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Using Hedonic Prices to Estimate Quality Changes concerning Iranian Automobile Market

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Abstract

This paper sketches a model of product differentiation according to the hedonic hypothesis that is based on the theory of consumer behavior of Lancaster (1971). Lancaster suggested that utility is derived from the characteristics of the good and not the good itself. Thus, from the perception of the consumer, every characteristic has a price. This is the hedonic (or implicit) price. We have estimated implicit price and quality changes of Iranian car market for the years 2005 to 2010. The empirical results indicate that during this period the safety variables (types of airbags and brakes) have been the most important variables affecting the price of automobile, and also the changes in the quality of new automobiles sold in Iran have been responsible for price increases of about 47% during this period.

Keywords: Iranian Automobile Market, Hedonic price, Quality changes.
JEL Classification: D11, L62

1. Introduction

One of the goals in the classical price theory is quantification of the 'true' price change of a good, given a certain quality. In practice, goods change, typically improving over time. Therefore quality changes must be taken into account in order to provide a sound basis for price evaluation. In this

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paper, the hedonic approach is used to estimate the implicit price and quality changes of Iranian automobile market for the period of 2005-2010. Therefore, the main aim is to analyze the increases in the price of Iranian automobiles, thus the question would be how much of this price increase may have been due to the quality improvement.

2. Literature Review

Although the study concerning the effect of quality changes on prices is relatively old, the topic is perhaps more interesting now than ever before and the literature on the relation between quality change and prices has grown rapidly.

This paper sketches a model of product differentiation according to the hedonic hypothesis that is based on the theory of consumer behavior of Lancaster (1971). Lancaster suggested that utility is derived from the characteristics of the good and not the good itself. In his paper he broke with traditional theory, i.e. that goods are the direct objects of utility, and instead assumed that goods and their characteristics do not raise the consumer's utility, but are instead used as input factors by the consumers in producing the ultimate characteristics. Each characteristic therefore has a value for consumers, which is defined as implicit price. So, hedonic pricing models declare that the price of the good is the sum of the implicit prices of the different characteristics of that good.

The essence of the new approach of Lancaster can be summarized as follows, each assumption representing a break with tradition:

1. The good, per se, does not provide utility to the consumer, it possesses characteristics, and these characteristics rise to the utility.
2. In general, a good possess more than one characteristic, and many characteristics are shared by more than one good.
3. A good as a whole may possess characteristics different from those pertaining to the good separately.

Rosen (1974) suggested the general form of the hedonic price function, as follows:

$$P(Z) = P(Z_1, Z_2, Z_3, ..., Z_n)$$

Where P(Z) is the observed market price for a particular product, Z= $(Z_1, Z_2, Z_3, ..., Z_n)$ is vector of n objectively measured characteristics and z_i measuring the amount of the *i*th characteristic contained in each product. Bhowmick (2001) suggested that observed product prices and the specific number of characteristics associated with each good define a set of implicit or "hedonic" prices. Hedonic price functions have been widely used in empirical studies of durable goods that are differentiated by characteristics.

This study is primarily based on the work done by Bhowmick (2001) in which he estimates a quality index for automobiles based on hedonic pricing approach. Bhowmick estimates how much of the increase in prices can be attributed to an increase in quality for Japanese and American automobiles for their corresponding price rise from 1988 to 1998.

Hedonic regression models have been the subject of many studies. One of the main objectives of the literature on hedonic models for automobile prices has been to correct standard price indexes for quality change. Indeed, the pioneering work by Court (1939) was commissioned by General Motors, that was interested in pointing out that, despite the sharp increase in the official price index for new automobiles, quality-corrected prices of automobiles had been steadily declining since the mid 1920s.

This methodology was used by Triplet (1969), Griliches (1971) and then revived by Reis and Santos Silva (2006) who used hedonic regressions again to gauge the bias of standard price indexes caused by incorrectly accounting for quality changes in automobiles. Their work had a great impact on the profession and was quickly followed by a number of studies reappraising the effect of quality changes on price indexes.

Hedonic regressions were soon used for different purposes and the interest on quality-corrected price indexes was overshadowed by these new uses of the technique. For example, the early work of Boyel and Hogarty (1975) pioneered the used hedonic regressions to study competition and price setting behavior in the UK and US automobile markets. On a similar line, Mertens and Ginsburgh (1985) and Ginsburgh and Vanhamme (1989) analyzed product differentiation and price discrimination in the European automobile market. Feenstra (1987), Melo and Messerlin (1988) and Bourdet (1991) used hedonic regressions to study the effect of trade restrictions on the price and quality of automobile imports. On a different note, Ohta and Griliches (1986) used hedonic regressions to evaluate the impact of gasoline price increases on consumer tastes. Couton, Gardes and Thepant (1990), Levitt and Porter (2001), and Andersson (2005) have used the same method to estimate the value of safety characteristics for French and Swedish car industries.

In parallel, following the seminal work of the Rosen (1974), hedonic regression, were used as a tool to estimate, under suitable assumptions on consumer behavior and market structure, demand functions for product characteristics. Demand functions for automobile characteristics are estimated by different authors such as Agarwal and Ratchford (1980), Atkinson and Holvorsen (1990), Bajic (1988) and Arguea, Hsiao and Tylor (1994). Although hedonic regression is an important component in these studies, it is just the first in a two-step procedure to analyze consumer preferences. This literature pays considerable attention to the estimated coefficients of the product characteristics using the hedonic regression, rather than focusing on the proportion of the price that is explained by the characteristics.

3. Methodology

According to the Lancaster (1971) utility is derived from the characteristics of the commodity and not the commodity itself. Thus, the price (P) of the commodity can be written as a function of a set of qualities or characteristics (Z):

$$P = f(Z_1, Z_2, Z_3, \ldots, Z_n) \tag{1}$$

3.1 Model

To estimate the implicit price of each characteristic and estimate quality changes in Iranian car market, we have used the equation as follows:

$$Log(P_i) = \alpha_0 + \alpha_1(ENG_i) + \alpha_2(ACC_i) + \alpha_3(WID_i) + \alpha_4(HEI_i) + \alpha_5(FUEL_i) + \alpha_6(DBRAE_i) + \alpha_7(DBRF_i) + \alpha_8(DABRS_i) + \alpha_9(DABF_i) + g(D2010_i) + e_i \tag{2}$$

Variables used in this equation are; dollar price of automobile (P), engine displacement (ENG), acceleration 0-100 km/h (ACC), width measured in centimeter (WID), height in centimeter (HEI), fuel consumption measured in Liter/100Km (FUEL), Anti Lock Brakes and Electronic Brake-Force Distribution (DBRAE), dummy variable with 1 if present and 0 if not, Anti Lock Brakes, Electronic Brake-Force Distribution and Electronic Stability Program and Anti Slip Regulation

(DBRF), dummy variable with 1 if present and 0 if not, driver and passenger side Airbag (DABRS), dummy variable with 1 if present and 0 if not and dual front Airbags, side body Airbags and side head Airbags (DABF), dummy variable with 1 if present and 0 if not. "D2010" is a dummy variable that is zero in 2005 and one in 2010, and normally distributed random error term (e).

The coefficient of each characteristic (α_i) estimated from this regression will give the hedonic (implicit) price of that characteristic. This would show how that characteristic contributes determining the final price of the commodity. For instance, coefficient of variable "D2010" provides an estimate of the average percentage increase in the prices between the two periods, holding as constant the change in any of the measured quality dimensions.

In order to find the price changes due to quality changes we first calculated the average market prices using the market shares (S_{it}) and the market prices (P_{it}) of each concerning the years t = 2005 (n=24) and t = 2010 (n=22), as weighted mean (WM_{it}):

$$WM_{i2005} = \sum_{i=1}^{n} S_{i2005}P_{i2005} \; i = 1, \dots, 24 \;\; and$$
$$WM_{i2010} = \sum_{i=1}^{n} S_{i2010}P_{i2010} \; i = 1, \dots, 22 \qquad (3)$$

Then we have estimated the average quality prices as unit quality (U_{Qt}):

$$U_{Q2005} = \sum_{i=1}^{n} S_{i2005}\hat{P}_{i2005} \; i = 1,..,24 \;\; and \;\; U_{Q2010} = \sum_{i=1}^{n} S_{i2010}\hat{P}_{i2010} \; i = 1,..,22 \qquad (4)$$

In which, $\hat{P}_{it}$ is the estimated quality prices using the following hedonic regression[1]:

$$Log(P_i) = \alpha_0 + \alpha_1(ENG_i) + \alpha_2(ACC_i) + \alpha_3(WID_i) + \alpha_4(HIG_i) + \alpha_5(FUEL_i) + \alpha_6(DBRAE_i) + \alpha_7(DBRF_i) + \alpha_8(DABRS_i) + \alpha_9(DABF_i) + e_i \qquad (5)$$

The relative change in U_{Qt} to the relative change in U_{Vt} indicates a percentage price change due to quality change:

$$\left[\frac{\frac{U_{Q2010-U_{Q2005}}}{U_{Q2005}}}{\frac{WM_{i2010} - WM_{i2005}}{wM_{i2005}}}\right] * 100 \qquad (6)$$

3.2 Data

Iranian auto industry includes eight manufactures: Iran-Khodro Co., Saipa-Corp Co., Pars-khodro Co., Zagros-khodro Co., Bahman Group Co., Kerman-Motor Co., Modiran-Khodro Co. and Kish-Khodro.

We have gathered the different characteristics and prices of 46 Iranian automobiles from the brochures and formal websites of producers including 21 automobiles for the year 2005 and 25 automobiles for 2010 in which Peugeot206 includes 4 types (206-type2, 206-type3, 206-type5, and 206-v9). Table 1 shows the name and the market shares of the automobiles for 2010.

Table 1: Automobile in Iran: the Market Shares and Prices 2010

Row	Automobile	Company	Market Share	Observed price
1	Pride	Saipa-Corp	%47	8100
2	Rio	Saipa-Corp	%1.5	14200
3	Xantia	Saipa-Corp	%2	29000
4	C5	Saipa-Corp	%0.2	58000
5	Tondar	Pars-khodro&Iran-Khodro	%2.3	13200
6	Roniz	Pars-khodro	%0.3	32000
7	Maxima	Pars-khodro	%0.4	40000
8	Megan	Pars-khodro	%0.3	35000
9	Roa	Iran-Khodro	%7	8300
10	Peugeot206	Iran-Khodro	%8	15000
11	Samand	Iran-Khodro	%7	13500
12	Persia	Iran-Khodro	%6	18000
13	Peugeot 405	Iran-Khodro	%11	13150
14	Suzuki	Iran-Khodro	%1.1	47000
15	Peugeot 407	Iran-Khodro	%0.3	52000
16	Mazda3	Bahman-Group	%0.5	38000
17	Gol	Kerman-Motor	%0.25	18000
18	Avante	Kerman-Motor	%0.3	32000

Row	Automobile	Company	Market Share	Observed price
19	Lifan	Kerman-Motor	%0.4	16000
20	Verena	Kerman-Motor	%0.25	17000
21	Mvm110	Modiran-Khodro	%0.85	8100
22	GEN2	Zagros-Khodro	%0.6	26000

Peugeot206 includes 4 types (206-type2, 206-type3, 206-type5, and 206-v9)
Source: The Database of Ministry of Industry & Mines, http://www.mim.gov.ir

Iranian auto industry produced 1186033 passenger cars. Pride has the highest market shares of about %47 for year 2010. Table 2 provides some summery descriptive statistics of different characteristics for the years 2005 and 2010.

Table 2: Descriptive Statistics of the Characteristics

Characteristics	2005		2010	
	Mean	Standard Deviation	Mean	Standard Deviation
ENG	1767	504	1784	399
ACC	12.7	2.05	11.5	1.9
WID	170	9.58	170	7.45
HIG	152	41.6	147	10.15
FUEL	9.2	2.14	8.01	1.45
DBRAE	0.14	0.35	0.32	0.48
DBRF	0.04	0.21	0.16	0.37
DABRS	0.2	0.4	0.36	0.48
DABF	0.04	0.21	0.16	0.37
Price	16500	10595	24110	14178

Source: According to Data of Iranian Automobiles and Estimated by Excel Software

Table2 shows that all characteristics except (WID) and (HEI) have improved in quantity. For example, the car with BRAE has increased from 0.14 to 0.32, the mean FUEL has reduced from 9.2 to 8.01. Also, during 5 years, the arithmetic mean of price has increased by about 46%. According to the standard deviations, while deviation has reduced concerning ENG, ACC, WID, HEI, and FUEL, it has increased regarding to the characteristics such as DBRAE, DBRF, DABRS, and DABF.

4. Empirical Results

Using Ordinary Least Squares (OLS) estimation method has indicated the multicolinearity problem among explanatory variables. So that, we have used the "Farrar & Glauber" test, concerning the multicolinearity. The test has indicated that the variables ENG with ACC, and DABF with DBRF had high pair-wise correlation. Hence, the two less important variables ACC and DBRF were removed from the regression. The White test used has not supported the presence of heteroskedasticity problem in the data. The results are presented in Table3.

Table 3: Estimation of hedonic price function

Method: Ordinary Least Squares		
Variable	Coefficient	Prob.
Constant	4.594106	0.0018
ENG	0.000874	0.0002
FUEL	-0.097450	0.0253
WID	0.019928	0.0396
HEI	0.005558	0.1750
DBRAE	0.234144	0.0935
DABF	0.658717	0.0010
D2010	0.161680	0.0956
N	46	
R^2	0.84	
F	27.63	0.0000

Source: According to Data of Iranian Automobiles and Estimated by Eviews7 Software

The R^2 shows that %84 of the variation in prices are explained by the variables included in the regression. The coefficients of variables are the hedonic (implicit) prices of different characteristics of the commodity. As shown in Table3, the positive coefficient of 0.0009 for (ENG) indicates that a one cubic centimeters (**cc**) increase in displacement would result in a 0.09% increase in price. The coefficient of -0.1 for (FUEL) indicates that a one liter increase in petrol consumption would result in a 10% decrease in price. One centimeters increase in (WID) causes the price to increase by about 2%. The brake with Anti-Lock and Force Distribution is introduced as a dummy variable indicated 1 if present and 0 otherwise. Hence, the positive coefficient of 0.23 shows that its presence would lead to price increase of 23 percent. Similarly, the coefficient of 0.34 for complete Airbags (dual front Airbags, side body Airbags and side head Airbags). So, during 2005-2010, the safety variables (types of airbags and brakes) are the most important variable that affects the price of automobile. Coefficient of the included dummy for 2010 (observation before 2010 the D2010=0, for observation corresponding 2010, D2010=1) if significant, suggest the increase in price in that year that is not explained by any changes in characteristics. The coefficient of 0.16 for the year dummy 2010 reflects that 16 percent of the price change reflected in that year was not explained by any change in characteristics.

In the next step we have estimated the quality prices. An estimate of the price rise due to quality is found by computing the predicted price from the hedonic regression but not including the year dummy (D2010). To begin with the observed prices, we first found the unit value. Doing so, we took the weighted average price of all the cars for 2005 and 2010. The weights used were the market share of each model. The unit value for 2005 was $9846 and for 2010 was $12099. The procedure to compute unit quality was the same as above, but here we used the quality prices from the hedonic regression. The hedonic regression is used, without the year dummy to predict the quality price for each car model. Then for each year, we have calculated the unit quality by taking a weighted average to find the unit quality (price). The unit quality for the year 2005 was $4743 and for the year 2010 was $5285. Thus, the actual or observed price increase was about %22.88; but the quality included price increase (as measured by the increase of the unit quality) was 10.85%. For this data, 47% (%10.85 of %22.88) of the observed price increase was due to quality changes.

5. Conclusion

Car industry in Iran has been protected since the start. While the prices have been raising, the improvement concerning quality has been debated always. From the consumer point of view every goods characteristic has a price. From theoretical point of view this is the hedonic (or implicit) price. We have estimated implicit price and quality changes of Iranian car market for the years 2005 and 2010. The results indicate positive and significant coefficients of ENG, WID, DBRAE and DABF, while negative and significant coefficient of FUEL consumption. In other words, Iranian consumers are willing to pay extra prices for ENG, WID, and especially for safety standards such as complete Airbags (dual front

Airbags, side body Airbags and side head Airbags) and brake with Anti Lock and Force. During 2005-2010, the safety variables (types of airbags and brakes) have been the most important variables that affected the price of automobile in Iran. About half of the observed price increase during 2005-2010 has been due to car quality improvement. According to the relatively high accident statistics in Iran, this finding is quite natural. The policy recommendation based on the results obtained would be that Iranian consumers (concerning the high accident statistics in Iran) are willing to pay more for car safety options, therefore, the manufactures should focus on improving the car safety standards. Auto producers in Iran can help consumers choosing the right car by stating special features of automobile which are under investigation and production process concerning the vital importance of qualification such as fuel consume, safety and type of auto suspending system.

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Notes:

1. It is the same as equation 2, but without the dummy variable D2010.