What influences the pricing of automotive in U.S. market?

Ran Wang
Ph.D., School of Economics
Georgia Institute of Technology
Email: Wangran2010@gmail.com

Weiwei Yang
Regions Financial Corporation
Email: Wwy151430@gmail.com

Abstract
This paper analyzes the main factors that would influence the pricing of the automotive in the U.S.. Many factors, including market share, road test score, safety index, owner cost as well as MPG, oil price and number of models, plays important roles in pricing. However, different regions put different weights on the factors when making price. Also, culture pricing is also studied in this paper. Additionally, the paper shedsinsight onto the effect of automotive crisis from 2008 to 2010 on pricing strategy for automotive firms for SUVs and Sedan, respectively.

Keyword: culture pricing, variety effect, economy of scale, scope of economy

JEL: L13; L29; M31

1. Introduction

The competition in the automotive market is more and more fierce. There are competitions in price, model fashion and style as well as diversity. The number of new models is increasing each year. Among all these competitions, pricing strategy is an essential strategy to compete against the rivalry for the automotive firms. For the firm, the pricing strategy, in some degree, determines the market share and the competitive advantage, and further decides the profit. An overpriced automotive will cut back on its own demand, reducing the profit. On the other hand, underpriced automotive will hurt the profit though increase the demand.

Then what factors influence the pricing level of the auto firms is an important issue both for the auto firms and the consumers. Unfortunately, there are no exact answers due to different research methods and difference in data. Levinsohn and Pakes(1995) generated a theory framework to study the equilibrium price through analyzing demand and supply in the differentiated automotive industry. They provide a basic model to analyze the demand and supply bilateral relationship in the automotive market. This paper also serves as the theoretical basis for our analysis for Simultaneous Equation estimation in our paper.

Also, there are many empirical studies to research the factors that might influence the price. As for the relationship between automotive price and gasoline price, Makoto Ohta(1986) argued that the 1973 and 1979 gasoline price rise changed consumer views about the relative quality of different cars through a hedonic model. Similarly, we include the gasoline price (the weighted price for gasoline used for car of all grades) as independent variable. As for the effect of the gasoline price on the pricing level, we also check the effect of automotive crisis from 2008 to 2010 which is caused by energy crisis (world's oil price increase) from2003 to 2008, we estimate the effects of oil price change on the automotive's price strategy before the automotive crisis and after the crisis and get the difference in pricing strategy for different types of automotive.

Product horizontal differentiation and product vertical differentiation also play an important role in influencing the price level as stated in Peter and Brain (1995) and Goldberg (1995). It is shown that fashion and styling plays an important role in pricing strategy, which is the horizontal product differentiation. However, their papers do not pay attention to the vertical product differentiation. In the paper, we measure vertical product differentiation by the number of models each year. By including the number of models in each year for each firm, we can estimate the effect of vertical product differentiation on pricing strategy. Also, we analyze this effect from two opposite sides. On one hand, the increase in the number of models will decrease the production cost due to the existence of economy of scope, leading to the reduce in the price level. On the other hand, it will captures more variety effect since the consumers also prefers more choice, resulting in the increase in price. Whether there is positive or negative effect for the number of models depends on which effect dominates. This is one innovation in our paper.

Also the paper examines the common issue about the endogeneity of market share when estimating pricing level through comparison between OLS and Simultaneous Equation. The results show that the endogeneity of market share does exist. The other innovation in the paper lies in that we assume the market share effect is a measure of balance between market power effect and scale of economy effect. Also, the paper checks the culture pricing strategy which leads to different price level with same quality and other factors. The uniqueness of the paper also lies in the database. The database is collected from *Consumer Report: buying guide*. Since there is no public database for the quality index and price for each model, we set up the database manually.

The main findings are listed here. First, through comparisons of OLS and Simultaneous Equation Estimation results, it is shown that market share is endogeneous factor when estimating the price level. Second, from Simultaneous Equation Estimation results, many factors, including market share, road test score, safety index, owner cost as well as MPG (Miles Per gallon) oil price and number of models, plays important role in pricing. However, different regions put different weight on the factors when making price. Additionally, different region automotive firms have different market power effect over the scale of economy effect. Also they have different variety effect over scope of economy effect. Fourth, when checking the culture pricing, the Korean firms have overpricing strategy compared to other region firms. Finally, the automotive crisis does have some effects on the change in pricing strategy in SUVs and Sedan.

The remaining of the paper is organized as follows. In Section Two, the main estimation model is given. In Section Three, we describe the database as well as the variables that is used in the estimation. In Section Four, the estimation results from OLS and Simultaneous Equation are compared. Also the culture pricing is given by Blinder Oaxaca decomposition and the effect of automotive crisis in this section. In Section Five, the main conclusions as well as the limitations and potential extensions is illustrated.

2. Estimated Equation

The main equation to be estimated is given by the reduced form as equation (1), which is

$$y_i = x_i\beta + u_i \qquad (1)$$

Here, $i$denote the model for each firm since the observation unit is model-level. The dependent variable, y, is price for each model in each year. The independent variables include many factors that might influence the price level of the automotive. To be specific, the independent variables are overall road-test score (average test score from many road test), reliability (predicted reliability of the model), owner satisfaction index, owner cost index (a rating of the five-year projected cost to own a vehicle, including depreciation, fuel, interest, insurance, maintenance/repair and sales tax), safety index (weighted safety index from several test), fuel economy(miles per gallon(mpg), reflects a realistic mix of city, country road and highway driving), oil price (the weighted price for all grades gasoline for car), the model number for each firm in each year, the size and type of each model. Also we include the market share for each model into this equation, which might be endogenous in the equation. Other independent variables include the supply of oil,per capita income for each year and unemployment rate for each year.

3. Database and variables

The database is self-established automotive database collected from *Consumer report: buying guide* (from 2009 to 2012). And the survey results are from 2007 to 2010.Since there is no existing database that can get the quality index for each model in each year, we manually input the quality index data, which includes the overall road test score (average score from the several model road test), the owner satisfactions (satisfaction level of the automotive owner), the weighted MPG (miles per gallon) as an index of fuel economy, predicted reliability (predict of how well a new car will likely hold up based on previous Annual Auto Survey), owner cost (a rating of the five-year projected cost to own a vehicle, including depreciation, fuel interest, insurance, maintenance/repair and sales tax), safety (an overall score based on the combination of crash test and accident avoidance results).All above indexes are ranked in the consumer report as “good”, “above average”, “average”, “below average” and “bad”. And in this paper, we transform all the ranks into grades 5, 4, 3, 2, 1 into the database. The dependent variable, price of each model, is also from *Consumer report: buying guide*. In addition to the index and price, we also include the firm as well as the model and the size, type into the database for further detailed analysis. Since the oil is complementary goods to automotive, we include the oil price[1] as well as the oil supply[2] (including oil domestic production and oil import) to estimate the effect of oil on the auto price.

Also the annual market share for each automotive firm is collected from *wards auto.* There is one potential problem with the database due to the availability of detailed database on model level. All quality index data are model-level data, however, the market share data are firm-level data. In order to simplify the problem, we just assume that the firm-level market share can be divided equally to each model in that firm, neglecting the potential imbalance in the market share among different models. This assumption might be problematic for detailed analysis that we will discuss in the limitation part. The main statistics of the data that we use for the analysis is summarized in table 1. It is just cross section data from 2007 to 2010.

[1] The oil price data is from *US Energy.*

[2] The oil supply is dropped when estimate the equations.

Table 1. Summary of the variables

Variable	# obs	Mean	st.d.	Min	Max
Auto price	1134	35035.57	15320.15	12596	105855
Year	1135	2008.478	1.116345	2007	2010
Road test score	1134	70.35009	14.24567	1	99
Reliability	892	3.306054	1.167963	1	5
Owner satisfaction	858	3.538462	0.9848507	1	5
Owner cost	1133	2.943513	1.443391	1	5
Safety	596	4.097315	0.8622383	1	5
Mpg	1133	21.58605	6.649003	10	119
Oil price	1135	2.745374	0.4358426	2	3
U.S. oil supply	1135	1902921	75746.29	1811817	1998137
U.S. oil import	1135	3474961	153283.3	3289675	3661404
Firm market share	701	7.158787	6.573205	0.05	23.24
Number of model	1135	11.85815	6.078133	1	25
Model market share	701	0.5308844	0.6337677	0.0166667	3.655

4. Empirical Estimation and Results

In this section, we will give the estimation results for the price determinant equation. The basic OLS estimation is given first, followed by Simultaneous Equation estimation. Also in this part, we check the culture pricing strategy as well as the effects of the automotive crisis.

4.1 OLS and Results

First, we treat the data as normal pooling data, estimating the factors that might influence the automotive price. Also, we consider that there might be some differences in the auto firms' pricing strategies. In this paper, we divide the origins of the automobile into four regions, that is, Europe, U.S., Japan and Korea according to the headquarter of the firm. Here we get the estimates both for the overall automotive as well as for the individual region. And the result is given in Table 2.

Table 2. Comparisons of different pricing determinants using OLS[3]

Dependent: price	Overall	EU	US	Japan	Korea
Road test score	36*	-83	36	99***	104***
Reliability	255	-73	-108	278	80
Owner satisfaction	307	689	438	-21	1484*
Safety index	1470***	1589	865*	550	-41
Owner cost index	7073***	8137***	5781***	5528***	-3859**
MPG	146**	60	101	-69	-398
Oil price	-186	516	-690	-94	-2349*
Market share	1080***	15814	1261*	366	-31278*
Number of models	63	172	99	203*	651

Note: * p<0.10, ** p<0.05, *** p<0.01.

[3] All estimation results are from robust regression to avoid the heterogeneity problem.

The findings from the OLS regression estimates are listed as follows. First of all, reliability is not significant when evaluated at the overall population level and divided origin level. So, there is no significant effect of reliability on the pricing strategy. This finding may be somewhat counterfactual, but it is still possible that when taking other indexes into consideration, the reliability does not play an important role in pricing for any region. So, in later Simultaneous Equation estimation in this section, we will use reliability as the instrument for market share since it is not correlated with pricing level from the regression results. Also owner cost is negatively related to price level both for overall population and for each region firms. High owner cost will discourage the consumer demand, further lowering the price. And generally speaking, road test score, safety index, MPG and model level market share has positive marginal effect on pricing level, while owner cost has negative marginal effect. All the positive effects serve as proof of the importance of various quality indexes. However, it is proved to be smaller in magnitude than in Simultaneous Equation Estimation, as we will show later. The oil price has negative effect, but not significant since we have also include MPG as independent variable. So long as the marginal effect of MPG is positive, it shows that the price for the higher duel economy cars are, generally, higher. Due to the realization of environment effect and the rise of the oil price, the fuel economy plays an important role in recent years' pricing strategy. Since both MPG and oil price measures the sensitivity of the price to fuel, both positive sign from the marginal effect of MPG and negative sign from oil price (Korea) are indicating similar sensitivity. The negative effect of oil price can be interpreted when we look at oil and automotive as complementary goods. When the price for oil increases, the demand for oil decreases, leading to reduce in the demand for automotive. Similarly, positive sign of MPG states that the consumers prefer the more fuel-economy automotive with all other factor fixed, leading to high price for these models. Higher maintenance cost and repair cost which is included in owner cost will lead to lower demand for the automotive, leading to price drop. There would be two effects correlated with market share. One effect is market power effect, that is, the market power is large when the market share is high, further increasing the price. The other effect is economy of scale, that is, when the market share is large, the production quantity is also large, so the cost is reduced and the price should be lower. From this aspect, we should expect positive marginal effect when the market power effect dominates economy of scale effect and negative marginal effect when market power effect is dominated. Form the result, we can see that, overall, market power effect dominates scale of economy effect. Also, the marginal effect of the number of models each year produce interesting interpretation. We treat it as a balance measurement between scope of economy and variety effect. In this sense, large number of models leads to high scope of economy and more likely to reduce the price. On the other hand, consumers have more choices when the number of models is larger, the positive variety effects will lead to the increase of the price. The latter effect is what is normally argued as vertical product differentiation effect. From the overall estimation, we can see that the two effect are somewhat equalized since the marginal effect is not significant at 10% level.

When looking at the results for each region, only owner cost is essential for the price of European Automotive. It is well known that the maintenance cost and repair cost is really high for the EU auto, such as BMW. However, it does not make so much sense since all other variables are not so relevant to the pricing strategy for the EU auto firms. And this would be proved to be not robust results from estimation of Simultaneous Equation estimation. For the US firms, besides owner cost, safety index as well as market share plays an important role in pricing. For Japanese firms, road test score and market share together with owner cost is important for the pricing. As for the Korean firms, the determinants seem to be road test score, owner satisfaction, market share and oil price. What is more, we should pay attention to the opposite effect of market share for US auto firms price and for Korean. For the US firms, the market power effect overweighs the scales of economy effect, so larger market share means higher price, while for the Korean

firms the economy of scale effect outweighs the market power effect, so the effect is negative. Also, it is a little interesting when we look at the oil price effect. Since oil and automotive are complementary goods, the effect of oil price change should be negative, however, from the estimation from OLS, oil price is only significant for Korean auto firms' pricing.

4.2 Simultaneous Equation Method and Results

The concern that not only market share can influence the auto price, but also auto price influences the market share, we are try to figure out the estimation from solving this simultaneous equation system. The equation to be estimated here is

$$price = \beta_{01} + X\beta_{02} + \gamma_1 mktshare + u_1 \quad (2.1)$$

$$mktshare = \beta_{11} + X\beta_{12} + \gamma_2 price + \gamma_2 z + \varepsilon_1 \quad (2.2)$$

Here, X denotes all the independent variables that have been contained in previous OLS estimation except reliability since it is not significant for the overall level and region level estimations. The estimation of this simultaneous equation is quite simple, however, the difficulty lies in the selection of the instrument variable that would be used for estimation of the reduced form for the market share when using the 2SLS method. In this paper, we choose reliability as an instrument for market share. From the OLS regression, we know that reliability is not significant for auto price level. So, it is satisfied that reliability is not correlated with the error term u_1.And we checked the reduced form regression for equation (2.2). We can showthat the marginal effect of model reliability is significant when we included all other independent variables. And the result from the estimation of this Simultaneous Equation regression is given in Table 3.

Table 3. Simultaneous equation results overall and four regions

SEM results	Overall	EU	US	Japan	Korea
Market share	21438***	143292***	12561***	55216**	-218683***
	(984)	(21584)	(2433)	(17053)	(22815)
road test score	110***	-200***	-32	51*	269***
	(10)	(50)	(23)	(23)	(23)
owner satisfaction	-809***	-1680*	12	-3342**	4757***
	(160)	(768)	(391)	(1212)	(381)
Safety index	6349***	2783**	1600***	1712**	-1060**
	(283)	(980)	(396)	(540)	(343)
owner cost	-7322***	-7754***	-6353***	-8257***	-2833***
	(160)	(354)	(475)	(944)	(370)
MPG	588***	457**	405**	137	-59
	(44)	(134)	(139)	(99)	(123)
oil price	1581***	2220*	-528	-5383**	-10320***
	(258)	(991)	(739)	(1673)	(1089)
number of models	-89***	-2061***	1380***	-1646**	883***
	(19)	(359)	(280)	(566)	(231)

Note: * p<0.10, ** p<0.05, *** p<0.01. t statistics are given in bracket.

From table 3, we can see that the estimation from simultaneous equation is quite different from what we have got in OLS estimation. In this estimation, all independent variables are more significant compared to the estimation from OLS. For the overall estimation, all variables are significant. Compared to the OLS results, all the positive marginal effects are much larger for market share, road test score, safety index and MPG. And the negative effect of owner cost is larger than before. Also owner satisfaction is now significant

but negatively related to the auto price. Since owners are more satisfied with lower price, with all other equal, owner satisfaction is negatively affects the price. Overall, both MPG and oil price have positive effect on auto price. It is intuitive that higher MPG which means higher fuel economy, will lead the auto price to rise, so the marginal effect of MPG is positive for all results. However, it looks a little confusing that the marginal effect of the oil price is positive on the auto price. But since we have included the oil consideration in MPG, it is not so important when consider the oil price together with MPG. Also, for the overall estimation, number of models is negatively related to the auto price. That is, generally, variety effect is larger than the economy of scope. Since variety effect will lead to the increase of the auto price and the economy of scope effect leads to the opposite, the negative effect says that the variety effect dominates.

As for the four individual region estimations, the results are also quite different. For the European firms, all factors are taken into consideration when make prices compared to only considering the owner cost. We should pay attention that for European firms, the market share effect is largest and positive, and that is, the market power effect definitely dominates the economy of scale effect for the European firms. Also, the negative effect of the number of models is the largest due to the domination of the variety effect over economy of scope. Also the safety index effect is larger than other three regions. For the U.S. auto firms, market share, safety index, MPG and number of models have positive effect on the auto price while owner cost has negative price. What we want to mention here is the small effect of market share marginal effect compared to E.U. and Japan though they are all positive. So the market power effect weakly dominates the economy of scale for the U.S. And the number of models has negative effect on the auto price, that is, scope of economy effect dominates variety effect. For Japanese and Korean firms, only MPG is not irrelevant for auto price. Since Oil price has negative effect on the auto price, combining MPG and oil price together, these company still cares about fuel cost when make price.

As we have just mentioned, what is interesting here is the magnitude and sign of market share and number of models. Comparing the four independent regions, we can found that the ranking of the market share effect is E.U., U.S., Japan, Korea (negative). Since the market share effect is a balance between the market power effect and economy of scale effect as we argued in OLS results, for E.U., U.S., Japan, the market power effect dominates economy of scale effect and the domination level is E.U., U.S., Japan. For Korea, economy of scale effect dominates market power effect. Another interesting point is the sign and magnitude of number of models. The signs for E.U. (larger) and Japan are negative, but the signs for U.S. (larger) and Korea are positive. So, Variety effect dominates economy of scope effect for E.U. firms and Japan firms, and the domination level is higher for E.U. firms. But for U.S. and Korea firms, variety effect is dominated, and Korea firms enjoy least variety effect when making price.

From the above analysis, it is likely that the results from OLS are not robust. And this Simultaneous Equation Method is more suitable to analyze the factors and the marginal effect since it considers the interaction between the demand and price. Till this part, we have finished the analysis about the pricing strategy of the firm. We will move on to analyze the preference of the pricing strategy of the firms from different regions.

4.3 Culture pricing strategy

This part continues to study the factors that will influence the pricing level of the auto firms from different regions. We call this as “culture pricing effect” if there does be some differences in pricing level as long as it does nothing to the quality and other index with the auto and it just correlated with the regional culture. In other words, when the automotive from different regions have the same characteristics, the price level is different. We call this difference as culture pricing. Here we assume that there is no international policy effect on different regions, which makes the analysis more complicate. In this part, we use Oaxaca-Blinder

Decomposition method to estimate this culture pricing effect. The independent variables are just the same as Simultaneous Equation estimation. The results are given in Table 4. There does exist "culture pricing" since the coefficient is significant for Korea. The positive sign shows that overpricing exists for the Korean firm, with all other indexes equal. So, the pricing level is related to the "culture pricing effect".

Table 4. Comparison of four region using Oaxaca Decomposition

Decomposition	E.U.	U.S.	Japan	Korea
Endowments	-4177*	231	3228***	4877***
	(1760)	(1068)	(776)	(1290)
Coefficients	-596	-548	601	579*
	(568)	(393)	(442)	(246)
Interaction	-1688	-598	2487***	223
	(1011)	(438)	(509)	(420)

Note: * p<0.10, ** p<0.05, *** p<0.01. t statistics are given in bracket.

4.4 Auto crisis and price strategy

The common argument that shock will motivate the pricing strategy to adjust is also tested in the paper. There is automotive industry crisis from 2008 to 2010 that was caused by the energy crisis from 2003 to 2008. And the increase in the energy price lead to the increase in the demand for more fuel saving automotive instead of the fuel costly "SUV" and "Pickups". So here we want to analyze the automotive crisis' effect on the price strategy on demand increasing sedan and demand decreasing SUV. The results are given in Table 5. In this table, the first column is the overall estimation for before and after automotive crisis for all the models. In the second column, the estimation for SUVs price equation is given for period before the automotive crisis and the third column is for SUVs during automotive crisis. Similarly, the fourth column and fifth column are for sedan before crisis and during crisis. From table 5, we can see that the prices of SUVs are more sensitive to MPG during the crisis (992 and significant at 1% level compared to non-significant before the crisis) and the price of sedan is less sensitive to MPG during the crisis (drop from 785 to 614).Also the variety effect dominates the economy of scope effect such that the increase in the number of models for sedan will increase the price. So the pricing strategies for the two types are adjusted due to the shock of automotive crisis. These results coincide with previous studies on the shock effect and policy effect.

Table 5. Comparison before the crisis and during crisis

Price	**Overall**	**SUV_1**	**SUV_2**	**Sedan_1**	**Sedan_2**
market share	21438***	22885***	21918***	21485***	19468***
	(984)	(3007)	(1616)	(2941)	(2055)
road test score	110***	102*	72**	79	103***
	(10)	(47)	(22)	(48)	(16)
owner satisfaction	-809***	-640	-697*	-754	-737
	(160)	(521)	(322)	(551)	(384)
safety	6349***	6807***	6853***	5771***	5719***
	(283)	(1066)	(682)	(984)	(606)
owner cost	-7322***	-7387***	-7738***	-8164***	-7623***
	(160)	(838)	(240)	(463)	(281)
MPG	588***	781	992***	785***	614***
	(44)	(388)	(102)	(97)	(87)
# of models	-89***	-31	-50	-136	-116*
	(19)	(63)	(36)	(78)	(45)

Note: * p<0.05, ** p<0.01, *** p<0.001.

5. Conclusions and Limitations

The objective of the paper is to analyze the factors that might influence the pricing level of the automotive in the U.S. market. Using the model level data from *Consumer Report: buying guide* from 2007 to 2010, we get some interesting conclusions. First, we find some factors are not so relevant to the price level, especially when estimating at the region level, i.e. EU.However, it is proved to be not so robust of the estimation from OLS since the market share and price are simultaneously determined, leading to the endogeneity problem of market share.

Furthermore, the paper analyzes this simultaneous equation system using 2SLS. The instrument chosen for market share is the reliability index that is proved to be insignificant when we estimate price using OLS. From this estimation, we can see significant differences between OLS results and Simultaneous Equation results. Almost all factors have effects on pricing level, compared to only some factors have effect in OLS. Also the magnitudes of the effects are enlarged when excluding the endogeneity problem. From this estimation result, we can also rank domination level of the market power effect over the scale of economy effect as E.U., U.S., Japan, Korea (negative). For E.U., U.S., Japan, the market power effect dominates economy of scale effect and the domination level is E.U., U.S., Japan. For Korea, economy of scale effect dominates market power effect. And variety effect dominates economy of scope effect for E.U. firms and Japan firms, and the domination level is higher for E.U. firms. But for U.S. and Korea firms, variety effect is dominated, and Korea firms enjoy least variety effect when making price.

When estimating the culture pricing strategy effect, we find that overpricing strategy exists for the Korean automotive firms due to the culture difference. Also the shock of automotive crisis makes the automotive price more sensitive to the MPG (fuel economy) for the oil-consuming SUVs and less sensitive to MPG for the oil-saving Sedans.

However, there are some potential limitations for our analysis. The first problem lies in the data match problem. Since we can only get the firm-level market share data, we simply divide the firm-level market share into each model of that firm. But it is not the case in reality. This simplification might result in bias in the estimation. The second problem is the limited database capacity. The size and the duration of the database are not big enough to sustain the automotive crisis effect, although we can get some insights from this small database.

The paper can be extended in several aspects, which is our future work. Firstly, we can build up the whole database from year 1980 to 2012 to compare the effects in different periods and analyze the shock effect or policy effect. Secondly, when the database is large enough, we divide the analysis into the type-level, such as we can compare the pricing strategy for the luxury car and non-luxury car. Thirdly, we can study the competition among different automotive firms using firm-level data.

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