI relative price (incumbent)	overall	0.2001	0.7012	-4.5655	7.0132	N	=	48,441
	between		0.7133	-3.8519	6.6454	n	=	12,049
	within		0.2343	-3.6686	4.3448	T-bar	=	4.0203
patent ratio	overall	0.9669	1.4076	0.0010	36.0000	N	=	35,927
	between		1.5421	0.0010	36.0000	n	=	9,533
	within		0.3008	-1.3073	3.8013	T-bar	=	3.7687
R&D ratio	overall	0.0049	0.0332	0.0000	0.7959	N	=	35,927
	between		0.0245	0.0000	0.7959	n	=	9,533
	within		0.0272	-0.3808	0.6420	T-bar	=	3.7687

Table 2: Summary Statistics by Year

	UVPI chg rate	UVPI chg rate (new on old)	UVPI chg rate (incumbent)	UVPI relative price	UVPI relative price (new)	UVPI relative price (incumbent)	patent ratio	rd_ratio
				Observation				
CY2007	9637	3358	9469	9637	4976	9469	7052	7052
CY2008	8852	3439	8688	8852	4840	8688	6468	6468
CY2009	8221	3371	8036	8221	4571	8036	6110	6110
CY2010	7210	2854	7087	7210	3979	7087	5297	5297
CY2011	8307	3081	8190	8307	4353	8190	5828	5828
CY2012	7090	2587	6971	7090	3763	6971	5172	5172
Total	49317	18690	48441	49317	26482	48441	35927	35927
				Average				
CY2007	0.004	0.140	-0.003	0.236	-0.104	0.207	1.111	0.010
CY2008	0.017	0.175	0.007	0.238	-0.071	0.195	0.952	0.004
CY2009	0.006	0.153	-0.005	0.230	-0.053	0.181	1.028	0.003
CY2010	-0.007	0.136	-0.012	0.234	-0.099	0.204	0.967	0.004
CY2011	-0.001	0.126	-0.004	0.240	-0.083	0.210	1.109	0.003
CY2012	-0.009	0.086	-0.012	0.235	-0.134	0.205	0.555	0.004
Total	0.002	0.139	-0.004	0.236	-0.089	0.200	0.967	0.005
				Standard Deviation				
CY2007	0.072	0.489	0.057	0.658	0.910	0.683	1.608	0.074
CY2008	0.081	0.491	0.070	0.658	0.895	0.709	1.245	0.005
CY2009	0.078	0.484	0.063	0.667	0.922	0.718	1.445	0.004
CY2010	0.070	0.498	0.056	0.666	0.938	0.694	1.382	0.004
CY2011	0.069	0.515	0.055	0.665	0.921	0.693	1.579	0.005
CY2012	0.070	0.451	0.057	0.674	0.946	0.713	0.917	0.005
Total	0.074	0.490	0.061	0.664	0.921	0.701	1.408	0.033

2.4.2. Correlation between Variables

Table 3 provides the cross-correlation between the variables. There are different price behaviors for products by the same manufacturer. The correlation between the price change rates for all products and the price change rates for new to old products is positive but low. The correlation between the price change rates for incumbent products and the price change rates for new to old products is negative. R&D ratio and patent ratio have negative correlation.

Table 3: Pairwise Correlation between Variables

	UVPI chg rate	UVPI chg rate (new on old)	UVPI chg rate (incumbent)	UVPI relative price	UVPI relative price (new)	UVPI relative price (incumbent)	Patent ratio	R&D ratio
UVPI chg rate	1							
UVPI chg rate (new on old)	0.3752*	1						
UVPI chg rate (incumbent)	0.6155*	-0.0506*	1					
UVPI relative price	0.0256*	0.0768*	0.0220*	1				
UVPI relative price (new)	0.1654*	0.2639*	-0.0704*	0.5474*	1			
UVPI relative price (incumbent)	-0.0261*	0.0646*	0.0512*	0.9534*	0.4386*	1		
Patent ratio	-0.0446*	0.0328*	-0.054*	-0.0768*	-0.0446*	-0.0602*	1	
R&D ratio	-0.0055	0.0638*	0.001	0.0402*	0.0353*	0.0423*	-0.0326*	1

*Note: * shows statistical significance at the 0.05 probability level.*

3. Empirical Analysis

In this section, we implement several regression analyses on our dataset to understand how the R&D activities by a firm affect their pricing of the products included in the SRI data. As explained in section 2, we construct firm and category level unit value prices (UVPI), which are classified into 4 types: (1) UVPI of new goods; (2) UVPI of disappearing goods; (3) UVPI of incumbent goods; (4) UVPI of all goods. We are interested in the impact of the firm's R&D activities (R&D expenditures and Patent acquisitions) on price setting behaviors for all four UVPI categories. The impact of these activities on the pricing behavior for new goods is increasing relative to the disappearing goods or the general price level of all the commodities produced by a firm in the corresponding category. On the other hand, the impact of the activities on the price behavior of incumbent goods is decreasing relative to the past price of the goods or general price level of all the commodities produced in the category. So we assume 2 types of regression models: a price change model and a relative price model. The explained variables in the price change models are the price change rates of UVPI (all goods produced by the firm), UVPI (the new goods on the old goods of firm produced), and UVPI (incumbent goods produced by the firm). The explained variables in the relative price models are: relative unit value price of all goods of the firm produced against the unit value price of all goods of all firms produced in the category, relative unit value price of new goods of the firm produced against the unit value price of all goods of all firms produced in the category, relative unit value price of the incumbent goods of the firm produced against to the unit value price of all goods of all firms produced in the category.

3.1. Impact on Price Changes

3.1.1. Pooled Regression

Table 4 shows the results of a number of pooled regressions for price changes on the explanatory variables for R&D activities. We implement three types of estimation models for control variables; (1) only year dummies, (2) year dummies and store type dummies, (3) year dummies, store type dummies, and category dummies.

For the price change (all products) and price change (incumbent products), the coefficients of the patent ratio variable are significantly negative. However, the coefficients of the R&D ratio are not statistically significant in models (1), (2), and (3). For the price change (new on old products), the coefficients of patent ratio and R&D ratio are significantly positive in models (1) and (2). R&D activities have a positive impact on the price changes of the ratio of new to old products. On the other hand, R&D activities have a negative impact on the price changes of incumbent products due to demand substitution from incumbent to new products.

Table 4: Pooled Regression (Price Change Model)

Explained Variable	Change Rate of UVPI			Change Rate of UVPI (New on Old)			Change Rate of UVPI (Incumbent)		
Regression Model	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
ExplanatoryVariables									
patent_num/researchers	-0.00275***	-0.00277***	-0.00160***	0.00976***	0.00885***	0.00371	-0.00260***	-0.00262***	-0.00188***
	(0.000285)	(0.000285)	(0.000341)	(0.00264)	(0.00264)	(0.00353)	(0.000234)	(0.000234)	(0.000280)
total_rd_expense/sales	-0.0177	-0.0179	-0.00245	1.469***	1.447***	1.077***	-0.00384	-0.00415	-0.00167
	(0.0119)	(0.0119)	(0.0120)	(0.193)	(0.193)	(0.191)	(0.00971)	(0.00970)	(0.00980)
year_dummy2	0.0121***	0.0121***	0.0121***	0.0318**	0.0317**	0.0306**	0.00833***	0.00833***	0.00794***
	(0.00130)	(0.00130)	(0.00129)	(0.0131)	(0.0131)	(0.0128)	(0.00107)	(0.00107)	(0.00106)
year_dummy3	0.00128	0.00127	0.00115	0.00308	0.00220	-0.00524	-0.00369***	-0.00369***	-0.00396***
	(0.00132)	(0.00132)	(0.00131)	(0.0132)	(0.0131)	(0.0129)	(0.00109)	(0.00109)	(0.00108)
year_dummy4	-0.0112***	-0.0113***	-0.0112***	0.00423	0.00320	-0.00756	-0.00877***	-0.00884***	-0.00884***
	(0.00137)	(0.00137)	(0.00137)	(0.0140)	(0.0139)	(0.0137)	(0.00113)	(0.00113)	(0.00112)
year_dummy5	-0.00330**	-0.00334**	-0.00325**	-0.0245*	-0.0251*	-0.0204	-0.000103	-0.000149	-0.000411
	(0.00133)	(0.00133)	(0.00133)	(0.0136)	(0.0136)	(0.0133)	(0.00110)	(0.00110)	(0.00109)
year_dummy6	-0.0136***	-0.0136***	-0.0126***	-0.0373***	-0.0386***	-0.0397***	-0.00958***	-0.00963***	-0.00947***
	(0.00139)	(0.00139)	(0.00139)	(0.0143)	(0.0143)	(0.0140)	(0.00114)	(0.00114)	(0.00114)
sc_dummy2		0.00285**	0.00253**		-0.00174	0.00420		0.00384***	0.00351***
		(0.00117)	(0.00116)		(0.0114)	(0.0110)		(0.000962)	(0.000950)
sc_dummy3		0.00500***	0.00558***		0.0269**	0.00286		0.00635***	0.00678***
		(0.00118)	(0.00117)		(0.0116)	(0.0113)		(0.000972)	(0.000962)
sc_dummy4		0.00832***	0.00811***		-0.0417**	-0.0173		0.00975***	0.00924***
		(0.00155)	(0.00156)		(0.0168)	(0.0167)		(0.00129)	(0.00129)
sc_dummy5		0.00618***	0.00596***		0.0371***	0.0369***		0.00438***	0.00405***
		(0.00118)	(0.00117)		(0.0118)	(0.0114)		(0.000974)	(0.000963)
Constant	0.00666***	0.00279**	-0.00986**	0.112***	0.102***	0.0179	0.000215	-0.00391***	-0.0116***
	(0.000958)	(0.00120)	(0.00431)	(0.0100)	(0.0123)	(0.0415)	(0.000789)	(0.000987)	(0.00356)
Observations	35,199	35,199	35,199	13,806	13,806	13,806	34,510	34,510	34,510
R-squared	0.015	0.016	0.043	0.007	0.010	0.093	0.012	0.015	0.047
Store Type Dummy		YES	YES		YES	YES		YES	YES
Category Dummy			YES			YES			YES

Note: Standard errors in parentheses. The asterisks *, **, and *** show statistical significance at the 0.1, 0.05, and 0.01 probability levels, respectively.

3.1.2. Panel Regression with Lag zero

Next, we implement panel regressions for our dataset in order to take advantage of our panel data. We implement three types of estimation models: between effects (BE) model, fixed effects (FE) model, and random effects (RE) model. We subsequently perform model selection tests. Table 5 shows the results of the panel regressions. The model selection tests imply that fixed effect models are suitable for the regressions of the price change rates for all products, the ratio of new to old products, and the incumbent products. For price changes of all products and incumbent products, the coefficients of the R&D activity proxies are not significant in these fixed effect models. For the price changes of the ratio of new to old products, the coefficient of the patent ratio is estimated to be significantly positive. However, the coefficient of the R&D ratio is not significant, indicating that R&D activities have only a limited positive impact on pricing with product turnover.

Table 5: Panel Regression with Lag 0 (Price Change Model)

Explained Variable	Change Rate of UVPI (Total)			Change Rate of UVPI (New on Old)			Change Rate of UVPI (Imcumbent)		
Regression Model	BE	FE	RE	BE	FE	RE	BE	FE	RE
ExplanatoryVariables									
patent_num/researchers	-0.00224***	0.00146	-0.00216***	0.00901**	0.0333**	0.0109***	-0.00203***	-0.00107	-0.00219***
	(0.000420)	(0.00135)	(0.000374)	(0.00380)	(0.0130)	(0.00331)	(0.000369)	(0.00108)	(0.000329)
total_rd_expense/sales	0.0160	-0.00872	-0.00930	1.661***	0.0816	1.214***	0.0440**	-0.00435	0.000575
	(0.0237)	(0.0138)	(0.0119)	(0.202)	(0.330)	(0.194)	(0.0207)	(0.0110)	(0.00966)
year_dummy2	0.0121***	0.0125***	0.0122***	0.0246	0.0315**	0.0305**	0.00420	0.00880***	0.00843***
	(0.00409)	(0.00130)	(0.00121)	(0.0282)	(0.0133)	(0.0121)	(0.00353)	(0.00105)	(0.000977)
year_dummy3	-0.00827*	0.00141	0.00124	0.0167	-0.00557	-0.000415	-0.00918**	-0.00291***	-0.00337***
	(0.00436)	(0.00133)	(0.00123)	(0.0274)	(0.0136)	(0.0122)	(0.00382)	(0.00107)	(0.000999)
year_dummy4	0.00142	-0.0117***	-0.0114***	0.0505	-0.0122	-0.00278	-0.00472	-0.00834***	-0.00862***
	(0.00449)	(0.00142)	(0.00129)	(0.0313)	(0.0146)	(0.0130)	(0.00395)	(0.00114)	(0.00105)
year_dummy5	0.00839**	-0.00480***	-0.00400***	-0.00641	-0.0267*	-0.0261**	-3.25e-05	0.000181	-0.000127
	(0.00329)	(0.00142)	(0.00126)	(0.0275)	(0.0147)	(0.0128)	(0.00288)	(0.00114)	(0.00102)
year_dummy6	-0.0169***	-0.0116***	-0.0131***	-0.0496*	-0.0353**	-0.0414***	-0.0145***	-0.00721***	-0.00846***
	(0.00324)	(0.00154)	(0.00132)	(0.0267)	(0.0164)	(0.0135)	(0.00283)	(0.00124)	(0.00107)
Constant	0.00230	0.00248	0.00530***	0.0977***	0.0957***	0.112***	-0.000441	-0.00195	-0.00122
	(0.00199)	(0.00179)	(0.00102)	(0.0175)	(0.0190)	(0.0103)	(0.00174)	(0.00144)	(0.000867)
Observations	35,199	35,199	35,199	13,806	13,806	13,806	34,510	34,510	34,510
Number of maker_id	9,468	9,468	9,468	4,649	4,649	4,649	9,328	9,328	9,328
Within R-squared	0.00468	0.0164	0.0160	0.00118	0.00451	0.00303	0.00685	0.0118	0.0117
Between R-squared	0.00877	0.00101	0.00536	0.0182	0.00235	0.0166	0.00787	0.00570	0.00640
Overall R-squared	0.00622	0.00881	0.0144	0.00627	0.00247	0.00733	0.00886	0.0113	0.0124
sigma_u		0.0595	0.0384		0.380	0.220		0.0518	0.0371
sigma_e		0.0700	0.0700		0.421	0.421		0.0558	0.0558
F-test for that all u_i=0		1.49***			1.64***			1.70***	
Hausman Test		36.06***			28.36**			12.52*	
Breusch-Pagan LM Test		90.28***			398.09***			181.01***	

Note: Standard errors in parentheses. The asterisks *, **, and *** show statistical significance at the 0.1, 0.05, and 0.01 probability levels, respectively.

3.1.3. Panel Regression with Lag one

To consider the gestation period corresponding to the launch of a new product at the retail store level, we estimate models with a one period lag in the explanatory variables.

Table 6 shows the results of the panel regression on patent and R&D ratios with one year lags. The model selection tests imply that fixed effect models are more suitable for the regressions of the price change rates of all products, new to old products, and incumbent products. The coefficient of patent ratio for the fixed effects model of incumbent products is found to be significantly negative. It is likely that the patent acquisitions leading to the launch of new products lead to a price reduction of the incumbent goods. The coefficient of the R&D ratio for price changes of the ratio of new to old products is significantly negative. However, it is hard to explain the meaning of this result f.

Table 6: Panel Regression with Lag One (Price Change Model)

Explained Variable	Change Rate of UVPI (Total)			Change Rate of UVPI (New on Old)			Change Rate of UVPI (Imcumbent)		
Regression Model	BE	FE	RE	BE	FE	RE	BE	FE	RE
ExplanatoryVariables									
L. patent_num/researchers	-0.00266***	-0.00238	-0.00283***	0.00243	-0.00690	0.00379	-0.00312***	-0.00279*	-0.00300***
	(0.000443)	(0.00179)	(0.000394)	(0.00405)	(0.0176)	(0.00360)	(0.000379)	(0.00145)	(0.000338)
L. total_rd_expense/sales	-0.0511	-0.00738	-0.0135	0.648*	-1.343***	-0.411*	-0.0122	0.00184	-0.000174
	(0.0358)	(0.0141)	(0.0126)	(0.366)	(0.304)	(0.236)	(0.0304)	(0.0113)	(0.0102)
year_dummy3	0.0101**	-0.0128***	-0.0107***	-0.0681**	-0.0370***	-0.0366***	0.0119***	-0.0127***	-0.0109***
	(0.00416)	(0.00142)	(0.00129)	(0.0278)	(0.0136)	(0.0121)	(0.00354)	(0.00116)	(0.00105)
year_dummy4	-0.0279***	-0.0260***	-0.0248***	-0.0207	-0.0498***	-0.0431***	-0.0110***	-0.0186***	-0.0173***
	(0.00356)	(0.00144)	(0.00131)	(0.0284)	(0.0143)	(0.0127)	(0.00305)	(0.00117)	(0.00106)
year_dummy5	-0.00142	-0.0211***	-0.0189***	0.00443	-0.0718***	-0.0592***	-0.00611**	-0.0107***	-0.00974***
	(0.00360)	(0.00152)	(0.00135)	(0.0300)	(0.0151)	(0.0131)	(0.00302)	(0.00123)	(0.00109)
year_dummy6	-0.00727**	-0.0301***	-0.0268***	-0.0991***	-0.0858***	-0.0845***	-0.00809***	-0.0195***	-0.0182***
	(0.00296)	(0.00162)	(0.00138)	(0.0256)	(0.0162)	(0.0134)	(0.00252)	(0.00131)	(0.00112)
Constant	0.0101***	0.0226***	0.0209***	0.162***	0.186***	0.167***	0.000276	0.0107***	0.00914***
	(0.00177)	(0.00235)	(0.00107)	(0.0156)	(0.0246)	(0.0103)	(0.00151)	(0.00192)	(0.000899)
Observations	25,732	25,732	25,732	10,887	10,887	10,887	25,274	25,274	25,274
Number of maker_id	7,959	7,959	7,959	4,089	4,089	4,089	7,842	7,842	7,842
Within R-squared	0.00782	0.0272	0.0270	0.000305	0.00798	0.00649	0.00213	0.0190	0.0189
Between R-squared	0.0140	0.00731	0.00817	0.00534	8.81e-05	0.00134	0.0156	0.0102	0.0110
Overall R-squared	0.00934	0.0209	0.0214	0.00149	0.00133	0.00362	0.00625	0.0174	0.0177
sigma_u		0.0590	0.0347		0.394	0.237		0.0500	0.0321
sigma_e		0.0692	0.0692		0.419	0.419		0.0555	0.0555
F-test for that all u_i=0		1.39 ***			1.67***			1.51***	
Hausman Test		55.06***			32.36***			36.69***	
Breusch-Pagan LM Test		58.12***			298.02***			89.20***	

Note: Standard errors in parentheses. The asterisks *, **, and *** show statistical significance at the 0.1, 0.05, and 0.01 probability levels, respectively.

3.2. Impact on Relative Prices

3.2.1. Pooled Regression

Table 7 shows the results of the pooled regression estimation for relative prices. All the coefficients of patent ratio are significantly negative. While the coefficients of the R&D ratio are positive for models (1) and (2) and all explained variables, these coefficients are significant positive in model (3) only for the relative price of new products. The coefficients of the R&D ratio for relative price of new products are higher than those for the relative price of incumbent products. The impact of R&D activities on relative prices is relatively large for new products.

Table 7: Pooled Regressions (Relative Price Model)

Explained Variable	Relative UVPI			Relative UVPI (New Product)			Change Rate of UVPI (Incumbent)		
Regression Model	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
ExplanatoryVariables									
patent_num/researchers	-0.0355***	-0.0354***	-0.0684***	-0.0281***	-0.0292***	-0.0255***	-0.0288***	-0.0285***	-0.0690***
	(0.00253)	(0.00252)	(0.00272)	(0.00449)	(0.00448)	(0.00528)	(0.00270)	(0.00269)	(0.00292)
total_rd_expense/sales	0.742***	0.725***	0.0786	1.724***	1.683***	0.962***	0.827***	0.811***	0.0544
	(0.106)	(0.105)	(0.0960)	(0.356)	(0.355)	(0.329)	(0.112)	(0.112)	(0.103)
year_dummy2	0.00326	0.00210	-0.0161	0.0445**	0.0431**	0.0255	-0.0171	-0.0183	-0.0380***
	(0.0115)	(0.0115)	(0.0103)	(0.0215)	(0.0214)	(0.0195)	(0.0124)	(0.0123)	(0.0111)
year_dummy3	0.00153	-0.000528	-0.0171	0.0612***	0.0586***	0.0354*	-0.0237*	-0.0260**	-0.0448***
	(0.0117)	(0.0117)	(0.0105)	(0.0217)	(0.0216)	(0.0197)	(0.0126)	(0.0125)	(0.0113)
year_dummy4	-0.000484	-0.00157	-0.0381***	0.0106	0.00872	-0.0540***	0.00220	0.00102	-0.0386***
	(0.0122)	(0.0121)	(0.0109)	(0.0228)	(0.0227)	(0.0209)	(0.0131)	(0.0130)	(0.0118)
year_dummy5	-0.0237**	-0.0243**	-0.0260**	-0.00775	-0.00881	-0.0255	-0.0273**	-0.0281**	-0.0286**
	(0.0118)	(0.0118)	(0.0106)	(0.0223)	(0.0222)	(0.0204)	(0.0127)	(0.0126)	(0.0114)
year_dummy6	-0.00393	-0.00494	-0.0343***	-0.0260	-0.0294	-0.0528**	0.00625	0.00525	-0.0314***
	(0.0123)	(0.0123)	(0.0111)	(0.0232)	(0.0232)	(0.0213)	(0.0132)	(0.0131)	(0.0119)
sc_dummy2		0.0367***	0.0457***		0.0207	0.0291*		0.0353***	0.0460***
		(0.0103)	(0.00923)		(0.0190)	(0.0172)		(0.0111)	(0.00994)
sc_dummy3		0.0706***	0.0428***		0.0520***	0.0133		0.0705***	0.0387***
		(0.0104)	(0.00934)		(0.0192)	(0.0175)		(0.0112)	(0.0101)
sc_dummy4		-0.110***	-0.132***		-0.203***	-0.327***		-0.115***	-0.135***
		(0.0137)	(0.0124)		(0.0266)	(0.0246)		(0.0148)	(0.0135)
sc_dummy5		0.119***	0.116***		0.0870***	0.0785***		0.120***	0.116***
		(0.0105)	(0.00935)		(0.0194)	(0.0176)		(0.0112)	(0.0101)
Constant	0.268***	0.228***	-0.0275	-0.0844***	-0.101***	-0.428***	0.229***	0.189***	-0.115***
	(0.00851)	(0.0106)	(0.0344)	(0.0162)	(0.0200)	(0.0651)	(0.00911)	(0.0114)	(0.0372)
Observations	35,199	35,199	35,199	19,335	19,335	19,335	34,510	34,510	34,510
R-squared	0.008	0.017	0.222	0.004	0.011	0.200	0.006	0.014	0.212
Store Type Dummy		YES	YES		YES	YES		YES	YES
Category Dummy			YES			YES			YES

Note: Standard errors in parentheses. The asterisks *, **, and *** show statistical significance at the 0.1, 0.05, and 0.01 probability levels, respectively.

3.2.2. Panel Regression with Lag Zero

Table 8 shows the results of the panel regression for the relative price models. The model selection tests imply that fixed effect models are better suited for the regressions of the price change rates of all products, new on old products, and incumbent products. However, only the coefficient of the patent ratio for the relative price of incumbent products is significantly positive at the 10% level in the fixed effect models. Other coefficients of R&D activities are not significant in the fixed effect models.

In the BE models, the coefficients of the R&D ratio are found to be significantly positive significantly, similarly to the results of models (1) and (2) in the pooled regressions. This implies the possibility that continuing R&D expenditure may be related to higher quality products. Results of the BE models show that the inter-manufacturer impact of patent ratio is negative on price changes for all products and incumbent products.

Table 8: Panel Regressions with Lag Zero (Relative Price Model)

Explained Variable	Relative UVPI (Total)			Relative UVPI (New Goods)			Relative UVPI (Imcumbent Goods)		
Regression Model	BE	FE	RE	BE	FE	RE	BE	FE	RE
ExplanatoryVariables									
patent_num/researchers	-0.0236***	0.00427	-0.0104***	-0.0214***	0.0123	-0.0204***	-0.0178***	0.00436	-0.0126***
	(0.00486)	(0.00399)	(0.00302)	(0.00764)	(0.0158)	(0.00661)	(0.00510)	(0.00534)	(0.00360)
total_rd_expense/sales	1.157***	-0.0705*	-0.0447	2.289***	-0.0352	0.763**	1.335***	-0.0829	-0.0349
	(0.275)	(0.0408)	(0.0404)	(0.492)	(0.385)	(0.312)	(0.287)	(0.0543)	(0.0533)
year_dummy2	0.0751	-0.00399	-0.00572	0.161***	0.0125	0.0212	0.0526	-0.0266***	-0.0284***
	(0.0473)	(0.00385)	(0.00382)	(0.0607)	(0.0161)	(0.0154)	(0.0489)	(0.00518)	(0.00511)
year_dummy3	0.0940*	-0.00302	-0.00416	0.221***	0.00913	0.0248	0.0984*	-0.0313***	-0.0323***
	(0.0505)	(0.00394)	(0.00391)	(0.0590)	(0.0165)	(0.0158)	(0.0529)	(0.00530)	(0.00525)
year_dummy4	-0.0279	0.00504	0.00218	0.0761	-0.0565***	-0.0429**	-0.0204	0.00599	0.00245
	(0.0520)	(0.00420)	(0.00415)	(0.0655)	(0.0177)	(0.0168)	(0.0547)	(0.00564)	(0.00554)
year_dummy5	-0.0682*	0.0112***	0.00660	0.0829	-0.0626***	-0.0506***	-0.118***	0.0142**	0.00771
	(0.0381)	(0.00421)	(0.00413)	(0.0548)	(0.0178)	(0.0165)	(0.0398)	(0.00564)	(0.00549)
year_dummy6	0.0171	0.00914**	0.00291	0.260***	-0.108***	-0.0867***	0.0373	0.0117*	0.00446
	(0.0375)	(0.00457)	(0.00442)	(0.0528)	(0.0196)	(0.0174)	(0.0392)	(0.00614)	(0.00585)
Constant	0.252***	0.227***	0.259***	-0.289***	-0.0750***	-0.121***	0.208***	0.196***	0.224***
	(0.0230)	(0.00530)	(0.00823)	(0.0338)	(0.0227)	(0.0165)	(0.0241)	(0.00713)	(0.00908)
Observations	35,199	35,199	35,199	19,335	19,335	19,335	34,510	34,510	34,510
Number of maker_id	9,468	9,468	9,468	6,140	6,140	6,140	9,328	9,328	9,328
Within R-squared	0.000701	0.000949	0.000478	0.000222	0.00579	0.00484	0.00267	0.00500	0.00454
Between R-squared	0.00757	0.00636	0.00308	0.0103	0.00272	0.00165	0.00741	0.00468	0.00115
Overall R-squared	0.00386	0.00499	0.00445	0.00143	1.31e-05	0.00319	0.00184	0.000259	0.00242
sigma_u		0.689	0.673		0.851	0.727		0.720	0.694
sigma_e		0.208	0.208		0.619	0.619		0.276	0.276
F-test for that all u_i=0		35.06 ***			4.65***			21.29***	
Hausman Test		68.79***			60.28***			73.12***	
Breusch-Pagan LM Test		41741.87***			6455.50***			35248.65***	

Note: Standard errors in parentheses. The asterisks *, **, and *** show statistical significance at the 0.1, 0.05, and 0.01 probability levels, respectively.

3.2.3. Panel Regression with Lag One

Table 9 shows the results of the panel regression for the relative price models with one period lag in the explanatory variables. The model selection tests imply that fixed effect models are better suited for the regressions of the price change rates for all products, new to old products, and incumbent products. The coefficient of the R&D ratio is significantly negative. The coefficient of the R&D ratio for the relative price of new products is significantly negative. However, it is difficult to explain the meaning of this result in economic terms.

Table 9: Panel Regression with Lag One (Relative Price Model)

Explained Variable	Relative UVPI (Total)			Relative UVPI (New Goods)			Relative UVPI (Imcumbent Goods)		
Regression Model	BE	FE	RE	BE	FE	RE	BE	FE	RE
ExplanatoryVariables									
L. patent_num/researchers	-0.0280***	-0.00253	-0.0178***	-0.0255***	0.00901	-0.0226***	-0.0218***	-0.00241	-0.0202***
	(0.00506)	(0.00475)	(0.00342)	(0.00796)	(0.0208)	(0.00726)	(0.00536)	(0.00695)	(0.00418)
L. total_rd_expense/sales	2.604***	-0.0342	-0.0125	1.946**	-1.332***	-0.611	2.988***	-0.00877	0.0376
	(0.409)	(0.0375)	(0.0374)	(0.820)	(0.425)	(0.379)	(0.430)	(0.0544)	(0.0540)
year_dummy3	0.0440	-0.00158	-0.00408	0.157**	-0.0245	-0.0140	0.0446	-0.00498	-0.00808
	(0.0475)	(0.00378)	(0.00372)	(0.0625)	(0.0166)	(0.0156)	(0.0500)	(0.00555)	(0.00542)
year_dummy4	-0.0520	0.00593	0.00416	-0.0815	-0.0868***	-0.0753***	-0.0329	0.0277***	0.0250***
	(0.0407)	(0.00383)	(0.00380)	(0.0571)	(0.0172)	(0.0163)	(0.0431)	(0.00561)	(0.00553)
year_dummy5	0.105**	0.00937**	0.00671*	0.373***	-0.0870***	-0.0579***	0.0778*	0.0369***	0.0329***
	(0.0411)	(0.00404)	(0.00397)	(0.0584)	(0.0183)	(0.0169)	(0.0428)	(0.00592)	(0.00575)
year_dummy6	-0.105***	0.00742*	0.00171	-0.0553	-0.142***	-0.135***	-0.133***	0.0374***	0.0282***
	(0.0338)	(0.00429)	(0.00416)	(0.0512)	(0.0194)	(0.0173)	(0.0357)	(0.00629)	(0.00599)
Constant	0.260***	0.226***	0.256***	-0.216***	-0.0366	-0.0785***	0.209***	0.170***	0.197***
	(0.0203)	(0.00625)	(0.00881)	(0.0313)	(0.0292)	(0.0175)	(0.0214)	(0.00920)	(0.00990)
Observations	25,732	25,732	25,732	14,794	14,794	14,794	25,274	25,274	25,274
Number of maker_id	7,959	7,959	7,959	5,302	5,302	5,302	7,842	7,842	7,842
Within R-squared	5.02e-05	0.000764	0.000436	3.35e-05	0.00894	0.00803	0.000324	0.00565	0.00519
Between R-squared	0.0139	0.00176	0.00562	0.0135	0.000684	0.00164	0.0132	0.000271	0.00279
Overall R-squared	0.00484	0.00209	0.00752	0.00241	0.000128	0.00302	0.00348	0.000586	0.00452
sigma_u		0.674	0.658		0.876	0.752		0.710	0.681
sigma_e		0.184	0.184		0.600	0.600		0.266	0.266
F-test for that all u_i=0		38.17***			4.66***			19.68***	
Hausman Test		86.75***			76.38***			90.39***	
Breusch-Pagan LM Test		26613.75***			4292.82***			21952.69***	

Note: Standard errors in parentheses. The asterisks *, **, and *** show statistical significance at the 0.1, 0.05, and 0.01 probability levels, respectively.

4. Discussion

4.1. Impact of R&D and Patent Acquisitions on Price Changes

According to the results of the fixed effect regression, patent acquisition has a significantly positive impact on price changes with product turnover. The results of the pooling regression indicate that R&D activities lead to an increase in the price change rates with product turnover. On the other hand, R&D activities reduce the price change rates of incumbent products, most likely through demand substitution. Since the negative impact of R&D expenditure on price changes of new to old products is hard to interpret economically, additional research is needed in terms of the gestation period for the launch of new products after R&D expenditures.

4.2. Impact of R&D and Patent Acquisitions on Relative Prices

According to the results of the pooling regression, patent acquisition has a significantly negative impact and R&D expenditures have a significant positive impact on the relative prices for new and incumbent products. The results of the fixed effects regression indicate that R&D activities do not have a sufficiently strong impact on relative prices. However, the results of the BE regression show that higher R&D ratios are related to higher relative prices of the new and incumbent goods. R&D intensive firms may therefore have high quality products without distinguishing between new and incumbent products.

5. Conclusion

The purpose of this study is to examine the relationship between R&D activities and the prices of products with product turnovers. It is found that quality improvements are promoted by the R&D activities by maker firms. Hence, empirical research on the relationship between R&D activities and price setting with product turnover provides important clues regarding the measurement of the impact of quality changes on price changes.

In order to examine the effect of R&D activities on price changes in sales data, we implement an empirical analysis of a combined dataset containing weekly POS data, patent database (IIP-DB) data, and Survey of Research and Development data. This study provides some basic facts concerning the relationship between price changes with product turnover and R&D activity, including patent acquisition. Using our dataset, we use pooling and panel regression. As a result of the analysis, we find that while the effect of the price increase due to the new product introduction is observed to result from R&D behavior, a negative effect on the price of the incumbent product is observed. In addition, the relative prices of new products and incumbent products tend to be high in companies with significant R&D expenditures. It is suggested that ongoing R&D activity is necessary to keep introducing high value products when prices are under pressure.

The difficulty in the economic interpretation of the results for the panel regression with one period lag in the explanatory variables presents us with the next issue to address, namely, research on the product gestation period using POS data and the patent database.

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