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Have CAFE Standards Reduced the Effect of Gasoline Prices on Domestic Automobile Manufacturers’ Market Share of the US Market?

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Have CAFE Standards Reduced the Effect of Gasoline Prices on Domestic Automobile Manufacturers’ Market Share of the US Market?

Abstract
One of macroeconomists’ major concerns is GDP volatility, and understanding what causes this volatility is essential when attempting to reduce it. For decades, the automotive industry has been a major component of US GDP. Therefore, understanding the driving forces behind this industry indirectly contributes to the study of GDP volatility. This paper focuses on CAFE standards and how they change the effect of oil prices on US automobile sales.

What motivates this paper is the fact that during the mid-to-late 80s, fluctuations in the market share of domestic automobile manufacturers diminished substantially. Figure 1 presents the sales of domestic automakers’ automobiles as a fraction of the domestic market (market share) from January 1974 to June 2004. One can easily notice that around month 170, which corresponds to February 1988, there is a dramatic decrease in volatility. What could be the cause in the decrease of this volatility?

Keywords
Automobile, car manufacturer, American car manufacturer, GDP, automaker, gasoline prices, market volatility, fuel efficiency, Corporate Average Fuel Economy

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INTRODUCTION

One of macroeconomists’ major concerns is GDP volatility, and understanding what causes this volatility is essential when attempting to reduce it. For decades, the automotive industry has been a major component of US GDP. Therefore, understanding the driving forces behind this industry indirectly contributes to the study of GDP volatility. This paper focuses on CAFE standards and how they change the effect of oil prices on US automobile sales.

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One of the major differences between American and foreign automobiles has been their fuel efficiencies. In their hedonic technique for estimating the demand for automobile fuel efficiency, Atkinson and Halvorsen conclude that an increase in the price of gasoline results in an increased demand for “foreign, more fuel efficient, automobiles.” This finding is not surprising because gasoline is a complement for automobiles. This paper focuses on Corporate Average Fuel Economy (CAFE), a policy that increases fuel efficiency, to explain the reduction in the volatility of domestic automobile manufacturers’ national market share.

CAFE REGULATIONS

CAFE standards were enacted in 1975 in response to the 1973-1974 Arab oil embargoes. CAFE is the sales weighted average fuel economy, expressed
in miles per gallon, of a manufacturer’s fleet of passenger cars manufactured for sale in the United States. Fuel economy is defined as the average mileage traveled by an automobile per gallon of gasoline. The mileage standard increased to 27.5 mpg in 1985, and it currently remains at that level.

Congress specified that CAFE standards must be set at the “maximum feasible level”. This means that factors such as technological feasibility and economic practicability must be taken into consideration before setting a standard. Thus, the burden of CAFE standards should be reasonable.

Manufacturers’ domestic and import fleets must separately meet the 27.5 mpg CAFE standard so as not to be subjected to any penalties. Penalties include a civil fine of $55 per car/mpg. For example, if a manufacturer produces one million cars with a sales-weighted mpg of 26.5 mpg, that firm would be subject to a fine of $55 per car/mpg * 1 million cars * 1 mpg, or $55 million. Some foreign automakers view this fine as a tax, and manufacturers such as BMW and Mercedes-Benz have routinely paid CAFE fines (Kleit 1981). However, American firms view these standards as binding because their lawyers have advised them that if they violate the standards, they would be liable for civil damages in stockholders’ suits. Thus, domestic manufacturers have never paid a civil penalty. Asian manufacturers have never paid civil penalties either. The next section provides an important event in the domestic automobile industry.

A BRIEF HISTORY

In 1981, the US was suffering the effects of the second OPEC oil price shock. Faced with higher gasoline prices, consumers began to shift their demand from low fuel efficiency US autos to higher fuel efficiency Japanese autos. In fact, Chrysler Corporation would have gone bankrupt if it weren’t for the US government’s subsidized loans. After several discussions with the US trade representatives, the Japanese eventually agreed to a Voluntary Export Restraint policy on auto exports, which lasted until the early 90s. The result of VERs was to increase the price for the importing countries because of a reduction in supply. Portney et al. (2003) found that tighter CAFE standards raised the price of new vehicles, so one would think VERs slightly offset the price effect of tighter CAFE standards by making Japanese automobiles slightly less attractive. However, many Japanese manufacturers shipped unassembled autos to Taiwan and
South Korea, where they were assembled and exported to the US. Furthermore, manufacturers such as Honda, Mazda, Toyota, Mitsubishi, and Nissan opened assembly plants in the US and were not included in the export restriction.

**LITERATURE REVIEW**

Extensive work on CAFE standards and their impact on general welfare has been done, and although many economists have found the standards to save some gasoline, the welfare losses associated with CAFE standards are too large. Kleit (2004) found that a long run 3.0 MPG increase in the CAFE standard would impose an estimated welfare loss of about $4 billion per year and save about 5.2 billion gallons of gasoline per year. He also suggests that an 11 cent-per-gallon tax would generate the same amount of fuel saving while only costing $290 million per year. Portney et al. (2003) also found that tighter standards would save gasoline, but they would also increase the price of new vehicles, worsen traffic congestion and--depending on how they are phased in--possibly even reduce occupant safety.

To my knowledge, no economist has examined the effect of CAFE standards on the volatility of the automotive domestic market share. Kleit (2002), among others, goes so far as to find that the standards shift revenue away from U.S. automakers to foreign firms. However, it is reasonable to believe that CAFE standards make domestic vehicles on par with foreign vehicles in terms of fuel efficiency. Also, it should come at no surprise that fluctuations in oil prices have been found to have a significant effect on the sales of automobiles: Atkinson and Halvorsen (1984) conclude that an increase in the price of gasoline results in an increased demand for fuel efficiency. Although Duncan (1980) did not find the price of gasoline to have a significant effect on the aggregate demand, he found it affected the relative ratios of different vehicles significantly. One explanation behind this is that some people cannot be without cars because of impractical alternatives (non-hassle free public transportation), so they decide to purchase more fuel-efficient vehicles instead.

**MODEL**

In modeling the effects of CAFE standards, this paper uses the domestic market share of domestic automakers (auto market share). This variable has many advantages over using gross sales. For example, when dealing with
market share, we can concentrate on factors that lead to an increase or decrease in foreign automobile sales in domestic markets without having to worry about consumers switching to other forms of transportation such as light trucks or public transportation. Therefore, analyzing changes in market distribution can help shed light on how CAFE standards have changed the competitiveness of domestic automobiles in comparison with foreign automobiles.

The rest of the model is based on affordability; given certain assumptions, whether a consumer will purchase a domestic automobile or a foreign automobile will depend on several factors that contribute to affordability. Before purchasing a vehicle, a consumer will consider interest rates, which dictate his cost of borrowing to purchase the car. Given a consumer who needs to purchase a new car, the higher the interest rate, the more likely his/her choice will be affected by the car's price because of differences in interest payments. Although one argument against using this variable is that the lending rate is the same whether one buys foreign or domestic automobiles, it is included in the model because Portney et al (2003) found that tighter CAFE standards increase the price of new cars. If the standards raise the prices of domestic automobiles, then this variable is relevant. Another important factor is the exchange rate, which affects the prices of foreign automobiles, making them more or less competitive. Thus, a high exchange rate (price of domestic currency in this case) should have a negative impact on the domestic share of the domestic market. A third factor that would matter is disposable income. As disposable income increases, one would expect consumers to purchase an automobile without as much price consideration. Thus, the model uses this idea to try and correct for any price effect that would otherwise not be visible. Finally, oil prices, which are determined in part by the state of the US economy, because the US consumes about 25% of the world's oil production, matter when buying a domestic or foreign automobile because of historical differences in fuel efficiencies. This variable is very important because as CAFE standards become tighter, we would expect fuel efficiencies to converge, making this variable less significant. Finally, given the US government's pro free trade characteristics, tariffs are not assigned a role in this model.

Some reasonable assumptions are made in this model. The first assumption is that technology is homogenous. This means that domestic automakers can borrow foreign automakers' technology and produce everything they produce. Of course, there are some adjustment costs for domestic manufacturers. The
second assumption dictates that ceteris paribus, American consumers prefer domestic automobiles. This is a reasonable assumption if one considers sentiments of nationalism, or knowledge of how economy works, coupled with the desire to see it grow. Another argument for the latter assumption would be employee discounts and bonuses, which without loss of generality can also be considered a preference for domestic vehicles.

DATA

All the data are monthly and range from January 1974 to June 2004. Unadjusted monthly data on motor vehicles unit sales were obtained from the Bureau of Economic Analysis. The variable auto market share is created and represents domestic automobile sales as a fraction of domestic plus foreign automobile sales. The prime rate, in percent, was obtained from the Saint Louis Federal Reserve’s database as a measurement of the interest rate. The exchange rate is composed of a weighted average of the major currencies that were traded against the US dollar and was obtained from the same database as the prime rate. Disposable income is in real terms, and oil prices denote the price per barrel that refineries pay to acquire their oil.

There is extensive literature about testing and correcting for unit roots when working with time series data. To be safe, the Dickey-Fuller test was used to test whether the null, which assumes a unit root, could be rejected at the 5% level. When it could be rejected, the variable was left unchanged. However, when there was not enough evidence to reject the unit root, the first difference of the variable was taken and the whole process repeated. Table 1 displays the results for the Dickey Fuller tests.

Table 1

<table>
<thead>
<tr>
<th>variable</th>
<th>undifferenced</th>
<th>differenced</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>test statistic</td>
<td>p-value</td>
<td>test statistic</td>
<td>p-value</td>
</tr>
<tr>
<td>oil prices</td>
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<td>0.7175</td>
<td>-12.528</td>
<td>0.0000</td>
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<td>0.6873</td>
<td>-13.675</td>
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<tr>
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<td>0.6405</td>
<td>-10.777</td>
<td>0.0000</td>
</tr>
<tr>
<td>disposable income</td>
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<td>1</td>
<td>-22.819</td>
<td>0.0000</td>
</tr>
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<td>0.0019</td>
<td>-3.917</td>
<td>0.0019</td>
</tr>
</tbody>
</table>
Table 2 shows some descriptive statistics for the final variables throughout the entire time period. The number of observations sheds light on whether the variable was differenced or not.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.7709162</td>
<td>0.0504563</td>
<td>0.6594085</td>
<td>0.8789939</td>
</tr>
<tr>
<td>exchange_rate</td>
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<td>-0.0502025</td>
<td>1.718167</td>
<td>-6.898399</td>
<td>5.458206</td>
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<tr>
<td>prime_rate</td>
<td>365</td>
<td>-0.0156712</td>
<td>0.5629499</td>
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<td>4.290001</td>
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<tr>
<td>disposable_income</td>
<td>365</td>
<td>0.0024172</td>
<td>0.0077151</td>
<td>-0.0393429</td>
<td>0.0573816</td>
</tr>
<tr>
<td>oil</td>
<td>365</td>
<td>-0.0153425</td>
<td>2.056409</td>
<td>-12.01</td>
<td>11.27</td>
</tr>
</tbody>
</table>

**METHODOLOGY**

“VAR [vector autoregression] methodology superficially resembles simultaneous-equation modeling in that we consider several endogenous variables together (Gujarati).” An advantage of VARs is that each endogenous variable is explained by the lags of all the other endogenous variables, and there are usually no exogenous variables. VAR models also make use of the Cholesky decomposition to provide impulse response functions. When graphed, these response functions show dynamic responses of certain variables to shocks in other variables. The model to be estimated is:

\[
W_t = a_0 + A(L)W_{t-1} + u_t
\]

where \(W\) is the vector composed of changes in oil prices (O), changes in the exchange rates (\(e\)), changes in the prime rate (\(i\)), changes in disposable income (\(d\)), and the domestic auto market share (\(m\)). (L) is the lag operator that begins with the identity matrix. Thus, the Cholesky ordering is as follows:

\[
\begin{bmatrix}
O_t \\
e_t \\
i_t \\
d_t \\
m_t
\end{bmatrix} = \begin{bmatrix}
A_1 \\
A_2 \\
A_3 \\
\vdots \\
A_{12}
\end{bmatrix} \begin{bmatrix}
O_{t-1} \\
e_{t-1} \\
i_{t-1} \\
d_{t-1} \\
m_{t-1}
\end{bmatrix} + \begin{bmatrix}
O_{t-2} \\
e_{t-2} \\
i_{t-2} \\
d_{t-2} \\
m_{t-2}
\end{bmatrix} + \cdots + \begin{bmatrix}
O_{t-12} \\
e_{t-12} \\
i_{t-12} \\
d_{t-12} \\
m_{t-12}
\end{bmatrix}
\]
The VAR model assumes certain variables are only explained contemporaneously by some of the other variables. Oil is contemporaneously determined by everything else, whereas exchange rates are contemporaneously affected by all the variables except oil. Changes in the prime rate are contemporaneously affected by changes in disposable income and the auto market share, whereas changes in disposable income are only contemporaneously affected by auto market share. This model assumes all variables can be explained by the lags of all the other variables in the model.

A difficult component in estimating VAR models is choosing the number of lags. There exists, as one might expect, a tradeoff between choosing too many or too few lags (degrees of freedom). One way to determine the number of lags to be used is the Akaike criterion. This consists of running the VAR estimation several times using a different number of lags and choosing the number of lags that yields the most negative value for the Akaike estimation. Another method involves calculating autocorrelations and partial autocorrelations to help one decide the lags to be included based on their significance. In this paper, I take both methods into consideration while choosing the lags that I believe to be important. This is done because econometricians claim that theory must come before numbers. The lags chosen are 1, 3, 6, and 12. Notice that this choice reflects what happened in the previous month, which shows the most recent conditions, what happened in the end of the previous quarter, which in certain
months is important for some firms, and what happened six months ago as well as last year, which were chosen because of common practice in time series.

Finally, the data is broken down into two groups: pre and post 1985, which is the year the CAFE standards reached their highest point. The Cholesky decomposition was used in obtaining the graphs of impulse response functions; the responses of US auto market share to shocks in the prices of oil are displayed in the results section.

RESULTS

As can be seen from figures 2 and 3, there is a stronger response in auto market share to shocks in oil prices from 1974 to 1984. Furthermore, this shock is negative and significant, which means that as the price of oil jumped up before 1985, auto market share decreased. From figure 3, one can notice that fuel efficiencies have converged as the CAFE standards reached their peak because oil shocks no longer have a significant effect on auto market share.

SUMMARY & CONCLUSIONS

Many events have occurred in the automotive industry since 1974. However, the most notable of these changes was the implementation of CAFE standards. Thanks to these standards, changes in the price of oil have ceased to significantly affect domestic auto-manufacturers’ share of the domestic market. Other events, such as the Japanese voluntary export restraints, have also taken place during this time period, but there is no theoretical evidence supporting their relevance in the decreased volatility of automobile manufacturer’s domestic market share. Furthermore, when the VERs are given up, fluctuations in the market share do not pick up.

An interesting question, which is a hot debate at the moment, is whether CAFE standards must be increased or not. For now, the results of this paper show that the standards do not need to be raised because oil prices have little effect on market share volatility. However, one must consider the fact that technology is continuously improving, and as foreign vehicles become more efficient, CAFE standards may need to be raised in order to keep up with the competition.
Figure 1.
(sales of domestic automakers’ automobiles as a fraction of the domestic market)
Source: National Highway Traffic Safety Administration

Figure 2

varbasic, oil, auto_market_share

Graphs by irfname, impulse variable, and response variable
Figure 3
REFERENCES


