No. 306

Hedonic Price Indexes of Japanese Passenger Cars over 1970-83: A Note

by
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May 1986

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Abstract

This note presents three kinds of estimated annual percentage changes in the hedonic price indexes of used cars for 1970-83 and of new cars for 1970-82 in Japan. Estimations are done both by unweighted and by weighted regressions with sales as weight. We compare these estimated indexes with each other and with the CPI (Official CPI is calculated only for new cars in Japan). Our findings are summarized in the conclusion.

I. INTRODUCTION

Studies are very scarce about hedonic price index (that is, quality-adjusted price index estimated by hedonic regressions explained in section III) of Japanese cars. Exceptional works are Nakamura (1974) for 1965-71 and Ohta (1978) for 1970-76. Both of them and Japanese official Consumer Price Index (CPI) do not study about used cars but study only about new cars.

This note will present three kinds of estimated hedonic price indexes of Japanese used cars for 1970-83 as well as new cars for 1970-82, and will compare them with each other and with the CPI. This period includes the two oil shocks in 1973 and 1979 (see Table 1 for the CPI of gasoline). Section II will describe the data, III will present the estimates and IV will conclude the note by summarizing the findings.

II. DATA

Japanese passenger cars are classified into three size classes: Regular (displacement of engine is larger than or equal to 2,000 cc), compact (from 550 to 2,000 cc) and mini car (less than 550 cc). Their shares of new car registrations are about 2, 92 and 6 percent, respectively, in 1975 and 1980. We will confine our data to compact cars.

We collected the following data for each sample car: (1) vintage, (2) introduction month, (3) used car price in April, (4) weight (in kg, WT), (5) number of doors (ND), (6) number of cylinders (NOC), (7) wheelbase (in mm, WB), (8) length (in mm, L), (9) width (in mm, W), (10) displacement of engine (in cc), (11) horsepower (in ps, HP), (12) automatic transmission dummy (AT=1 if it is a standard equipment, 0 otherwise), (13) power steering dummy (PS=1 if standard, 0 otherwise), (14) air conditioning dummy (AC=1 if standard, 0 otherwise), (15) fuel economy with speed of 60 km/h on the level road (in km/l, KPL), which is called "Teichi-Sōkō Nenpi" in Japan, (16) new car registration. Capital letters in the parentheses above are abbreviations to be used later.

(1) to (5) were taken from the April issue of Red Book, (6) to (11) from Jidōsha Gaido Bukku (Japanese Motor Vehicles Guide Book) and (12) to (14) were from Catalogues issued by automobile manufacturers. Data of (15) on and after the 1976 vintage were obtained from the Guide Book and those before 1976 were from Catalogues. (16) is taken from Jidōsha Nenkan (Automobile Yearbook). We will use (16) as sales data to weight the hedonic regression. A summary of data is shown in Table 2. The size of KPL-available sample is small until the mid-seventies' vintages.

III. EMPIRICAL RESULTS

Hedonic approach regresses the price of a good on its characteristics to adjust for quality change. In our case of cars, characteristics that are used often are horsepower, weight, wheelbase, etc. Ohta (1986) found that the estimated coefficients of cars' characteristics were stable over time in the adjacent half-year (April and October) hedonic regressions in Japan, even without taking gasoline cost into account despite of the two oil shocks. So our standard hedonic regression equation for used cars does not take gasoline cost into account as below.

$$\log P(x,KPL,s,t) = \text{Constant} + \Sigma_k \pi_k T_k + \Sigma_s \delta_s D_s + \Sigma_i \alpha_i x_i + u \qquad (1)$$

where $P(x,KPL,s,t)$ denotes the price at time t of a car of age s with a vector of characteristics x and fuel economy KPL, T_k and D_s are dummies for time k and age s, respectively, and u is a disturbance. Here x does not include KPL.

Following characteristics are used in the regression: HP, NOC, WT, WBW (WB times W), NOD2 (1 if NOD<4, 0 otherwise), NOD5 (1 if NOD>4, 0 otherwise), AT, PS and AC. HP and NOC contribute to the speed and acceleration, WT, WBW, NOD and AC to the quality of ride, and AT and PS to the ease of driving and maneuvering.

π_k is a proportional rate of change of hedonic price index (that is, quality-adjusted price index) from the base time to time k. We will call the hedonic index estimated by equation (1) the "traditional hedonic index" (T-index), following Ohta and Griliches(1986a). We will call the index the "T-index with KPL", when the fuel economy KPL is added to the above characteristics list and is treated like other characteristics.

Ohta and Griliches (1986b) derived a following hedonic regression equation that takes gasoline cost into account.

$$\log P(x,KPL,s,t) = \text{Constant} + \Sigma_k \pi_k T_k + \Sigma_s \delta_s D_s + \Sigma_i \alpha_i x_i - G/P(x,KPL,s,t) + u \quad (2)$$

Here G is the expected present value of gasoline cost over the remaining life of the car. G/P is interpreted as its "real" value, where P serves as a deflator.

Now π_k in equation (2) is the proportional rate of change of what is called "new-fashioned hedonic price index" in Ohta and Griliches (1986a). This index takes the change in the expected present value of gasoline cost into account. Its proportional rate of change is equal to the sum of those of T-index and the expected "real" present value of gasoline cost G/P.

We parameterize G as follows, following Ohta and Griliches (1986b).

$$G \simeq \beta/KPL + \gamma \cdot s + \varepsilon \cdot s/KPL \quad (3)$$

Substituting (3) into (2) yields the folllowing.

$$\log P(x,KPL,s,t) = \text{Constant} + \Sigma_k \pi_k T_k + \Sigma_s \delta_s D_s + \Sigma_i \alpha_i x_i - (\beta/KPL + \gamma s + \varepsilon s/KPL)/P + u \quad (4)$$

According to the finding of Ohta (1986) stated before, we can safely assume the gasoline cost parameters β, γ and ε to be constant over time. We will call the new-fashioned index estimated under this constancy assumption "N1-index", following Ohta and Griliches (1986a).

Thus we will estimate three kinds of hedonic indexes: T-index, T-index with KPL and N1-index. We will call the corresponding hedonic regressions the T-regression, the T-regression with KPL and the N1-regression. We use both unweighted and weighted regressions with sales as weight. We will call the corresponding indexes the unweighted and the weighted indexes, respectively. The weighted index represents the market better. We will do an adjacent several-year regression instead of a two-year one to use better

estimates of the characteristics coefficients, because the coefficients are stable over time (Ohta 1986).

We will study new car price first. New car hedonic regression equations are obtained by deleting age dummies D_s and age variable s from (1) and (4). Years 1970-73, 1973-76, 1976-79 and 1979-82 are pooled in one regression. We will call these poolings pool AN, BN, CN and DN, respectively. Numbers of observations are 330 (62), 439 (159), 558 (475) and 685 (682), respectively (Numbers in the parentheses show the sample size for which KPL data is available). Table 3 lists the weighted regression results for 1979-82 as an example. Weighting by sales does not improve R^2 and the standard error of regression (SER) much.

Table 4 lists estimated percentage changes in the weighted hedonic price indexes together with the result of Ohta (1978) and the CPI of new car. Changes in the unweighted indexes were not significantly different from those of the weighted indexes for all the three indexes (T- , T- with KPL and N1-index) for all the periods except for the 1973-74 and 1978-79 changes of the T-index. Percentage increases of the unweighted T-indexes are 4.8 (1.2) and 3.5 (1.1) for these two periods, respectively (standard errors in the parentheses). Here we say that the two estimates are significantly different from each other if the difference between them is larger than the sum of their standard errors.

T-index with KPL and N1-index are estimated only for the KPL-available data, while T-index listed in the table is estimated using all the sample. The estimated changes in the T-index based on the KPL-available data were not significantly different from the changes in the T-index with KPL. So the inclusion of KPL like the other characteristics does not affect the estimated changes in the hedonic indexes. This will be because KPL is

explained well by the other characteristics. Changes in the T-index based on all the sample are significantly different from those based on the KPL-available data for 1974-75 and 1975-76. The latter estimates are 6.2 (1.8) and 6.9 (1.8), respectively, in percent. So changing the sample affects the estimates. Estimated changes in the N1-index are not significantly different from those in the T-index with KPL. This suggests that car manufacturers do not pay much attention to the "real" gasoline cost G/P in their pricing policy and/or that G/P does not differ much among Japanese cars.

Our estimated changes in the T-index differ from those in Ohta (1978) for 1971-72, 1972-73 and 1974-75. This will be due to the differences in the sample and in the explanatory variables in the hedonic regression. Ohta (1978) includes mini and regular as well as compact cars in the sample: They are about 18, 9 and 73 percent, respectively, in the data. Explanatory variables include dummies for regular and mini cars.

We list annual averages of the CPI of new cars for the comparison with our T-index in the table, because new car models are not introduced solely in the autumn but rather evenly over the year. Roughly speaking, our T-index moves similarly with CPI: The sum of annual percentage increases of our T-index is 53.0 percent and that of the CPI is 47.2 percent for 1970-82. They are very similar. But the estimated annual changes differ from those of the CPI by more than twice their standard errors in 1973-74, 1974-75, 1975-76, 1976-77, 1980-81 and 1981-82. This will be partly because price data are different between our sample and the CPI but partly because the CPI includes mini as well as compact cars. They are about 20 and 80 percent, respectively, in the CPI data.

Now we proceed to the used car price. We use a half-year interval of age dummies instead of a year interval that is used usually in the U.S. studies, because new car models are introduced rather evenly over the year in Japan as stated before. For example, age 3 includes the ages from 2 years and 10 months to 3 years and 3 months. We use 1.5 to 4 years old cars in estimation whenever possible, because these ages will represent the used car market well.

Based on the finding of Ohta (1986), we will pool adjacent several years instead of just two years in one regression to use stable estimates of the characteristics' coefficients. There are 5 poolings of years, AU, BU, CU, DU and EU. AU pools 1970 (1969), 1971 (1970), 1972 (1971) and 1973 (1972), where the years in the parentheses show the vintages of cars used as sample for the year. BU pools 1971 (1969-70), 1972 (1970-71), 1973 (1971-72) and 1974 (1972-73). CU pools 1974 (1970-72), 1975 (1971-73), 1976 (1972-74) and 1977 (1973-75). DU pools 1977 (1973-75), 1978 (1974-76), 1979 (1975-77) and 1980 (1976-78). EU pools 1980 (1976-78), 1981 (1977-79), 1982 (1978-80) and 1983 (1979-81). Thus the age structure of sample cars is the same for all the years in the same pool. Numbers of observations are 131 (21), 429 (79), 1108 (269), 1403 (768) and 1838 (1720) for each pool, respectively (Numbers in the parentheses are those of KPL-available data).

Table 5 shows a weighted regression result for 1980-83 as an example. In contrast to the new car case, weighting by sales improves R^2 and SER much.

Table 6 lists estimated annual percentage increases in the weighted hedonic price indexes of used cars together with the T-index and the CPI of new cars. We did not list the estimated changes in the T-index with KPL and NI-index for the years the vintages of whose sample cars are all before

1973, because these two indexes are estimated only for the KPL-available data and the data is very small before then (Table 2). We estimated the changes in T-index for the KPL-available data, but they were not significantly different from those in T-index with KPL. So the introduction of KPL just like the other characteristics does not affect the estimated changes in the index. Changes in the unweighted indexes are not significantly different from those in the weighted indexes except for 1981-82 in N1-index: 4.9 (1.4) percent for the unweighted.

T-index with KPL and N1-index are not significantly different from each other. T-index and T-index with KPL are significantly different from each other in 1978-79 and 1979-80: The latter index increased less than the former. This is due to the difference of the sample.

Let us compare the movement of the hedonic indexes of used cars with that of new cars. New car prices increased more in the first oil shock 1973-74 but used car prices increased more after then till 1979. Again in the second oil shock 1979-80, new car prices increased more: Actually used car prices fell. But roughly speaking, both prices moved similarly on the whole and the sum of the percentage increases in the used car price indexes is not very different from that of new cars over the period 1970-82 (60.6 and 53.0 percent, respectively). This is in sharp contrast to the case of the U.S.: Used car prices increased much higher than new car prices there. The CPI of used cars increased by 165.1 percent from April 1970 to April 1982 in the U.S., while that of new cars increased by 82.9 percent. Also we listed January-March average of the CPI of new cars in the table for reference: CPI is not calculated for used cars in Japan and the April used car price data of Red Book will be collected before April. Similar observations holds for the comparison between the hedonic price index of

used cars and the CPI of new cars as between the hedonic indexes of used and new cars.

IV. CONCLUSION

We summarize our findings as a conclusion. (1) to (4) below hold both for new and for used cars. (5) and (6) are our major findings. (1) Estimated percentage changes in the unweighted and weighted indexes are not significantly different from each other except for rare cases. This is true for all the three indexes (T- ,T- with KPL and N1-index). (2) Inclusion of KPL just like other characteristics into the hedonic regression does not affect the estimated changes in the hedonic indexes significantly. (3) Estimated changes in the N1-index are not significantly different from those in the T-index with KPL. (4) Differences in the sample affect the estimated changes in the index significantly sometimes. This is seen in the comparison between T-index and T-index with KPL. Also it will be one of the causes that produce significant differences occasionally in the estimated annual changes among our T-index, index estimated in Ohta (1978) and the CPI. (5) Roughly speaking, T-index of new cars moves similarly with the CPI on the whole over the period 1970-82, although their annual changes differ significantly sometimes. Their sums of annual percentage changes over the period are very similar (53.0 and 47.2 percent, respectively). (6) Roughly speaking, hedonic price indexes of new and used cars move similarly over the period 1970-82, althogh their annual percentage changes are often significantly different from each other: Used car prices increased by 60.6 percent over 1970-82, while new car prices increased by 53.0 percent. This is in sharp contrast with the case of the U.S. There the CPI of used cars increased by twice as much as new cars over the same period (165.1 and 82.9 percent, respectively).

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Table 1. Relevant CPI Components in Japan: April Values (1970=100)

Year	General	Gasoline	New Car	Year	General	Gasoline	New Car
1970	100	100	100	1977	203.6	232.1	141.6
71	105.7	108.9	101.2	78	211.6	211.5	144.1
72	110.4	109.2	101.5	79	217.1	208.6	147.3
73	120.9	120.7	101.5	80	235.1	304.7	148.4
74	151.2	193.2	125.1	81	247.2	283.4	149.2
75	171.6	211.5	129.7	82	254.0	325.1	156.3
76	187.7	215.4	138.9	83	259.0	307.1	157.2

Source: Bureau of Statistics, Office of Prime Minister, Annual Report on the Consumer Price Index.

Table 2. Data

Vintage	No. of obs.[a]	Weighted Average of Horsepower[b]	Weight[c]	Fuel Economy[d]	New Car Price[e]	Used Car Price at age 3[f]
1969	49	79.4	868	20.0	62.7	30.6
	18	(21.0)	(190)	(2.0)	(17.6)	(11.1)
70	63	87.7	900	18.4	64.7	35.5
	6	(18.0)	(173)	(1.1)	(17.4)	(9.6)
71	73	89.7	901	20.6	68.7	39.6
	13	(18.3)	(174)	(0.8)	(18.3)	(12.2)
72	87	92.6	925	20.4	70.5	48.4
	14	(18.8)	(189)	(0.8)	(19.7)	(14.1)
73	107	96.1	948	20.6	77.1	58.8
	29	(20.2)	(187)	(1.4)	(23.8)	(18.9)
74	114	94.6	944	19.7	91.0	62.2
	34	(21.4)	(181)	(2.1)	(26.7)	(18.9)
75	103	94.3	983	19.5	106.1	67.0
	40	(21.2)	(209)	(2.5)	(40.5)	(26.9)
76	115	92.4	1006	19.1	112.1	69.9
	56	(21.8)	(201)	(2.8)	(42.2)	(28.6)
77	142	97.0	1007	19.1	122.4	73.5
	128	(22.2)	(183)	(2.8)	(40.0)	(28.6)
78	137	94.3	994	19.7	120.7	68.5
	129	(21.7)	(186)	(3.1)	(38.8)	(21.9)
79	164	94.8	987	19.7	124.5	76.8
	162	(20.6)	(187)	(3.5)	(43.8)	(30.1)
80	187	94.1	981	20.8	125.0	76.1

	187	(21.2)	(191)	(3.9)	(42.3)	(28.6)
81	168	95.4	984	21.4	133.8	---
	167	(21.9)	(195)	(4.1)	(52.7)	
82	166	93.6	970	22.5	130.6	---
	166	(20.5)	(178)	(4.4)	(48.1)	

[a]Total number of observations is shown first and that for which fuel economy data is available is shown next. [b]ps. [c]kg. [d]km/l on the level pavements with speed of 60 km/h. [e,f]10,000 yen.

NOTE: Standard deviations in the parentheses. Averages are calculated for the total observations except for fuel economy: they are weighted by sales.

Table 3. Weighted OLS Hedonic Regression for 1979-82: New Cars

Estimated Coeff. of	T-regression	T-regression with KPL	N1-regression
Constant	6.119	6.061	6.355
	(.069)	(.065)	(.069)
T_{1979}	-.017	.005	.012
	(.010)	(.010)	(.010)
T_{1981}	.055	.042	.029
	(.010)	(.010)	(.010)
T_{1982}	.055	.029	.012
	(.010)	(.010)	(.010)
HP[a]	.040	.049	.036
	(.003)	(.003)	(.003)
NOC	-.011	-.015	-.011
	(.007)	(.007)	(.007)
WT[b]	.123	.140	.099
	(.005)	(.005)	(.005)
WBW[c]	-.150	-.106	-.063
	(.023)	(.022)	(.023)
NOD2	.026	.018	.008
	(.009)	(.008)	(.008)
NOD5	.021	.021	.011
	(.012)	(.012)	(.012)
AT	.055	.096	.073
	(.010)	(.011)	(.010)
PS	.046	.036	.025
	(.015)	(.014)	(.015)

AC	.127	.141	.103
	(.018)	(.017)	(.017)
1/KPL	---	-73	---
		(7)	
$1/(KPL \cdot \hat{P})$	---	---	-74026
			(7185)
No. of Obs.	685	682	682
R^2	.914	.925	.926
SER	.092	.086	.085

$^{a}_{10ps.}$ $^{b}_{100kg.}$ $^{c}_{m^2.}$

NOTE: Standard errors in the parentheses.

Table 4. Annual Percentage Increases in the Weighted Hedonic Price Indexes of New Cars (%)

Years Compared	Pooling[a]	T-index	T-index with KPL[b]	N1-index[c]	Ohta(1978)	CPI[d]
1970-71	AN	.4	---	---	1.5	1.2
		(1.1)			(1.0)	
71-72	AN	-1.2	---	---	1.3	.3
		(1.1)			(1.1)	
72-73	AN	4.6	---	---	.8	3.0
		(1.0)			(1.2)	
73-74	BN	18.2	18.0	21.7	19.7	20.5
		(1.1)	(1.9)	(2.5)	(1.3)	
74-75	BN	9.8	5.9	7.5	5.4	4.2
		(1.1)	(1.8)	(2.0)	(1.6)	
75-76	BN	3.4	7.4	8.3	4.9	6.5
		(1.1)	(1.8)	(1.9)	(1.8)	
76-77	CN	7.4	6.1	4.3	---	1.9
		(1.2)	(1.3)	(1.4)		
77-78	CN	2.0	.1	-.2	---	1.7
		(1.1)	(1.0)	(1.0)		
78-79	CN	1.2	1.5	1.0	---	1.9
		(1.1)	(1.0)	(1.0)		
79-80	DN	1.7	-.5	-1.2	---	.8
		(1.0)	(1.0)	(1.0)		
80-81	DN	5.5	4.2	2.9	---	2.3
		(1.0)	(1.0)	(1.0)		
81-82	DN	-.0	-1.3	-1.7	---	2.9

		(1.0)	(1.0)	(1.0)

[a]See text for the pooling designation. [b,c]Estimates are not listed in the early 1970's because the size of KPL-available data is too small. [d]Annual average of the CPI of new cars.

NOTE: Standard errors in the parentheses.

Table 5. Weighted OLS Hedonic Regression for 1980-83: Used Cars

Estimated Coeff. of	T-regression	T-regression with KPL	N1-regression
Constant	5.365	5.446	5.444
	(.068)	(.070)	(.119)
T_{1980}	-.005	.002	.007
	(.011)	(.012)	(.012)
T_{1982}	.096	.081	.075
	(.010)	(.011)	(.011)
T_{1983}	.102	.078	.073
	(.011)	(.011)	(.012)
D_2	-.078	-.070	-.049
	(.013)	(.013)	(.014)
$D_{2.5}$	-.191	-.180	-.136
	(.013)	(.014)	(.017)
D_3	-.251	-.231	-.154
	(.013)	(.013)	(.022)
$D_{3.5}$	-.401	-.383	-.258
	(.014)	(.015)	(.030)
D_4	-.485	-.450	-.269
	(.013)	(.014)	(.042)
HP[a]	.054	.066	.060
	(.003)	(.004)	(.004)
NOC	.053	.045	.034
	(.006)	(.007)	(.007)
WT[b]	.069	.080	.073
	(.006)	(.007)	(.007)

WBW[c]	-.028	-.033	-.046
	(.024)	(.025)	(.025)
NOD2	.051	.045	.039
	(.009)	(.009)	(.009)
NOD5	.054	.051	.038
	(.015)	(.015)	(.015)
AT	.048	.072	.052
	(.013)	(.014)	(.013)
PS	.084	.092	.092
	(.016)	(.018)	(.018)
AC	.181	.240	.209
	(.020)	(.022)	(.021)
1/KPL	---	-50	---
		(8)	
$1/(KPL \cdot \hat{P})$	---	---	7052
			(10471)
$s/\hat{P}$	---	---	25
			(10)
$s/(KPL \cdot \hat{P})$	---	---	-11354
			(3332)
No. of Obs.	1838	1720	1720
R^2	.824	.830	.833
SER	.159	.156	.155

[a]10ps. [b]100kg. [c]m^2.

NOTE: Standard errors in the parentheses.

Table 6. Annual Percentage Increases in the Weighted Hedonic Price Indexes of Used Cars (%)

Years Compared	Pooling[a]	T-index	T-index with KPL[b]	N1-index[c]	T-index New Car[d]	CPI New Car[e]
1970-71	AU	-2.9	---	---	.4	1.2
		(2.2)			(1.1)	
71-72	BU	2.8	---	---	-1.2	.5
		(1.5)			(1.1)	
72-73	BU	2.1	---	---	4.6	.0
		(1.4)			(1.0)	
73-74	BU	5.5	---	---	18.2	19.8
		(1.3)			(1.1)	
74-75	CU	16.1	---	---	9.8	5.7
		(1.0)			(1.1)	
75-76	CU	16.0	---	---	3.4	8.5
		(.9)			(1.1)	
76-77	CU	7.5	7.7	11.1	7.4	1.9
		(1.0)	(1.8)	(2.1)	(1.2)	
77-78	DU	3.7	1.9	2.6	2.0	1.8
		(1.2)	(1.8)	(1.8)	(1.1)	
78-79	DU	2.9	-1.4	-.6	1.2	1.5
		(1.2)	(1.6)	(1.6)	(1.1)	
79-80	DU	-3.2	-5.9	-4.5	1.7	1.5
		(1.1)	(1.4)	(1.4)	(1.0)	
80-81	EU	.5	-.2	-.7	5.5	.4
		(1.1)	(1.2)	(1.2)	(1.0)	
81-82	EU	9.6	8.1	7.5	-.0	4.7

		(1.1)	(1.1)	(1.2)	(1.0)	
82-83	EU	.7	-.3	-.2	---	.8
		(1.0)	(1.0)	(1.0)		

[a]See text for the pooling designation. [b,c]Estimates are not listed for the years whose sample vintages have too small sizes of KPL-available data. [d]Taken from Table 4. [e]January-March average.

NOTE: Standard errors in the parentheses.