

Summer project

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Lihua Chen

Abstract

The main objective of this article is to employ a panel data on the US sedan characteristics to estimate a hedonic car price model. This enables us to examine the price differences between various sedan models and to figure out those factors that customers value when they make buying decisions. The second objective of the article is to provide some guideline for automakers when they are making decisions about advertising, resource assignment and entering new market.

Background

The increasing technological sophistication and innovations has brought out a growing range of vehicle types and models to meet the needs and preferences of the target customer segments. In the automobile market, there are all kinds of vehicles with different criteria and attributes: sedans, convertibles, pickup trucks, wagons, SUVs and etc, whose safety, affordability and comfort are different. On the other side, customers' choices are consistent with their needs and preferences involving safety, comfort, and affordability. Sales of vehicles are also different among vehicle segments and automakers. For example, in the US automobile market, Japanese automakers have performed successfully with a substantially increasing market share especially in recent years. What has been done by the Japanese automakers to attract customers?

Given the influence of the automotive market to the national economy and the major technological innovations in the manufacturing industry, it is very important to figure out the factors that affect the customers' buying decisions.

Back in 1976, Wynne and Hoffer had investigated the effects that safety-related recalls have on the sales of vehicles. Their conclusion, which is based on the data from 27-month period ending April 1973, showed that market share was not affected significantly for most makes. The penalty caused by product recalls is explored by

Rhee and Haunschild (2006) in the case of companies' higher reputation and lower reputation. Lienert (1998) analyzed how the brand management affects market share. Biderman et al. (2005) used a model to analyze the effects of the 2mm technology on market share and that on automakers' make-ups for US-made vehicles. The relationship between warranty and quality has been studied by introducing joint price, warranty and quality decision with data from US auto market (Douglas et al, 1993). Automaker cost and customer preference were found to account for the negative relationship between warranty and quality. Favero et al. (2006) built a semi-logarithmic hedonic price model to assess the vehicle attributes associated with customers' preference and sales of vehicles.

As far as the relations with suppliers, Richardson (1993) presented parallel sourcing strategy to illustrate the performance differences between U.S. firms and Japanese competitors. The study by Dyer (1996) exploited the relationship between the performance of automakers and their inter-firm activities. A positive relationship between supplier-automaker specialization and automaker performance is confirmed. Lee and Masters (1997) applied a hedonic price model to judge the competitiveness of U.S. automakers versus Japanese automakers. Meanwhile, automaker performance is measured by used-car prices and quality is found to be the crucial factor of customer loyalty and market demand. U.S. automakers have denied the gasoline price and sales of vehicles for long time. However, the article by McManus (2007) presents theoretical reasons and data from the U.S. auto market to prove Detroit's conventional belief false. Thus, fuel economy is viewed as a substantial factor that affects auto market share. The relationship between intermediaries, dealers, and the sales of vehicles has been analyzed by Verhoef et al. (2006) through their contribution to brand retention. The findings show that dealers selling volume brands could support brand retention.

The objective of this paper is to investigate factors that affect customers' decision when they buying vehicles in the U.S. car market. In this article, special attention

would focus on the part of passenger car to know more about the situation.

Investigation of the US automobile market and Anticipated Need for Adjustment

There are a couple of characteristics which underline distinctive automobile preferences among customers in the US automotive market. Actually, customer preference is highly based on the vehicle specifications. First, the safety attribute may mean a lot to the customers. In 2002, 43,002 people were killed in vehicle crashes (data from: www.NHTSA.gov). It is claimed by NHTSA that vehicle crashes are the leading cause of death in the U.S. for every age from 3 through 33 in that year. In 2005, 43,443 people were killed in motor vehicle crashes, which means a 1.4% increase from 2004 and is the highest level killed since 1990 (data from: www.NHTSA.gov). Meanwhile, there were 2,699,000 people injured in 2005. Secondly, with the price of gasoline soaring, more and more customers care about fuel efficiency now. Take unleaded regular gas for example. Its retail price (cents per gallon, including taxes) was only 138.2 in 2000, while in 2004, its price was 188 (Wards automotive yearbook 2005), increased by 36%. Especially in May of 2007, the price of unleaded regular gasoline even hit 321.8 (cents per gallon), which was barely tying the historic record (inflation-adjusted) of 322.3 (cents per gallon) set in March 1981 (Steven Mufson, 2007). Thirdly, quality is crucial to a product, especially to an automobile. With the highly dependent on the private transportation, opportunity cost is very high with a broken vehicle. Car owners are even less responsive to the repair cost than the repair frequency (Lee and Masters, 1997). Meanwhile, long-term performance is also a criterion for quality assessment. Fourthly, vehicle miles of travel are also increasing year by year. The miles of travel (in Millions) in 2003 for light vehicles are 2,658,832, while in 1999, the number is 2,470,122 (data from: Wards automotive yearbook 2005). With more travel, customers would value the speed and status much more than before. Another measurement is involved with the comfort, which is highly related to the internal dimensions. Larger internal dimensions require more materials in terms of bodywork, glass and materials to cover the interior and thus cost more than smaller one.

Data Source

This section describes the collection of car data samples and measures of the characteristics. The data are involved with passenger car models sold through the year of 2003, 2004, and 2005 in the US automobile market. The article takes only 4 door sedan economy passenger cars as the target segment. Specification data of cars and sales of vehicles are from Ward's automotive yearbook 2003, 2004, and 2005.

To make the sample more reasonable, those models whose sales of vehicles are less than 10,000 are not selected as sample data. With a small number of sales, a vehicle model can be hardly viewed as a representative for a package of characteristics.

Methodology

In this study, we would assess a lot of automobiles, analyze their characteristics and their related model information, and examine which attributes provide the greatest value in the customers' decision. Hedonic price model is used in the article since the consumers' decision could be viewed as a "package" of characteristics subject to a range of budget. The hedonic pricing method is doing regression of the prices of a product against its characteristics in order to estimate the implicit value customers give to those characteristics (Rosen, 1974). The automobile markets can use this model to determine which attributes produce a substantial value and emphasize those attributes in their advertisements. Furthermore, marketers can know the customer preference in a particular market, which could be used as a guideline to enter the market.

Hedonic price method has been well documented in a lot of studies for analyzing price-specification relationships of particular products, especially on those durable products: automobiles (Atkinson and Halverson, 1985; Lee and Masters, 1997; Favero et al, 2006), housing (Mason and Quigley, 1996; Veron et al., 1997; Can and Megbolugbe, 1997; Colwell and Munneke, 2006), computers (Baker, 1997) and so on.

For these durable products, their attributes can be efficient measures of satisfactory or utility for the consumer. One of its advantages is that both quantitative and qualitative attributes could be considered as dependent variables. However, as Mason and Quigley (1996) stated, the most difficult step is to select appropriate attribute variables to explain the value of the products. Fortunately, it is relatively easy to obtain a range of appropriate attribute variables for automobiles; meanwhile, we still need to be careful about the interdependency between variables.

The principal hypothesis for hedonic price model is to assume that the price can be viewed as the payments for the level of a bundle of characteristics (Rosen, 1974). Although characteristics are not priced separately, the price of a product assembled using these characteristics represents the valuation of all the attributes within it. Each characteristic's implicit price is embodied in the product's price and the selling price is regressed as a measurement of its characteristics. Regarding the task to define relevant attributes, it is helpful to assume that consumer preference functions are equivalent for identical attribute values and their product perceptions are based on the attributes values.

Definitions of the Hedonic Variables

Variables	Definition
<i>POW</i>	Power, measured by engine size (Liter):
<i>SZ</i>	Vehicle overall size, according to the ward's automotive yearbook categories:

$$SZ = \begin{cases} 1 & \textit{Lower_small} \\ 2 & \textit{Upper_small} \\ 3 & \textit{Small_specialty} \\ 4 & \textit{Lower_middle} \\ 5 & \textit{Upper_middle} \\ 6 & \textit{Middle_specialty} \\ 7 & \textit{Large} \end{cases}$$

ABS Dummy variable
 if ABS, $ABS = 1$; No ABS, $=0$

Cntrl Stability Control or Traction Control

$$= \begin{cases} 1 & \text{If } Yes \\ 0 & \text{If } No \end{cases}$$

MPG Fuel economy, measured by the miles per gallon driven on highway and city; the MPG values equal to 55% of that on city and 45% on highway (EPA)

$$MPG = \begin{cases} 1 & < 22 \\ 2 & \geq 20 \text{ _and _} < 24.5 \\ 3 & \geq 24.5 \text{ _and _} < 27 \\ 4 & \text{If } \geq 27 \text{ _and _} < 29.5 \\ 5 & \geq 29.5 \text{ _and _} < 32 \\ 6 & \geq 32 \text{ _and _} < 35 \\ 7 & > 35 \end{cases}$$

Trnsmnsn Standardized transmission:

$$= \begin{cases} 1 & Auto \\ 0 & Manual \end{cases}$$

Trnsopt Transmission Option

$$= \begin{cases} 1 & \text{If } yes \\ 0 & \text{If } no \end{cases}$$

WGHT Curb weight (lbs.)

$$= \begin{cases} 1 & < 2500 \\ 2 & \geq 2500 \text{ _and _} < 2700 \\ 3 & \geq 2700 \text{ _and _} < 2900 \\ 4 & \text{If } \geq 2900 \text{ _and _} < 3100 \\ 5 & \geq 3100 \text{ _and _} < 3300 \\ 6 & \geq 3300 \text{ _and _} < 3500 \\ 7 & > 3500 \end{cases}$$

WHLBS Wheel Base (ins.)

RWD Drive type: Dummy variable

$$= \begin{cases} 1 & RWD \\ 0 & FWD_or_AWD \end{cases}$$

Org Country that Original Brand is from

$$= \begin{cases} 1 & Foreign \\ 0 & BigThree \end{cases}$$

Cyl Cylinder

$$= \begin{cases} 1 & DOHC \\ 0 & SOHC \end{cases}$$

Inj Injection

$$= \begin{cases} 1 & SFI \\ 0 & MFI \end{cases}$$

In our model, the price of the vehicle is the dependent variable, and all the other attributes listed previously are independent variables. A couple of independent variables are dummies, where 1 indicates the presence of a given attribute, and 0 indicates its absence.

Based on the above model, the ordinary-least squares estimation method was applied to the 2003, 2004 and 2005 models. According to the SAS printout, we know that the model prices of 2003, 2004 and 2005 have normal distribution. The following model is the hedonic price model and *Table 1* displays the estimation results of the regression coefficients of 2003, 2004, and 2005, respectively.

$$P = \beta_0 + \beta_1 Org + \beta_2 SZ + \beta_3 RWD + \beta_4 WHLBS + \beta_5 WGHT + \beta_6 Cyl$$

$$\beta_7 POW + \beta_8 Vlv + \beta_9 Inj + \beta_{10} Cntrl + \beta_{11} ABS + \beta_{12} MPG + \beta_{13} Trnsmsn + \beta_{14} Trnsopt + \varepsilon$$

Table 1 Regression Results

	2003model	2004model	2005model
R-Square	0.96	0.97	0.97
Adjusted R2	0.93	0.91	0.96
Number	39	38	38

Intercept	305.25	201.04	244.65
Orgn	-8.66(-1.12)	-1.86(-0.22)	-0.85(-0.14)
SZ	15.94(3.36 ^{**})	8.48(1.89 [*])	15.71(4.13 ^{**})
RWD	9.56(0.60)	11.98(0.87)	21.99(2.36 ^{**})
WHLBS	-2.82(-2.61 ^{**})	-0.83(-0.65)	-1.98(-4.65 ^{**})
WGHT	9.20(2.09 ^{**})	12.11(3.14 ^{**})	-2.06(-0.51)
Cyl	1.22(0.22)	1.32(0.29)	-1.28(-0.22)
POW	6.98(0.83)	-3.96(-0.43)	29.1(5.08 ^{**})
Vlv	-5.40(-1.16)	-9.06(-2.08 [*])	-0.17(-0.04)
Inj	-9.37(-1.21)	-3.80(-0.61)	0.6(0.09)
Cntrl	-4.26(-0.54)	12.34(1.28)	5.46(0.77)
ABS	16.70(2.15 ^{**})	18.06(2.84 ^{**})	5.53(1.03)
MPG	1.00(0.32)	-1.92(-0.76)	0.27(0.1)
Trnsmn	64.09(1.83 [*])	32.03(1.99 [*])	35.05(3.94 ^{**})
Trnspt	73.10(2.03 [*])	25.82(2.02 [*])	13.89(2.12 [*])

T statistics in parentheses: * means $\alpha = .1$ and ** $\alpha = .05$.

Results and Analysis

The hedonic price model appears to perform fairly well, with satisfied R^2 's greater than 90%. The sample model prices are explained adequately by the combinations of the characteristics. According to the Table 1, we could notice that the three year outcomes are consistent with each other. Those estimated coefficients with star or stars are significant. Among the variables considered in our model, the most significant ones to emerge from the tests are vehicle size or engine power, weight or wheel base, ABS and Transmission.

The results of our study highlight the importance of speed, comfort and safety in customers' buying decision. A greater increase in vehicle price as a result of greater engine power and vehicle size implies that speed and status are highly valued. Similarly, the increase in the price of the vehicle resulting from the presence of ABS illustrates the extent to which customers value safety-related concerns. On the other hand, the attributes, including fuel efficiency, origin country, and cylinder do not contribute significantly to the hedonic price, which suggesting their negligible impacts on customer valuations. In the study by Mannering and Mahmassani (1985)

and McCarthy and Tay (1989), it is claimed that imported cars receive higher consumer valuations than domestics. While in this study, there is no significant difference between domestic vehicles and imported ones.

What hedonic analysis means to the automobile industry is that the value of a vehicle depends on the combination of its characteristics. Therefore, it is critical for the decision makers in automobile industry to take into account the consumer preference about the attributes of vehicles (Favero et al. 2006). With this guideline, technologies and resources could be assigned in an optimal way to design and produce vehicles, so does marketing. From the view of supply chain, all the members of supply chain understanding the hedonic price concept will definitely improve the competitiveness of the entire chain (Chopra & Meindl, 2001).

There are a couple of limitations in this study. The first one is involved with the attributes. Since the customers' preference is more diversified than before, the attributes taken into the model could be more miscellaneous, such as color, accessories. Another limitation is the objective segment of the sample data. It could be more convincing if all the vehicle types are studied, not only the 4 door sedan. Furthermore, with more characteristics, semi-logarithmic, double logarithmic functional form can also be applied and compared in the future study for a better goodness-of-fit.

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