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MEASURING THE COST OF LIVING INDEX, OUTPUT GROWTH, AND PRODUCTIVITY GROWTH IN THE RETAIL INDUSTRY: AN APPLICATION TO JAPAN

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This study applies a framework that enables one to estimate quality, exact cost of living (COL) indexes, and output growth for the retail industry. The framework is based on discrete choice theory, in which product differentiation and quality change are explicitly modeled. For illustration, the framework is then applied to the Japanese retail industry. The estimated quality index shows that, between 1985 and 1999, Japanese retail services quality improved, and the estimated COL index declined monotonically. Furthermore, the results from growth accounting suggest that ignoring both differentiation in the retail services market and changes in service quality may downwardly bias estimated output and productivity growth.

1. Introduction

This study applies the framework of Feenstra (1995) to estimate quality, exact cost of living (COL) indexes, and output growth in the retail industry. For empirical studies of service industries, the appropriate definition of services output and accurate measures of the corresponding price indexes are crucial. In disputes about the *productivity paradox*, for example, some researchers have pointed out that mismeasurement of services output and prices has led to negative correlations between the productivity of service industries and IT use. This is because most IT investment has been undertaken in the services sector, for example in retail trade, finance, insurance, real estate, and leasing.[1]

As Utsunomiya (2004) pointed out, the hedonic method is commonly used in official statistics. However, when using the hedonic method, it is difficult to account adequately for imperfect competition, which is typical in services markets,

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[1]For discussion of the *productivity paradox*, see Triplett (1999). Many researchers have tried to measure the productivity of service industries. For example, Berger and Humphrey (1992) reviewed definitions of output in the commercial banking sector. Studies of other service industries are Sherwood's (1999) study of property and casualty insurance services, Bernstein's (1999) study of the Canadian life insurance industry, and Nakamura's (1999) study of retail services. Studies of Japanese service industries include Nakajima's (2001) study of property and casualty insurances, orchestra performance services, and railway services, Omori and Nakajima's (2000) study of commercial banking, Matsuura and Nakajima's (2002a, 2002b) studies of retail services, and Utsunomiya's (2004) study of railway services.

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particularly in the retail services market. As Davis (2006) and Nakamura (1999) pointed out, retailers usually have some market power because they supply differentiated services: when consumers go shopping, they choose certain stores based on such factors as their location, hours of operation, and the range of products sold.

The framework of this study is based on consumer discrete choice theory, in which product differentiation, imperfect competition, and quality change are explicitly modeled. The advantage of this framework is that, under some assumptions, it enables one to recover the model parameters from aggregated data. In addition, the demand model employed in this framework exhibits other special features: although previous studies have used the multinomial logit (MNL) model, which implies that consumers are constrained to buy only a single unit of the product they choose, this framework is based on constant elasticity of substitution (CES)-type consumer preferences, under which consumers are not restricted in this way. Another advantage of using this framework is that the social welfare and expenditure functions can be used to construct an exact COL index.

For illustrative purposes, the framework is applied to the Japanese retail industry. To my knowledge, this study may be the first to apply the CES model of Feenstra (1995) to the retail industry.[2] Feenstra (1995) argues that a log-linear hedonic regression, which is derived from the CES model, overstates the marginal values of characteristics, and biases the hedonic price index downwards. To overcome this problem, in this paper, I explicitly model the supply side, and estimate a market model (that is, a supply and demand model) of retail trade, explicitly deriving the closed-form pricing function based on the assumption of Bertrand competition among retailers.

The estimated quality index shows that Japanese retail services quality improved between 1985 and 1999. In addition, the estimated COL index, adjusted for quality, declined monotonically but gradually. In addition, I conduct growth accounting analysis by using sales data, the COL index, and data from the JIP Database.[3] To be specific, I compare productivity growth based on the estimated COL index with the corresponding measure from the JIP Database, which does not incorporate product differentiation, imperfect competition, and quality change in retail trade services. According to my indexes, productivity exceeds the levels implied by the JIP indexes. These results indicate that ignoring both the differentiation in the retail services market and changes in retail services quality may downwardly bias estimates of output and productivity growth.

This paper is organized as follows. In Section 2, the measurement framework used by Feenstra (2005) is briefly described, and I derive the market model of retail trade. In Section 3, I discuss econometric and data issues, and report the estimation results from the market model. In Section 4, a COL index for Japanese retail

[2]Nevo (2003) applied the logit model with random coefficients to the U.S. breakfast cereal market.

[3]The JIP Database is a comprehensive database of the Japanese economy, which is suitable for measuring total factor productivity (TFP) growth in the Japanese economy by industry. It is compiled by the research group at the Economics and Social Research Institute, Cabinet Office, Government of Japan, and contains information on 84 industrial sectors from 1970 to 1998. The database has detailed data on capital and labor inputs, annual input–output tables, and various deflators, and information on, for example, R&D stocks and trade. For more details of the JIP Database, see Fukao *et al*. (2003).

services is estimated and growth accounting analysis is conducted. In Section 5, I check the robustness of the empirical results by relaxing the assumption of the substitution patterns implied by the CES approach. In Section 6, I discuss some controversial issues inherent in the framework used in this study. The final section concludes the paper.

2. The Model

2.1. *Demand Side*

The framework of this study relies on the CES model of Feenstra (1995). The model explicitly incorporates product differentiation, imperfect competition, and quality change. The model is frequently applied to product differentiation theory because of its simplicity.[4] It is well known that the CES demand system can be derived from a particular discrete choice model.

There are M statistically independent and identically distributed (i.i.d.) consumers. Each consumer has an income of b and purchases a certain variant, but is not constrained to purchase a single unit of this variant. Thus, although the discrete choice nature of consumer behavior is incorporated, consumers can buy variable amounts of the variants chosen. This setup differs from that on which the MNL model is based, and seems appropriate for modeling retail services.

It is assumed that the conditional direct utility of consumer i, who buys variant j, is as follows:

$$u_{ij} = \frac{\alpha}{\mu}\ln x_0 + \frac{1}{\mu}\ln\left(x_j q_j\right) + \varepsilon_{ij}, \tag{1}$$

where $\mu > 0$ and $\alpha > 0$. The subscripts $j = 1, \ldots, N$ denote variants (types of business in the case of retail trade, such as department stores or convenience stores) of the differentiated product, and the subscript 0 represents the numeraire good. In addition, q_j represents the quality of variant j, x_j is the amount of variant j purchased by the consumer, x_0 is consumption of the numeraire good, and ε is an i.i.d. random variable. Consumers maximize this utility function subject to the following budget constraint:

$$b = x_0 + p_j x_j. \tag{2}$$

Given that the consumer selects variant j, the conditional demand of variant j and that of the numeraire good, respectively, are:

$$x_j = \frac{1}{1+\alpha}\frac{b}{p_j}, \tag{3}$$

$$x_0 = \frac{\alpha}{1+\alpha} b. \tag{4}$$

[4]The model used in this section is based on those of Anderson *et al.* (1992) and Feenstra (1995).

Substituting both demand functions into the direct utility function yields the following indirect utility function:

$$(5) \qquad v_{ij} = \frac{1}{\mu}\left[(1+\alpha)\ln b - \ln\left(\frac{p_j}{q_j}\right) + \alpha\ln\alpha - (1+\alpha)\ln(1+\alpha)\right] + \varepsilon_{ij}.$$

It is assumed that ε conforms to the type-I extreme-value distribution.[5] Consumers choose the variants that maximize their utility, which depends on the value of ε. Maximization yields the following expected demand function of brand j and that of the numeraire good:

$$(6) \qquad X_j = Mx_jP_j = M\frac{y}{p_j}\frac{(p_j/q_j)^{-1/\mu}}{\sum_{k=1}^{N}(p_k/q_k)^{-1/\mu}},$$

$$(7) \qquad X_0 = \alpha My,$$

where $y = b/(1 + \alpha)$ is the income spent on variant j by the consumer who chooses that variant. P_j represents the probability that variant j is chosen. This means that MP_j (of M) consumers choose variant j and each of them purchases x_j units of j.

Rearranging (6) yields the following sales (that is, expenditure) share function for variant j:

$$(8) \qquad S_j \cong \frac{p_jX_j}{My} = P_j = \frac{(p_j/q_j)^{-1/\mu}}{\sum_{k=1}^{N}(p_k/q_k)^{-1/\mu}}.$$

Equations (6) and (8) imply the following own-price and cross-price elasticities:

$$(9) \qquad \eta_{jr} = \begin{cases} -[(1-S_r)/\mu + 1], & \text{if } j = r \\ S_r/\mu & \text{if } j \neq r \end{cases}.$$

The elasticity of substitution is $\sigma = (1/\mu) + 1$. When $\mu > 0$, equation (9) is valid. The ratio of the demands for two different variants depends only on their relative price and is independent of all other prices. This property of the CES model is similar to the assumption of the independence of irrelevant alternatives in the MNL model.

2.2. *Supply Side*

It is assumed that each of the N variants is produced by a particular monopolistic firm, so there are N firms. However, variants are substitutes for each other.[6] For simplicity, the cost function has a linear form. Total cost is the sum of variable

[5]As demonstrated by Berry (1994), this assumption facilitates solving the model analytically.

[6]This is rather restrictive. In other empirical work based on discrete choice models, market structures are more complicated. In the models developed by, for example, Berry (1994), Berry *et al.* (1995), Bresnahan *et al.* (1997), and Petrin (2002), a particular firm produces a subset of the N variants. However, given the aim of this study, this simple model is sufficient.

and fixed costs, and marginal cost is independent of output. The firm producing brand j solves the following profit maximization problem:

$$\max \pi_j = (p_j - c_j) MyS_j - F_j, \tag{10}$$

where c_j is marginal cost and F_j denotes fixed cost. The first-order condition, together with the assumption of a Bertrand–Nash equilibrium, implies that the price–cost margin ratio can be expressed as a function of the sales share, S_j, as follows:

$$PCM_j = 1 - m_j = \frac{1}{(1 - S_j)/\mu + 1}, \tag{11}$$

where PCM denotes the price–cost margin ratio and:

$$m_j = \frac{c_j}{p_j}. \tag{12}$$

Hence, (12) implies that firms with large sales shares earn higher margins. The difference from the logit model is that the price–cost margin based on the CES model depends on the share in value terms, whereas that based on the logit model depends on the share in volume terms.

2.3. *Welfare*

Anderson *et al*. (1992) and Feenstra (1995) show that, in this setting, the following social welfare function can be derived:

$$V(Y, \mathbf{p}, \mathbf{q}; \alpha, \mu) = B^{1+\alpha} \left[\sum_{j=1}^{N} (p/q)^{-1/\mu} \right]^{\mu} = B^{1+\alpha} W(\mathbf{p}, \mathbf{q}; \mu), \tag{13}$$

where $B = Mb$, and:

$$W(\mathbf{p}, \mathbf{q}; \mu) = \left[\sum_{j=1}^{N} (p/q)^{-1/\mu} \right]^{\mu}. \tag{14}$$

The corresponding expenditure function, which is obtained by inverting (13), is:

$$E(U, \mathbf{p}, \mathbf{q}; \alpha, \mu) = U^{1/(1+\alpha)} \left[\sum_{j=1}^{N} (p/q)^{-1/\mu} \right]^{-\mu/(1+\alpha)} = U^{1/(1+\alpha)} W(\mathbf{p}, \mathbf{q}; \mu)^{-1/(1+\alpha)}. \tag{15}$$

One can construct an exact COL index by using the expenditure function (Feenstra, 1995). This index is the following ratio of expenditure functions at constant utility, and allows for varying prices and qualities:

(16) $$COL = \frac{E(U^0, \mathbf{p}^1, \mathbf{q}^1; \alpha, \mu)}{E(U^0, \mathbf{p}^0, \mathbf{q}^0; \alpha, \mu)} = \left[\frac{W(\mathbf{p}^1, \mathbf{q}^1; \mu)}{W(\mathbf{p}^0, \mathbf{q}^0; \mu)}\right]^{-1/(1+\alpha)}.$$

In this study, the real output of the retail industry is defined as $Q = E/[(1 + \alpha)COL] = Y/COL$, which is the total sales of retail services deflated by the COL index. Consequently, the growth rate of real services output is the difference between the growth rate of total expenditure and that of the COL index, which is:

(17) $$\frac{d\ln Q}{dt} = \frac{d\ln Y}{dt} - \frac{d\ln COL}{dt} = \frac{d\ln Y}{dt} + \frac{1}{1+\alpha}\frac{d\ln W}{dt},$$

where $Y/B = 1/(1 + \alpha)$ is the share of income devoted to the consumption of retail services. Given estimates of μ and $\mathbf{q}$, one can determine real retail output growth.

2.4. *Econometric Modeling*

To evaluate the growth rate of W, one must determine μ and obtain measures of service quality for the respective variants. The ratio of the sales shares of any two variants, j and k, is expressed as:

(18) $$\frac{S_j}{S_k} = \left(\frac{p_j/q_j}{p_k/q_k}\right)^{-1/\mu}.$$

The quality levels of the respective variants are specified by using the following simple log-linear form:

(19) $$\ln q_j = z_j\beta + \xi_j,$$

where z_j denotes observable service characteristics and ξ_j denotes the unobservable service characteristics of variant j, which is a random variable with a mean of zero. Then, one obtains the following linear regression equation:

(20) $$\ln\left(\frac{S_j}{S_k}\right) = -\frac{1}{\mu}\ln\left(\frac{p_j}{p_k}\right) + \frac{1}{\mu}(z_j - z_k)\beta + \frac{1}{\mu}(\xi_j - \xi_k).$$

This is termed the sales share equation.

The logarithm of the price is expressed as:

(21) $$\ln p_j = \ln c_j - \ln[m_j(S_j; \mu)].$$

As well as assuming that marginal cost is invariant to output, I also assume that marginal cost is linear in cost characteristics, as follows:

(22) $$\ln c_j = w_j\gamma + \upsilon_j,$$

where w_j denotes the observable cost characteristics of variant j, and υ_j, which is a random variable with a mean of zero, denotes its unobservable cost characteristics. Then, one obtains the following nonlinear regression equation:

$$\ln\left[\frac{p_j(1-S_j)}{p_k(1-S_k)}\right]=(w_j-w_k)\gamma+\ln\left(\frac{1-S_j+\mu}{1-S_k+\mu}\right)+(\upsilon_j-\upsilon_k). \tag{23}$$

This is termed the pricing equation.

Note that the sample size is not equal to the number of variants. This is because both regression equations are defined for any two variants. In addition, although the data used in this study represent a combination of time-series and cross-section data, so far, only cross-section aspects have been discussed. If there are N variants in each of T time periods, the sample size used for the regression analysis is equal to the number of combinations of variants multiplied by the number of time periods, which is given by $T[N(N-1)/2]$. Details of the estimation strategy are described below.

3. Application: The Case of the Japanese Retail Industry

3.1. *Data*

Sales

The primary data source is the *Shogyo Tokei Hyo, Gyotai Betsu Tokei Hen* (*Census of Commerce, Report by Type of Business*; hereafter CC/TB), which reports official aggregated data compiled by the Ministry of Economy, Trade, and Industry. The CC/TB editions for 1985, 1988, 1991, 1994, 1997, and 1999 are used. The CC/TB reports statistics based on the business classification of retail outlets. The business classification used in the CC/TB is adjusted for consistency throughout the sample period; this classification is henceforth termed "business classification (A)." The 15 types of business (or store) are as follows: (1) department stores; (2) general supermarket stores; (3) clothing specialty supermarket stores; (4) foods specialty supermarket stores; (5) do it yourself (DIY) specialty supermarket stores; (6) convenience stores (24-hour or late opening); (7) convenience stores (others); (8) other supermarket stores; (9) clothing specialty stores; (10) foods specialty stores; (11) DIY specialty stores; (12) clothing semispecialty stores; (13) foods semispecialty stores; (14) DIY semispecialty stores; and (15) other retailers.[7] The sales data summarized below, which are based on this classification, are taken from the CC/TB. Total annual sales (in millions of yen) and detailed sales data are reported, based on the industry classification (sales categories) by type of business.[8]

Figure 1 presents an overview of Japanese retail sales. DIY specialty stores constitute a large part of this industry, accounting for about 30 percent of industry

[7]In the CC/TB, there is another type of business, "other general supermarket stores," except for 1997 and 1999. However, because this business's share of total sales and its number of establishments are negligible, and because information on business confidence is lacking, this business is omitted from this study.

[8]These are total sales of goods during the year and include consumption taxes.

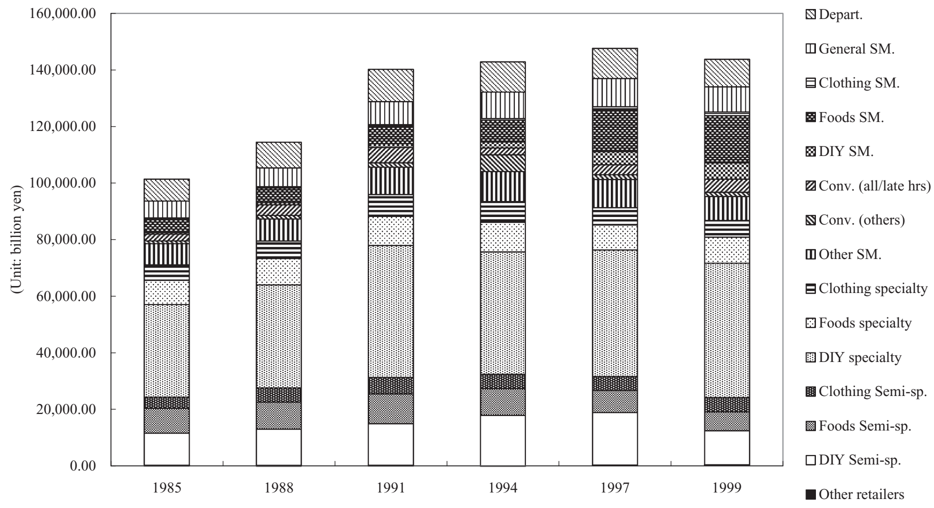

Figure 1. Total Sales by Type of Business
Notes: The original data source is the CC/TB. For details, see main text.

TABLE 1
Sales by Type of Business

		1985	1988	1991	1994	1997	1999
1.	Department stores	7,779.720	9,062.760	11,414.030	10,640.330	10,670.240	9,705.460
2.	General supermarkets	5,914.350	6,637.490	8,159.580	9,335.930	9,956.690	8,849.660
3.	Clothing specialty supermarket stores	461.920	428.280	482.430	540.920	1,153.740	1,270.680
4.	Foods specialty supermarket stores	4,788.380	5,177.530	6,182.350	7,740.230	14,768.130	16,747.990
5.	DIY specialty supermarket stores	522.050	788.430	1,337.820	2,145.370	4,518.090	5,710.830
6.	Convenience stores (24-hour or late opening)	2,345.250	3,784.080	5,462.000	2,343.060	3,589.310	4,666.810
7.	Convenience stores (others)	1,037.650	1,228.470	1,522.860	5,992.220	1,634.090	1,468.080
8.	Other supermarket stores	7,411.840	7,764.140	9,666.270	10,568.830	9,985.690	8,440.450
9.	Clothing specialty stores	5,515.820	6,191.620	7,679.220	7,318.960	6,117.610	5,926.630
10.	Foods specialty stores	8,547.580	9,315.530	10,337.360	10,451.550	8,810.520	9,206.840
11.	DIY specialty stores	32,730.390	36,380.610	46,591.260	43,247.740	44,750.940	47,464.920
12.	Clothing semispecialty stores	3,935.060	5,026.910	5,782.980	5,038.570	4,931.580	5,041.350
13.	Foods semispecialty stores	8,742.600	9,574.480	10,540.680	9,429.670	7,767.130	6,680.210
14.	DIY semispecialty stores	11,637.310	13,081.080	14,932.860	18,110.920	18,835.870	12,281.930
15.	Other retailers	191.200	137.390	235.010	17.180	253.480	370.690
	Total	101,561.100	114,578.810	140,326.700	142,921.470	147,743.120	143,832.550

Notes: The source of the original data is the CC/TB. Figures are reported in current prices in billions of yen. For details, see main text.

sales. In addition, the sales of foods specialty supermarket stores grew steadily to reach about 12 percent of industry sales in 1999 from only 4.7 percent in 1985. Table 1 reports sales by type of business. Although these are nominal values, and one must consider time-series comparisons, they indicate general trends in the industry.

Service and Cost Characteristics

The following variables from the CC/TB are used as observed service characteristics, z.

(1) *Operating hours per day*: This is the mean number of operating hours, as a proportion of 24. Mean operating hours are calculated as a weighted average from information on the number of establishments by operating hours.[9] The longer a store stays open, the more accessible it is to consumers. Hence, the longer a store stays open, the greater quality it must provide.

(2) *Single store ratio* (*SSR*): This is the ratio of the number of single stores, which have neither a head office nor branches run by the same person in other locations, to all stores. Single stores may be inferior to chain stores in terms of the availability of items, the service provided by sales clerks, and the availability of information. This suggests that single stores provide lower quality services.

At the same time, longer operating hours may raise costs, and single stores may run less efficiently than chain stores. Hence, these two variables can also be characterized as observed cost characteristics, w. The following variables are also used as observed cost characteristics.

(1) *Sales floor area per employee* (*SFA*/*EMP*): The numerator is the total floor space (m^2) of shops excluding eating and drinking establishments (restaurants and coffee shops) and outdoor exhibition areas (run by, for example, gardeners and stonemasons); the denominator is the number of people employed by the establishment, as at July 1 of the survey year. The variable *SFA*/*EMP* is a proxy for the capital–labor ratio.

(2) *The log of unit labor costs*: This variable is estimated as a weighted average of the wages of wholesale, retail, and restaurant industries by prefecture, which are taken from *Chingin Kozo Kihon Chosa* (*Basic Survey of the Wage Structure*), with the numbers of employees by prefecture used as weights.

(3) *The log of unit buying cost*: Similarly to the estimated price indexes for goods on shelves described in the previous subsection, this variable is calculated as the mean of the wholesale price index (WPI), rather than the CPI, by using business sales by industry as weights.[10]

Variables (2) and (3) are proxies for input prices. The data on unit labor costs and unit buying costs are deflated by the CPI for food products (1995 average = 100.0).

Prices

The secondary data source is the *Zenkoku Bukka Tokei Chosa Hokoku* (*National Survey of Prices*; hereafter NSP), which reports official aggregated data

[9]This variable is estimated as a weighted average of the number of establishments classified by opening or business hours.

[10]It is assumed that the wholesale market is competitive. Hence, I use a simple weighted average of the WPI. Correspondence between the industry classification of the WPI and business classification (A) is available from the author.

TABLE 2

Business Classifications (A) and (B)

		I	II	III	IV	V
	Business classification (A)					
1.	Department stores	O				
2.	General supermarket stores		O			
3.	Clothing specialty supermarket stores			O		
4.	Foods specialty supermarket stores			O		
5.	DIY specialty supermarket stores			O		
6.	Convenience stores (24 h or late)				O	
7.	Convenience stores (others)				O	
8.	Other supermarket stores		O			
9.	Clothing specialty stores					O
10.	Foods specialty stores					O
11.	DIY specialty stores					O
12.	Clothing semispecialty stores					O
13.	Foods semispecialty stores					O
14.	DIY semispecialty stores					O
15.	Other retailers					O
	Business classification (B)					
I.	Department stores					
II.	Supermarkets					
III.	Volume sales specialty stores					
IV.	Convenience stores (except for 1982)					
V.	General retail outlets					

Notes: Business classification (A) is based on the business classification of the CC/TB, whereas business classification (B) is based on the business classification of the NSP. The column headings (I to V inclusive) refer to business classification (B). For details, see main text.

compiled by the Ministry of Internal Affairs and Communications. The NSP editions for 1982, 1987, 1992, and 1997 are used to obtain information on prices. It is noteworthy that the NSP reports the shop prices of identical commodities; for example, there is information on the price of a given volume of a particular brand of detergent at each store. Hence, price differences between stores for identical commodities may represent differences in service quality and market power. The NSP reports statistics based on the business classification of retail outlets. The business classification of the NSP is adjusted for consistency throughout the sample period; this classification is henceforth termed "business classification (B)." The five types of business are as follows: (I) department stores; (II) supermarkets; (III) volume sales specialty stores; (IV) convenience stores (except for 1982); and (V) general retail outlets. Hence, business classifications (A) and (B) imply different numbers of types of business. The correspondence between the business classifications is based on the definitions of the original statistics; Table 2 reports this correspondence. Commodity price data based on business classification (B) are collected. The number of commodities is about 100 for each year, but the items listed differ from year to year. When an item from the 1997 list was missing for a particular year, the most similar commodity was used instead for that year.

In the Appendix, I explain how price variables that are consistent with the CC/TB were constructed from the NSP. Price series are deflated by the CPI for food products (1995 average = 100.0). Food products were used to deflate prices

TABLE 3

Estimated Price Indexes by Type of Business

		1985	1988	1991	1994	1997	1999	Mean
1.	Department stores	1.146	1.081	1.056	1.062	1.102	1.087	1.089
2.	General supermarkets	1.017	0.987	0.964	0.939	0.929	0.916	0.959
3.	Clothing specialty supermarket stores	0.756	0.643	0.603	0.640	0.859	0.854	0.726
4.	Foods specialty supermarket stores	0.978	0.985	0.985	0.963	0.943	0.943	0.966
5.	DIY specialty supermarket stores	1.020	0.978	0.992	0.932	0.904	0.863	0.948
6.	Convenience stores (24 h or late)	0.999	1.011	1.000	1.029	1.041	1.040	1.020
7.	Convenience stores (others)	0.988	1.003	0.999	1.024	1.040	1.037	1.015
8.	Other supermarket stores	0.961	0.968	0.960	0.938	0.935	0.930	0.948
9.	Clothing specialty stores	0.973	1.329	1.393	1.352	1.064	1.066	1.196
10.	Foods specialty stores	1.012	1.014	1.002	0.996	0.989	0.987	1.000
11.	DIY specialty stores	1.167	1.149	1.048	1.027	0.977	0.951	1.053
12.	Clothing semispecialty stores	0.979	1.359	1.400	1.387	1.073	1.097	1.216
13.	Foods semispecialty stores	1.008	1.009	0.981	0.986	0.982	0.979	0.991
14.	DIY semispecialty stores	1.107	1.103	1.042	1.037	0.979	0.948	1.036
15.	Other retailers	1.024	1.082	1.043	1.291	0.972	1.000	1.069
	Mean	1.009	1.047	1.031	1.040	0.986	0.980	

Notes: The price series are deflated by the CPI for food products (1995 average = 100.0). For details, see main text.

because their quality may not have changed much throughout the period. Table 3 reports the estimated price indexes. Clearly, although supermarket prices were low, department stores, convenience stores, DIY specialty stores, and semispecialty stores charged relatively high prices.

3.2. *Estimation*

To control for other business-type specific service and cost characteristics, the following nine type-of-business dummy variables are used: (1) department stores dummy; (2) general supermarkets dummy; (3) other supermarkets dummy; (4) convenience stores dummy; (5) specialty stores dummy; (6) semispecialty stores dummy; (7) foods specialty dummy; (8) clothing specialty dummy; and (9) DIY specialty dummy. For example, for "foods specialty stores," which is No. 10 under business classification (A), the specialty stores dummy and the foods specialty dummy take values of unity, and the other dummies take values of zero.[11]

Clearly, the unobservable service characteristics, ξ, and the unobserved cost characteristics, υ, correlate with prices and sales. Thus, the OLS estimator would not be consistent. Hence, I use instrumental variables that are orthogonal to ξ and υ. Berry *et al.* (1995) recommended using certain functions of the product characteristics as instruments. I consider the following variables as potential instruments: (1) the observed cost characteristics (*SFA*/*EMP*, unit labor cost, and unit buying cost) of *j*-type businesses; and (2) the means of characteristics of other types of businesses (rivals).[12]

[11]A table that reports how these dummies correspond to the types of business is available from the author.

[12]In this study, own operating hours per day and *SSR* are treated as endogenous. The identifying assumption is that a business type's unobserved service/cost characteristics in a given period are not correlated with observed characteristics of other types of business and own cost-side characteristics.

TABLE 4
Descriptive Statistics

	Obs.	Mean	S.D.	Min.	Max.
Sales share	630	0.041	2.028	–4.570	7.831
Price	630	–0.061	0.189	–0.843	0.561
Operating hour/24	630	0.031	0.202	–0.614	0.655
Single store ratio	630	–0.315	0.321	–0.882	0.301
SFA per employee	630	0.425	0.721	–1.452	2.222
Unit labor cost	630	0.014	0.029	–0.058	0.100
Unit buying cost	630	–0.001	0.037	–0.145	0.114

Notes: All variables are defined as log differences between two different types of business. Because the dataset covers 15 types of business over six time periods, the sample size used for the regression analysis is 630 (= 6 × 15 × (15 – 1)/2). For details, see main text.

Berry *et al*. (1995) also proposed using supply-side variables for demand-side instruments. Thus, I use the number of establishments as an instrument because when a large number of establishments operate in the same type of business, competition is strong, and competition forces retailers to lower their prices. Moreover, business-type dummies are treated as being exogenous. Table 4 reports descriptive statistics for the main variables. Because the dataset covers 15 types of business over six time periods, the sample size used for the regression analysis is 630 (= 6 × 15 × (15 – 1)/2).

3.3. *Results*

The CES Model

Table 5 reports the estimated parameters and the list of instruments for the respective specifications. For reference, the first column of this table presents OLS estimation results for the sales share equation. In this specification, all explanatory variables are treated as exogenous. The estimate of μ is –1.834. It is significant, but does not satisfy the theoretical requirement that $\mu > -1$. In addition, the coefficients of the service characteristics, daily operating hours, and the *SSR* have unexpected signs, and the *SSR* coefficient is significant. However, as already explained, the OLS estimates are expected to be spurious.

The second column reports the 2SLS estimation results for the sales share equation. The instruments used are the differences between the two corresponding variants in the following variables: the *SFA*/*EMP* ratio, the log of unit labor costs, the log of buying costs, the log of the mean of the other *SFA*/*EMP* ratios, and the log of the mean of the other *SSR* values. I also used business-type dummies. The estimate of μ is 0.456. It is significant at the 1 percent level, and satisfies the theoretical requirement. The coefficients of daily operating hours and the *SSR* are significant at the 1 percent level, and have the expected signs given that they represent service characteristics. That is, stores that operate for longer hours and chain stores, such as franchises, may provide higher retail services quality. Based on a test statistic for the overidentifying restrictions of 0.775, one cannot reject the null hypothesis that the instruments are orthogonal to the unobservable characteristics. This suggests that endogeneity is not a concern in this specification.

TABLE 5

Estimation Results for the Sales Share and Pricing Equations

	(1) Share Eq. OLS			(2) Share Eq. 2SLS			(3–1) Share Eq. 3SLS			(3–2) Pricing Eq. 3SLS		
	Est.	S.E.		Est.	S.E.		Est.	S.E.		Est.	S.E.	
μ	–1.834	0.732	**	0.456	0.107	***	0.106	0.018	***			
β and γ												
Operating hours/24	–0.987	0.705		2.157	0.501	***	1.247	0.187	***	–0.439	0.266	*
Single store ratio (*SSR*)	9.076	4.145	**	–3.038	0.651	***	–1.120	0.164	***	0.315	0.103	***
SFA/*EMP* (log)										0.519	0.115	***
Unit labor cost (log)										9.441	1.091	***
Unit buying cost (log)										1.276	0.268	***
Department stores	–2.743	1.003	***	0.272	0.181		–0.150	0.070	**	–0.959	0.129	***
General supermarket stores	–0.843	0.518		–0.555	0.180	***	–0.536	0.090	***	–0.701	0.095	***
Other supermarkets	–6.450	2.539	**	1.322	0.359	***	0.150	0.067	**	–0.438	0.048	***
Convenience stores	–4.932	1.999	**	0.478	0.190	***	–0.192	0.073	***	–0.078	0.079	
Specialty stores	–15.278	6.495	**	4.322	0.951	***	1.281	0.184	***	–0.019	0.040	
Semispecialty stores	–14.971	6.396	**	4.259	0.935	***	1.277	0.183	***			
Foods specialty	5.969	2.702	**	–1.967	0.409	***	–0.714	0.095	***	–0.040	0.026	
Clothing specialty	8.927	3.894	**	–2.738	0.591	***	–0.914	0.131	***	–0.376	0.068	***
DIY specialty	6.189	2.813	**	–2.024	0.427	***	–0.732	0.101	***	–0.103	0.025	***
$\sigma = (1/\mu) + 1$				3.191	0.516	***	10.437	1.646	***			
Sample size		630			630					630		
Adjusted R^2		0.852										
Hansen *J* statistics					0.775					1.976		
p-value					0.679					0.160		
Degrees of freedom					2					1		
Instruments												
Difference of												
Business-type dummies		No			Yes					Yes		
SFA/*EMP* (log)		No			Yes					No		
Unit labor cost (log)		No			Yes					Yes		
Unit buying cost (log)		No			Yes					Yes		
No. of rivals within same type		No			No					Yes		
Mean of rivals' *SFA*/*EMP* (log)		No			Yes					No		
Mean of rivals' *SSR* (log)		No			Yes					Yes		

Notes: The first column reports the OLS estimates of the sales share equations. The second column reports the 2SLS results. The third and fourth columns report the 3SLS estimates of the system comprising the sales share and pricing equations. Information on the instrumental variables used for the 2SLS and 3SLS regressions are also presented, as are the results of tests of the overidentifying restrictions.

***, **, and * denote significance at 1, 5, and 10 percent, respectively. For details, see main text.

The third and fourth columns report the 3SLS estimation results for the system of equations comprising the sales share and pricing equations. The instruments used are the differences between the two corresponding variants in the following variables: the log of unit labor costs, the log of buying costs, the number of establishments, and the log of the mean of the other *SSR* values. I also included business-type dummies. The estimate of μ is 0.106. It is significant at the 1 percent level, and satisfies the theoretical requirement. For the service characteristics, the coefficient of daily operating hours is positive and significant at the 1 percent level. The coefficient of the *SSR* is negative and significant at the 1 percent level. These coefficients have the expected signs. Thus, longer operating hours and chain store operations may improve retail services quality.

For the cost characteristics, although the coefficient of daily operating hours is negative and significant at the 10 percent level, the coefficients of the *SSR*, the log of *SFA*/*EMP*, the log of unit labor costs, and the log of buying costs are positive and significant at 1 percent. This means that, although retailers can reduce costs by increasing opening hours, retailers that operate as single stores and those who have high *SFA*/*EMP* ratios, high unit labor costs, or high buying costs experience higher costs. The effect of operating hours suggests economies of scale. It is difficult to interpret the effect of *SFA*/*EMP*, given that this is a proxy for the capital–labor ratio; this is because an increase in this ratio is expected to reduce costs. Based on a test statistic of the overidentifying restrictions of 1.976, one cannot reject the null hypothesis that the instruments are orthogonal to the unobservable service and cost characteristics. This suggests that there are no endogeneity problems. These final estimates are used in the analysis that follows.[13]

Elasticities and the Price–Cost Margin

Table 6 presents summary statistics for the own-price and cross-price elasticities, and for the price–cost margin by type of business. Although the own-price elasticity for DIY specialty stores is small, at –7.437 at the mean, those for clothing specialty supermarket stores, DIY specialty supermarket stores, two types of convenience stores, clothing specialty stores, and other retailers are relatively large.

The cross-price elasticities for DIY specialty and semispecialty stores are large, at 3.000 and 1.061 at the means, respectively, whereas those for clothing specialty supermarket stores and other retailers are small, at 0.051 and 0.014 at the means, respectively.

The price–cost margin for DIY specialty stores is the largest, at 0.134 at the mean, and the margins for clothing specialty supermarket stores and other retailers are relatively small, at 0.096 at the means. In addition, specialty supermarkets and convenience stores, except for foods specialty supermarket stores, have relatively small markups. This suggests that supermarket stores faced strong competition during the period. The standard deviations are small enough to suggest that these

[13]I also conduct the same analysis by using another set of estimated parameters from the share equation regression, obtained by 2SLS. Overall, the results are similar, but the absolute values of the estimates of the own-price and cross-price elasticities and those of the price–cost margin are greater than those presented in this paper.

TABLE 6

Estimated Own-Price and Cross-Price Elasticities and Price–Cost Margin Ratios

			Own-Price Elasticity		Cross-Price Elasticity		Price–Cost Margin Ratio	
		Obs.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1.	Department stores	6	–9.727	0.047	0.710	0.047	0.103	0.000
2.	General supermarkets	6	–9.857	0.039	0.580	0.039	0.101	0.000
3.	Clothing specialty supermarket stores	6	–10.386	0.022	0.051	0.022	0.096	0.000
4.	Foods specialty supermarket stores	6	–9.797	0.301	0.640	0.301	0.102	0.003
5.	DIY specialty supermarket stores	6	–10.269	0.133	0.168	0.133	0.097	0.001
6.	Convenience stores (24 h or late)	6	–10.172	0.077	0.265	0.077	0.098	0.001
7.	Convenience stores (others)	6	–10.287	0.121	0.149	0.121	0.097	0.001
8.	Other supermarket stores	6	–9.792	0.051	0.645	0.051	0.102	0.001
9.	Clothing specialty stores	6	–9.970	0.061	0.467	0.061	0.100	0.001
10.	Foods specialty stores	6	–9.751	0.090	0.686	0.090	0.103	0.001
11.	DIY specialty stores	6	–7.437	0.121	3.000	0.121	0.134	0.002
12.	Clothing semispecialty stores	6	–10.079	0.038	0.358	0.038	0.099	0.000
13.	Foods semispecialty stores	6	–9.792	0.154	0.644	0.154	0.102	0.002
14.	DIY semispecialty stores	6	–9.375	0.147	1.061	0.147	0.107	0.002
15.	Other retailers	6	–10.422	0.008	0.014	0.008	0.096	0.000

Notes: For details, see main text.

patterns varied little throughout the period. The estimation results from the market model suggest that product differentiation is an important feature of the Japanese retail market, and indicate that the market is not perfectly competitive.

4. The COL Index, Output, and Productivity Growth

4.1. *Service Quality*

Using the results of the previous section, I estimate output and productivity growth in the Japanese retail sector between 1985 and 1999. First, the quality index of a j-type business at time t is estimated as follows:

$$\theta_j^t = \frac{q_j^t}{q_{15}^{1985}} = \exp\left[\left(z_j^t - z_{15}^{1985}\right)\beta\right], \tag{24}$$

where q_{15}^{1985} is the estimated quality of "other retailers" at 1985. Hence, each quality index is normalized to be that of "other retailers" in 1985, when the index takes the value of unity. Table 7 reports the estimated quality indexes by type of business. The results show that specialty and semispecialty stores, department stores, and convenience stores (open long or all hours) provided relatively high-quality services. By contrast, specialty supermarket stores and other retailers provided relatively low-quality services. From 1985 to 1999, the mean of the retail services quality index increased slightly, from 1.412 to 1.576.

TABLE 7
Estimated Quality Indexes by Type of Business

		1985	1988	1991	1994	1997	1999	Mean
1.	Department stores	1.512	1.600	1.787	1.776	1.907	1.882	1.744
2.	General supermarkets	1.426	1.450	1.471	1.516	1.552	1.572	1.498
3.	Clothing specialty supermarket stores	1.040	1.019	1.025	1.081	1.004	1.043	1.035
4.	Foods specialty supermarket stores	1.308	1.319	1.343	1.330	1.184	1.236	1.287
5.	DIY specialty supermarket stores	1.213	1.221	1.253	1.283	1.246	1.277	1.249
6.	Convenience stores (24 h or late)	1.207	1.347	1.426	2.007	1.917	1.964	1.645
7.	Convenience stores (others)	0.915	1.057	1.165	1.223	1.522	1.606	1.248
8.	Other supermarket stores	1.542	1.611	1.570	1.551	1.349	1.386	1.501
9.	Clothing specialty stores	1.589	1.669	1.736	1.777	1.796	1.724	1.715
10.	Foods specialty stores	1.742	1.753	1.758	1.794	1.808	1.750	1.768
11.	DIY specialty stores	1.773	1.803	1.851	1.892	1.933	1.869	1.853
12.	Clothing semispecialty stores	1.497	1.536	1.587	1.591	1.615	1.606	1.572
13.	Foods semispecialty stores	1.643	1.679	1.695	1.667	1.671	1.612	1.661
14.	DIY semispecialty stores	1.773	1.824	1.850	1.843	1.882	1.837	1.835
15.	Other retailers	1.000	1.006	1.043	0.947	1.303	1.283	1.097
	Mean	1.412	1.460	1.504	1.552	1.579	1.576	

Notes: The quality indexes are estimated by using the estimated regression coefficients and are normalized so that the index for "other retailers" is unity in 1985. For details, see main text.

4.2. *The COL Index*

The COL indexes are estimated as follows. First, it is assumed that consumers purchased goods and received some level of service quality from retailers. That is, consumers pay retailers not only for goods, but also for quality of service. Second, by using the *Kakei Chosa Hokoku* (*Family Income and Expenditure Survey*), I estimated the average expenditure share of goods (as opposed to services) in total household expenditure.[14] The expenditure share for goods declined from 43.11 percent to 34.79 percent between 1985 and 1999. This implies that, during this period, Japanese household expenditure shifted from goods to services. In calculating the change in the COL index, this estimated expenditure share substitutes for the share of income devoted to the consumption of retail services, $Y/B = 1/(1 + \alpha)$, as follows:

$$\ln\left(\frac{COL^{t+1}}{COL^{t}}\right) = \frac{EXS^{t} + EXS^{t+1}}{2}\ln\left[\frac{W\left(\mathbf{p}^{t+1}, \mathbf{q}^{t+1}; \mu\right)}{W\left(\mathbf{p}^{t}, \mathbf{q}^{t}; \mu\right)}\right], \tag{25}$$

where *EXS* denotes the estimated expenditure share for goods from the *Family Income and Expenditure Survey*. Table 8 reports the *quality adjusted* COL index and the CPI (general, excluding imputed rent), normalized to be unity in 1985. The COL index declined monotonically but slowly: from 1985 to 1999, it declined by only about 2 percentage points. On the other hand, the CPI trended upwards throughout the period. This is because the CPI measures only changes in the prices of goods purchased by consumers and does not incorporate changes in retail

[14]The first row of Table 9 reports the estimate of this share, and the fourth row reports the average annual growth rate of the COL index.

TABLE 8
The Estimated COL Index and Other Price Indexes

	COL Index	CPI: General (excl. imputed rent)	Deflator of JIP: Retail	Superlative Index (Törnqvist–Theil)
1985	1.000	1.000	1.000	1.000
1988	0.996	1.007	0.837	1.020
1991	0.974	1.097	0.968	0.980
1994	0.957	1.133	1.012	0.968
1997	0.949	1.148	0.950	0.929
1999*	0.949	1.151	0.951	0.915

Notes: All series are normalized to be unity in 1985. The deflator from the JIP Database and that based on the COL index in 1999 were estimated by multiplying the 1997 value by twice the average annual growth rate (AAGR). For details of the JIP database, see main text.

services quality. Hence, the JIP deflator may overestimate the cost of living because it is based on the CPI and is not adjusted for quality.[15]

4.3. *Growth Accounting*

Retail Output Definition

Growth accounting analysis is conducted by using the data from the CC/TB, the estimated COL index, and the JIP Database.[16] Inklaar and Timmer (2008) pointed out the potential bias in international productivity comparisons based on national accounts data because of the lack of information on prices and quantities of goods purchased for resale. They used the double deflated margin to measure retail trade output to assess the bias in productivity estimates among U.S. and European countries. In the JIP Database, nominal output is a margin, which equals the difference between sales and the cost of purchases.

By contrast, in this study, retail sales are defined as nominal output, and real output is measured by deflating sales by the estimated COL index: as described above, the definition used in this study is consistent with consumer behavior, which explicitly incorporates product differentiation, imperfect competition, and quality change.

In practice, the deflators of the JIP Database are similar to those of the *Setsuzoku Sangyo Renkan Hyo* (*Linked Input–Output Tables*; hereafter LIOT), and the deflator for the retail industry used in the LIOT differs from standard price indexes.[17] The retail output of the LIOT is extrapolated based on the quantity index for the retail industry from the *Daisanji Sangyo Katsudo Shisu* (*Indices of Tertiary Industry Activity*). The index is estimated by using the retail sales data taken from *Shogyo Hanbai Tokei* (*Preliminary Report on the Current Survey of Commerce*), the CPI, and the weights from input–output tables. To be specific, the JIP Database (and the LIOT) defines real retail output as follows:

[15]In constructing official price indexes, statistical agencies adjust for quality change for items such as computers by using hedonic and other methods. However, the estimated COL index constructed in this study is adjusted for retail services quality.

[16]I follow the method used by Fukao *et al*. (2003) for their base case.

[17]In LIOT, the price index used to construct the real series is known as an *inflator* because real values are evaluated in current prices.

TABLE 9
Growth Accounting Results

		1985–88	1988–91	1991–94	1994–97	1997–99*
1.	Share of expenditure for goods	43.11%	41.78%	40.13%	36.89%	34.79%
2.	Sales	4.02%	6.76%	0.61%	1.11%	−1.34%
3.	COL index	–0.15%	–0.73%	–0.59%	–0.26%	0.00%
4.	Real output (COL) (= 2. − 3.)	4.17%	7.49%	1.20%	1.36%	−1.34%
5.	Nominal output (JIP)	−1.58%	9.80%	2.28%	0.94%	–4.51%
6.	Deflator (JIP)	–5.94%	4.86%	1.48%	–2.11%	0.08%
7.	Real output (JIP) (= 5. − 6.)	4.36%	4.94%	0.80%	3.05%	–4.60%
8.	Aggregated input (JIP)	–0.11%	0.21%	0.00%	0.26%	0.13%
9.	TFP (COL) (= 4. − 8.)	4.28%	7.28%	1.20%	1.10%	−1.47%
10.	TFP (JIP) (= 7. − 8.)	4.47%	4.72%	0.80%	2.78%	–4.73%

Notes: For 1997 to 1999, the AAGRs of variables in the JIP Database relate to growth rates between 1997 and 1998. This is because the JIP Database only covers the period up to 1998. For details, see main text.

$$Q^t_{JIP} = NMX^0_{JIP} \cdot IDX^t, \tag{26}$$

where *NMX* denotes nominal output and *IDX* is the quantity index of the *Indices of Tertiary Industry Activity* for retail, and the superscripts 0 and *t* denote base year and current values, respectively. The JIP deflator is reported in Table 8 (1985 = 1.0) and, as expected, the retail output deflator of the JIP Database appears to be biased upwards. On the other hand, the growth rate of real output equals that of the quantity index. Consequently, this study's estimate of real output growth is equivalent to the rate implied by replacing *IDX* in (26) by the real output index based on the COL index.

Results

Table 9 reports the growth accounting results. The second row of this table reports the average annual growth rate (AAGR) of the total sales of the retail industry from the CC/TB. Therefore, the difference between the figures in the second and third rows (the AAGR of the COL index) represents the AAGR of real retail output based on the definition used in this study. This is presented in the fourth row and is labeled "COL." These figures show that the growth of real retail output was relatively high in the 1980s: the average annual growth rate was 4.17 percent between 1985 and 1988 and was 7.49 percent between 1988 and 1991. However, growth declined steadily in the 1990s: the average annual growth rate was 1.20 percent between 1991 and 1994 and was 1.36 percent between 1994 and 1997. The growth rate was actually negative between 1997 and 1999, at –1.34 percent.

The fifth and sixth rows report the AAGRs of retail nominal output and the deflator from the JIP Database, respectively. The seventh row reports the annual rate of real output growth, which is the difference between the figures in the seventh and eighth rows. This second series for retail services output is labeled "JIP," and implies a smaller growth rate than does the real output series based on the COL index.

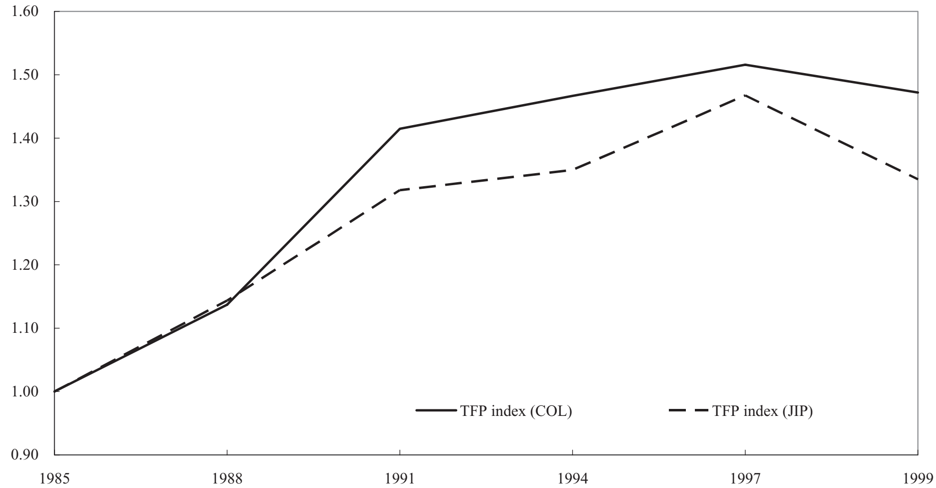

Figure 2. TFP Indexes Based on Two Definitions of Output (1985 = 1.0)

Notes: (COL) and (JIP) denote results based on definitions of real output used in this study and in the JIP Database, respectively. The two series were estimated from the results reported in Table 9. For details, see main text.

The eighth row presents the AAGR of aggregated factor inputs (labor, capital, and intermediate goods) used in the retail industry from the JIP Database. Hence, the annual rates of TFP growth based on the two definitions of retail services output, "COL" and "JIP," are as follows:

$$\frac{d\ln TFP}{dt} = \frac{d\ln Q}{dt} - \frac{d\ln H}{dt}, \tag{27}$$

where H represents the aggregated factor inputs. The ninth and tenth rows report the average annual TFP growth rate based on the two definitions of retail output. In addition, the TFP indexes based on the two output definitions are constructed so that both indexes are unity in 1985. They are illustrated graphically in Figure 2. This shows that the TFP index (COL) exceeds the TFP index (JIP). This suggests that ignoring differentiation and quality change in the retail services market biases estimates of output and productivity growth downwards.

5. Robustness

5.1. *Substitution Patterns*

In this framework, different types of business are assumed to be good substitutes for each other. Hence, it is assumed that consumers choose to shop at convenience stores rather than at DIY specialty stores because of observed store characteristics. However, in reality, consumers may have specific needs when they go shopping: someone needs a bottle of water, another may want to buy a digital camera, and so on.

I examine the correlations for the share of sales categories (a proxy for the assortment of each type of business) between types of business.[18] This shows that some types of business have similar ranges of goods: for example, the assortment breadth of convenience stores (others) is similar to that of food semispecialty stores (with a correlation coefficient of 0.961), but is different from that of DIY specialty and semispecialty stores (with a correlation coefficient of –0.159). If the specific needs of respective consumers are the most influential factor, the implied substitution patterns may contradict the independence of irrelevant alternatives assumption of the CES model.

5.2. *The Nested CES Model*

In order to check the robustness of the empirical results, I conduct the same analysis using the nested CES framework.[19] In this framework, the business types of retail stores are grouped into four exhaustive and mutually exclusive sets, as follows: (1) grocery {2, 4, 6, 7, 8, 10, and 13}; (2) clothing {1, 3, 9, and 12}; (3) DIY {5, 11, and 14}; and (4) miscellaneous {15}.[20] In the nested model, it is assumed that, initially, consumers choose what category of products to purchase, and then, subsequently, choose which types of store to go to. Therefore, the conditional direct utility attained from shopping at a j-type retail store within group g is as follows:

$$u_{ij} = \frac{\alpha}{\mu}\ln x_0 + \frac{1}{\mu}\ln\left(x_j q_j\right) + \varsigma_{ig} + (1-\rho)\varepsilon_{ij}, \tag{28}$$

where, for consumer i, ζ is common to all types of business in the same group and has a distribution that depends on ρ, with $0 \leq \rho < 1$. As ρ approaches unity, the within store group correlations between utility levels approach unity, and as ρ approaches zero, the within group correlations approach zero, as in the CES model.

The share equation based on the nested CES framework is as follows:

$$\ln\left(\frac{S_j}{S_k}\right) = -\frac{1}{\mu}\ln\left(\frac{p_j}{p_k}\right) + \frac{1}{\mu}\left(z_j - z_k\right)\beta + \rho\ln\left(\frac{S_{j|g}}{S_{k|l}}\right) + \frac{1}{\mu}\left(\xi_j - \xi_k\right). \tag{29}$$

Hence, the share equation of the nested CES model simply adds the within group share variable ($S_{j|g}$) to the right-hand side of the corresponding equation of the CES model. Under the nested CES framework, the COL index is defined as follows:

$$COL_N = \left[\frac{W_N\left(\mathbf{p}^1, \mathbf{q}^1; \mu, \rho\right)}{W_N\left(\mathbf{p}^0, \mathbf{q}^0; \mu, \rho\right)}\right]^{-1/(1+\alpha)}, \tag{30}$$

[18]The shares of sales categories are used to construct price data. Details are given in the Appendix. Because total sales only are available for department stores and general supermarket stores, the correlation coefficients for them are not reported. For details, see main text.

[19]The comprehensive derivation of the nested CES model appears in Matsuura and Sunada (2009).

[20]The numbers in brackets represent the types of business in Table 1.

where:

$$W_N(\mathbf{p}, \mathbf{q}; \mu) = \left[\sum_{g=1}^{G} D_g^{1-\rho} \right]^{\mu}, \tag{31}$$

and:

$$D_g = \sum_{k \in A_g} (p_k / q_k)^{-1/[\mu(1-\rho)]}. \tag{32}$$

On the other hand, under the nested CES framework, the price equation includes a complicated nonlinear term, which consists of the share and within group share variables. Therefore, only the share equation is estimated.

5.3. *The CES and the Nested CES Models*

Table 10 reports the estimation results for the share equation under the nested CES framework. Because the price and within group share variables are endogenous, the instruments from model (2) are used. The results are comparable with

TABLE 10

Estimation Results for the Sales Share Equation: The Nested CES Model

	(4)		
	Est.	S.E.	
μ	0.486	0.196	**
β			
Operating hours/24	2.083	0.643	***
Single store ratio (*SSR*)	−3.015	0.649	***
Department stores	0.446	0.996	
General supermarket stores	−0.333	1.265	
Other supermarkets	1.527	1.206	
Convenience stores	0.726	1.415	
Specialty stores	4.479	1.281	***
Semispecialty stores	4.424	1.301	***
Foods specialty	−1.939	0.426	***
Clothing specialty	−2.725	0.580	***
DIY specialty	−1.989	0.459	***
ρ	0.097	0.510	
Sample size		630	
Hansen *J* statistic		0.856	
p-value		0.355	
Degrees of freedom		1	

Notes: 2SLS estimation results for the nested CES model are presented. The instruments used are the same as those used for model (2), reported in Table 5.

***, **, and * denote significance at 1, 5, and 10 percent, respectively. For details, see main text.

TABLE 11

The COL Index and the TFP Index under Various Model Specifications

	(2) CES		(3) CES		(4) Nested CES	
	COL	TFP	COL	TFP	COL	TFP
1985	1.000	1.000	1.000	1.000	1.000	1.000
1988	0.979	1.156	0.996	1.137	0.980	1.156
1991	0.944	1.459	0.974	1.415	0.944	1.459
1994	0.924	1.518	0.957	1.467	0.925	1.517
1997	0.908	1.585	0.949	1.516	0.908	1.584
1999	0.913	1.530	0.949	1.472	0.914	1.529

Notes: The first and second columns present the COL index and the TFP index based on the results of model (2) reported in Table 5. The third and fourth columns present the corresponding indexes based on the results of model (3), which are the main results of this study. The final two columns report indexes based on the results from the nested CES model. For details, see main text.

those from model (2) reported in Table 5. The estimate of the parameter ρ, which determines the substitution pattern, is 0.097, and satisfies the theoretical requirement. However, the estimate is not statistically significant. The estimates of the other parameters, μ and β, are similar to those of model (2). However, the estimated coefficients of some business-type dummies, such as the one for department stores, are not significant. Based on a test statistic for the overidentifying restrictions of 0.836, there are no endogeneity problems in this specification.

Table 11 reports the estimated COL and TFP indexes based on the nested CES model, which is labeled (4), for comparison with those based on models (2) and (3) in Table 5. Using the nested framework seems to make little difference to the results except to lower (raise) the COL index (the TFP index) somewhat for model (3), which generates this study's main results. Because the results of the nested CES model are almost identical to those of model (2), the differences between the nested CES framework and model (3) probably arise because of differences in the estimation method (that is, single equation estimation versus system based estimation), rather than misspecification of the demand model, in this application.

6. Discussion

6.1. *The Superlative Index and the COL Index*

The superlative price index (the Törnqvist–Theil index, TT) is constructed based on the estimated price series in Table 3 and the sales data by type of business. The TT index is reported in the last column of Table 8. It exhibits large fluctuations: it increased to 1.020 in 1988, and then declined to reach 0.915 in 1999. The redefinition of the business type classification of the CC/TB between 1991 and 1994 seems to have generated sales surges in convenience stores (others) and for other retailers. Having eliminated these sales jumps by using counterfactual linear interpolation, I obtained a counterfactual TT index similar to the one reported in Table 8.

It is difficult to explain clearly the difference between the TT index and this study's COL index. The TT index is exact to a translog aggregator function and, given updated expenditure share weights, incorporates changes in substitution patterns that may be affected by quality change. However, the TT index does not directly incorporate changes in retail service quality. On the other hand, this study's COL index is exact to the CES expenditure function, and incorporates changes in retail service quality. The relationship between superlative indexes and the exact hedonic index proposed by Feenstra (1995) is a topic for future research.

6.2. *Marginal Cost*

Although the assumption of constant marginal cost may be restrictive, it is reasonable for a number of reasons. First, in existing studies based on discrete choice models, such as those of Berry *et al.* (1995) and Petrin (2002) of the U.S. car market, constant marginal cost was assumed. Second, retail trade has large fixed costs (incorporating, for example, store rents and fixed payroll costs) and constant unit costs (such as per-unit purchase costs and performance related payroll costs). Although volume discounts and rebates, which represent typical trade practices between wholesalers and retailers, may introduce concavity into the cost curve, a cost function incorporating constant marginal cost and a fixed cost is a reasonable and practical approximation of the cost structure of the retail trade sector.

7. Concluding Remarks

This study reveals the importance of appropriately incorporating market conditions such as imperfect competition, product differentiation, and quality improvement when measuring output growth in the retail industry. Discrete choice models that incorporate oligopolistic competition are applicable to other service industries. Several empirical industrial organization studies of competition in service industries are based on discrete choice models.[21] The models used in these studies explicitly incorporate product differentiation and imperfect competition, and are also appropriate for adjusting services price indexes for quality change.

There are limitations of this study. First, because of limited data availability, I could only control for retail services quality by using a few characteristics, and these may not be sufficient for capturing the quality of services. This may have affected the accuracy of the estimates. Second, I defined retail sales as nominal output, which differs from the standard practice used to construct official statistics. However, careful consideration must be given to whether the definitions on which the official statistics are based achieve consistency between industries.

The redefinition of the business classification of the CC/TB between 1991 and 1994 might have affected the quality estimates. For example, average operating hours of convenience stores (24-hour or late opening) increased from about 16 in 1991 to 24 in 1994. Thus, the redefinition may have biased upwards estimated

[21]For example, Davis (2006) studied movie theaters; Doganoglu and Grzybowski (2007) and Iimi (2005) analyzed mobile telecommunications services; Eilat and Einav (2004) studied tourism; Gaynor and Vogt (2003) investigated hospitals; Ohashi *et al.* (2005) analyzed air transportation services; and Thomadsen (2005) studied fast-food restaurants.

quality for this type of business. Although it is difficult to determine the overall effects of the redefinition, my finding of quality improvement and productivity growth at the industry level remains robust for the following reasons. First, the operating hours of another convenience store category (business type (7)) also increased from about 14 to 22 between 1994 and 1999 and, therefore, the increase in the operating hours of convenience stores seems reasonable. Second, I conducted a counterfactual exercise by replacing the operating hours of business type (6) between 1994 and 1999 with those of (7) and then computing the quality index and the TFP index. The results show that the average quality index at the industry level increased by about 10 percent from 1985 to 1999, and the TFP index remains larger than that from the JIP Database.

Deregulation, in the form of the relaxation (in the 1990s) and then abolition (in 1998) of the *Large Scale Retail Store Law*, which restricted the operations of large-scale stores such as department stores and large supermarkets, may have contributed to improving retail service quality.[22] Assessing the effects of deregulation is beyond the scope of this study, but remains an issue for future research.

Appendix

In this appendix, I explain how information from the NSP was used to obtain price data that are consistent with the CC/TB. Note the following issues.[23] First, the logarithmic difference between the price of commodity k of business type j and the average price of commodity k is estimated as follows:

$$d_{kj} = \ln\left(\frac{P_{kj}}{\bar{P}_k}\right), \tag{33}$$

where P denotes the price from the NSP and $\bar{P}$ denotes the average price across all types of business. The index k relates to the commodity classification of the NSP, and j relates to business classification (B). It is assumed that one can exclusively group each commodity included in the NSP into a single category that corresponds to the item classification on which the CPI is based. The set of commodities grouped into category K is defined as G_K, and the number of elements in that category is $\#_K$. The geometric mean deviation of the price of category K of business type j from the average price level is:

$$\bar{d}_{Kj} = \frac{1}{\#_K} \sum_{k \in G_k} d_{kj}. \tag{34}$$

Thus, one can estimate a CPI series for each category for business classification (B) as follows:

$$CPI_{Kj} = CPI_K \exp\left(\bar{d}_{Kj}\right). \tag{35}$$

[22]For more details, see Komoto (2000) and Matsuura and Nakajima (2002a, 2002b).

[23]The survey years for the CC/TB and NSP differ: for the former, these are 1982, 1985, 1988, 1991, 1994, 1997, and 1999; for the latter, they are 1982, 1987, 1992, and 1997.

However, the years to which these series relate are 1982, 1987, 1992, and 1997. The intervening years, 1985, 1988, 1991, 1994, and 1999, are estimated by using the CPI. For example, for 1988, I use:

$$CPI_{Kj}^{1988} = \frac{1}{2}\left[\left(\frac{CPI_K^{1988}}{CPI_K^{1987}}\right)CPI_{Kj}^{1987} + \left(\frac{CPI_K^{1988}}{CPI_K^{1992}}\right)CPI_{Kj}^{1992}\right]. \tag{36}$$

The retail services price charged by business type j is estimated as follows:

$$p_j = \sum_K w_{Kj} CPI_{Kj}, \tag{37}$$

where:

$$w_{Kj} = \frac{SALES_{Kj}}{\sum_l SALES_{lj}}. \tag{38}$$

Hence, a weight based on the share of the sales categories of each type of business is used. The index j relates to business classification (A). As explained above, the correspondence between this classification and business classification (B) is set out in Table 2. The correspondence between the category classification on which the CPI is based and the industry classification used by the CC/TB is set out in Nakajima *et al*. (2002).

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