The link between gasoline prices and vehicle sales:economic theory trumps conventional Detroit wisdom

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The Link Between Gasoline Prices and Vehicle Sales

ECONOMIC THEORY TRUMPS CONVENTIONAL DETROIT WISDOM

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Walter McManus is the Director of the University of Michigan Transportation Research Institute (UMTRI) Automotive Analysis Division. His research applies econometrics, competitive analysis, consumer demand theory, and forecasting to understand trends in the automotive industry. His business career includes nine years at General Motors in various assignments in economics, marketing, and product development and five years as executive director of forecasting for J.D. Power and Associates, in which he developed models for forecasting sales and conducted research on new automotive technologies. He is a member of NABE, the Society of Automotive Engineers, the American Economic Association, and the Society of Automotive Analysts. He earned a B.A. from Louisiana State University in 1977 and a Ph.D. in 1983 from UCLA, where he was a Sidney Stern Fellow.

This paper examines the link between fuel prices and sales of cars and trucks. U.S. automakers have long denied that such a link exists. One source of this false belief is an obsession with the crude count of units sold, equating Hummers with Minis. Another source is the conventional "wisdom" that Americans are unwilling to pay for fuel economy. The paper presents theoretical reasons and market evidence that refute Detroit's conventional wisdom. American manufacturers' reaction to rising fuel prices over the last few years revealed the shortcomings of the U.S. automakers' recent product and powertrain strategies. The effect of rising fuel prices has, in effect, been offset by reducing prices of vehicles in inverse proportion to fuel economy. Thus, unit sales of large SUVs could be maintained, but their revenue (and profit) fell because vehicle prices were cut, directly or indirectly. The paper concludes with a few practical guidelines that business economists should use to prevent their companies from experiencing the recent massive losses experienced by the U.S. automobile industry.

This paper tells a cautionary tale about what can go wrong when manufacturers "forget" that their demand curve slopes downward to the right and that in a market with highly differentiated products it is revenue not unit sales that is the better indicator of business health. One is hardly surprised when business leaders poorly trained in economics, and unwilling to hire and listen to business economists, make poor business choices. In truth, if business leaders had a firmer grasp of economics, the demand for economists would probably fall. The jobs of many economic advisers depend on the ignorance of management.

However, the self-inflicted wounds and woes now threatening the very survival of the domestic automotive companies cannot be blamed on a dearth of economists. U.S. automakers employ many smart economists, most of whom have regular and influential contact with top deci-

sion-makers. Moreover, if an in-house economist stumbles, hordes of economists who spend their days hunting and gathering more and yet more data about the world's most researched industry are ready to freely offer their insight in papers, press releases, and blogs.

With so many able economists on the case, it seems rational to hope that automakers would rarely get the fundamental economics of their market wrong. But this hope, however rational it may be, has been dashed by the experiences of the last few years.

A tragically flawed belief inhabits the minds of the domestic auto industry—the belief that the law of demand does not apply to their market—in particular, that rising fuel prices do not affect sales of light trucks and cars. One source of this false belief is the industry's obsession with the monthly, quarterly, and yearly enumeration of vehicles sold, an enumeration that equates Hummers with Minis. Another source is the conventional "wisdom" that Americans are unwilling to pay for fuel economy.

Suggesting a direct link between gasoline prices and SUV sales is "poor analysis and poor journalism," according to a Detroit business economist

(quoted in* Automotive News*, May 9, 2005).

This paper presents market evidence that refutes the conventional Detroit wisdom and suggests that the rising fuel prices over the last few years revealed the shortcomings of the U.S. automakers' product and powertrain strategies.

The paper concludes with a few practical guidelines that business economists should use to prevent their companies from experiencing the recent losses suffered by Ford Motor Company and General Motors Corporation.

Vehicle Prices Since 9/11/01

The years since the 9/11 attacks have been remarkable ones for the auto industry.[1] At first, Americans, stunned by the attacks and concerned about what might happen next, appeared to put all discretionary purchases—including purchases of new vehicles—on hold in the days immediately following the attacks. U.S. automakers were worried that in the aftermath of the attacks an extended stoppage in sales could be devastating to them, first to the auto industry but then spreading to the rest of the economy.

The slowest sales day in September 2001 was neither the 11th nor the 12th nor the 17th (when the stock markets reopened). The slowest sales day in September 2001 was the 19th, the day that Ronald Zarrella of GM announced the company's "Keep America Rolling" zero-percent financing promotional campaign:

> "We know this is a difficult time to talk about an incentive program, but GM has a responsibility to help stimulate the economy by encouraging Americans to purchase vehicles, to support our dealers and suppliers, and to keep our plants operating and our employees working."[2]

With these words Zarrella launched a marketing campaign that almost seemed like a price war, a very unusual move for a high-cost producer.[3] Ford and the Chrysler Group quickly launched zero-percent financing programs of their own. The "Keep America Rolling" price war lasted until March 2006, when GM announced that it was switching tactics: it would set lower list prices, use fewer incentives, and go to market as the "Value" leader.[4]

The impacts of the incentives war on real prices of cars and trucks vehicles are readily apparent in Figure 1. In September 2001, the real prices of both cars and trucks had been falling at a quickening pace since 1995. The flattening of that trend after September 2001 could be misleading, since incentives in the form of zero or low interest rate financing—the majority of incentive spending in October 2001 and a much larger share of incentives after that than before 9/11—are not part of the CPI's calculation. Correcting the CPI for this omission would result in a continuation of the trend. (See the Appendix for this correction.) The omission of non-cash incentives also accounts for the apparently greater volatility of prices

[1]My discussion in this section relies on information on daily auto sales from the Power Information Network. I later led a J.D. Power and Associates team that developed within-month sales forecasts using these data. Interest in daily sales rates had its origin in efforts in September 2001 to take the pulse of the industry in a period of high uncertainty when the conventional tools, all based on monthly information, were useless.

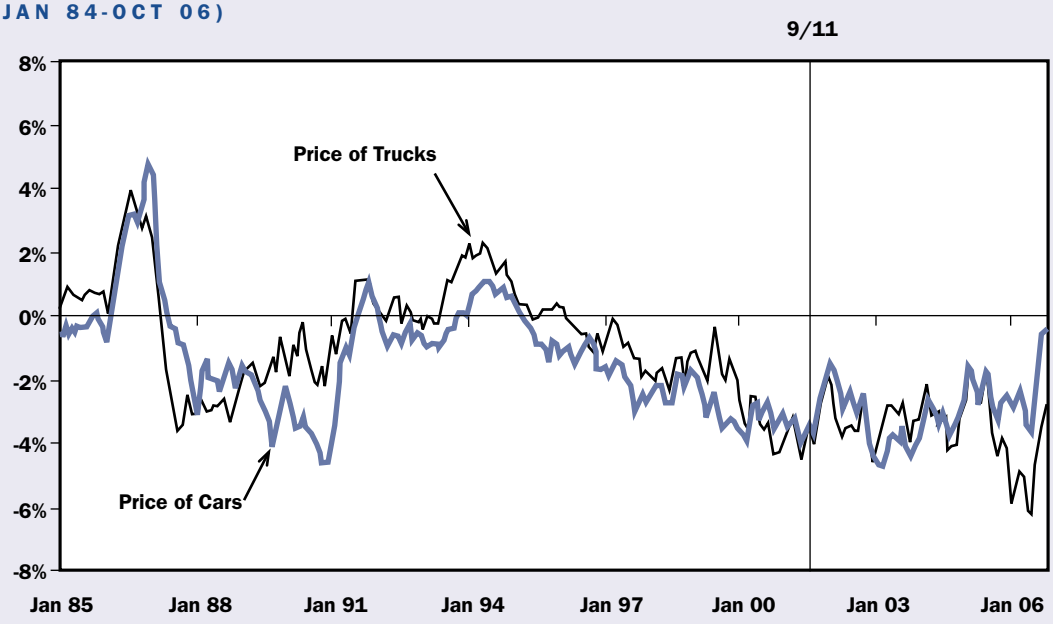
[2]General Motors Corporation (2001).

[3]Zarrella resigned from GM on November 13, 2001 to assume the chairmanship of Bausch & Lomb, so we do not know if he would have pursued the price war with the same intensity his successors (Bob Lutz and Rick Wagoner) did. It is suggestive that a key learning from the Bausch & Lomb case study has a familiar tone, "Aggressive sales drives…can, for a while, mask strategic business weaknesses."

[4]General Motors Corporation (2006). Quotation marks were in the original.

FIGURE 1

YEAR/YEAR CHANGES IN REAL PRICES OF CARS AND LIGHT TRUCKS (JAN 84-OCT 06)



Source: U.S. Bureau of Labor Statistics

after 9/11, as the automakers switched back and forth between cash and low-interest financing incentives, finding new ways to lower prices to stimulate sales. In 2005, the automakers added yet another form of incentive--employee discounts for everyone--that the CPI does not capture. Thus, real vehicle prices in the period since 9/11 have been falling at an unprecedented rate.

Vehicle Sales Since 9/11/01

Industry sales had been very strong for some time when the 9/11 attacks happened. In the year before the attacks, 2000, annual sales of light vehicles reached an all time high of 17.3 million units. Sales in 1998 had already passed the previous 1986 peak. The U.S. economy had been in a recession since March 2001; but through August, sales in 2001 were only five percent below what they had been in 2000, a pace that would have made 2001 the second best year in history.

Would the recession have deepened if Zarrella and GM had not launched the "keep America rolling" campaign? Did it in fact keep America rolling? We will never know, but we do know that in terms of unit sales the industry was already very strong in 2001 and that GM's campaign (and the matching campaigns of GM's competitors) was very effective in stimulating sales of vehicles. The campaign included the month with the highest one-month sales (seasonally-adjusted-at-annual-rate) in history (October 2001, 21.7 million SAAR) and the month with the third-highest one-month sales in history (July 2005, 20.7 million SAAR).

Copeland and Hall (2004) call the 9/11 phenomenon the automotive "demand shock that did not happen," pointing to the increase in expenditure per vehicle that occurred with the campaign. Many consumers used the opportunity of zero-percent financing to buy more expensive vehicles with more optional equipment than they otherwise would have. This general increase in demand could help explain why sales (in units) of SUVs would remain steady in the face of rising fuel prices and operating costs. Copeland and Hall (2004) attribute the impact of zero-percent financing to its "simplicity" rather than to the price reduction that the present value of saving finance costs represents.

The price impact of zero-percent financing on expenditure per vehicle is simpler to justify than its transactional "simplicity." Expenditure per vehicle rose because prices of more expensive vehicles were reduced disproportionately. In particular, the prices of SUVs and other trucks relative to cars were lowered.

Was the correlation of high demand and falling prices in recent years a true price war (a breakdown in tacit collusion among the automakers), as Bresnahan (1987) claims happened in 1955? Not very likely, given the number of brands and manufacturers selling in the United States today compared to 1955. Did it reveal an attempt by the incumbents to deter entry, as Plehn-Dujowich (2006) suggests? When the foreign "entrants" already have a third of the market, it is probably too late to deter. While price wars and entry deterrence could play some small role in explaining the last several years, a simpler explanation is found by looking at the effects of rising fuel prices on the demand for vehicles.

TABLE 1

AVERAGE U.S. RETAIL PRICE OF UNLEADED REGULAR GASOLINE (DOLLARS PER GALLON)

	NOMINAL	Y/CHANGE	REAL ('05)	Y/CHANGE
2002	$1.34	-	$1.46	-
2003	$1.56	16%	$1.66	14%
2004	$1.85	19%	$1.91	16%
2005	$2.27	23%	$2.27	19%
2005 H1	$2.06	-	$2.08	-
2006 H1	$2.59	26%	$2.53	21%

Source: U.S. Energy Information Administration and U.S. Bureau of Labor Statistics

Gasoline Prices Since 9/11

The same period that saw vehicle prices falling at an unprecedented rate, with unit sales remaining near their historic highs, also saw fuel prices rising faster than they had in 20 years. Table 1 documents the rapid and accelerating growth in nominal as well as real fuel prices that have occurred since 2002.[5] From 2002 to 2005, the pump (nominal) price of gasoline rose nearly 70 percent, from $1.34/gallon to $2.27/gallon. Over that same period, 2002 to 2005, the real (2005 terms) price of gasoline rose 56 percent. The real price of gasoline has risen by 14 percent or more annually since 2002.

In 2005, Hurricanes Katrina (August) and Rita (September) hit the Gulf of Mexico's oil production facilities and sent fuel prices soaring. The nominal price of regular unleaded gasoline, which was $2.186/gallon in May, before the seasonal rise in the summer, reached its highest ever level—$3.069/gallon in September.

Theory: Why Fuel Prices Matter

Despite the conventional wisdom of Detroit, economic theory predicts a direct link between fuel prices and SUV sales, and more broadly between fuel prices and vehicle sales. The purchase of a vehicle is an investment decision: the purchase price is paid now, and the vehicle yields services to its owner (or owners if it is later sold used) over its useful life. However, the vehicle's services (mobility) require the ongoing input of fuel. To make a rational choice at the time of purchase, the shopper needs a prediction (simple or sophisticated) of what future fuel prices are likely to be.

[5]The UMTRI detailed data on prices, sales, and attributes covers vehicles sold in the United States in 2002-05. Fuel prices have been generally rising since 1999--2002 was the most recent local minimum, and prices have steadily risen since then (year/year).

The value of a vehicle to a consumer depends on the attributes of the vehicle and the consumer's preferences. The "hedonic" equation, first suggested by Griliches (1961), puts this assumption about valuation of vehicles into a form that can be estimated:

$$1)\ P_{it} = \alpha + \beta_0 I_t + \beta_1 h_t + \beta_2 c_i + \beta_3 \left(\frac{\pi_o}{f_i}\right) + \varepsilon_{it}$$

predictions: $\beta_1 > 0,\ \beta_3 > 0$

where

i = vehicle

t = year

a = age of vehicle

P_i = purchase price of vehicle i

I_t = real disposable income per capita in year t

h_i = horsepower per ton of vehicle i

c_i = curb weight (lb.) of vehicle i

β_1 = marginal value of horsepower per ton

β_2 = marginal value of curb weight

$\beta_3 = m_o \int_o^A e^{(q+n-r)}$ marginal value of fuel cost per mile

π_o = price of fuel in year 0

m_o = expected miles driven in period 0

f_i = expected rate of economy for vehicle i

q = expected rate of change in real fuel price

n = expected rate of change in annual miles driven

r = real rate of interest

ε_{it} = error term for vehicle i in period t

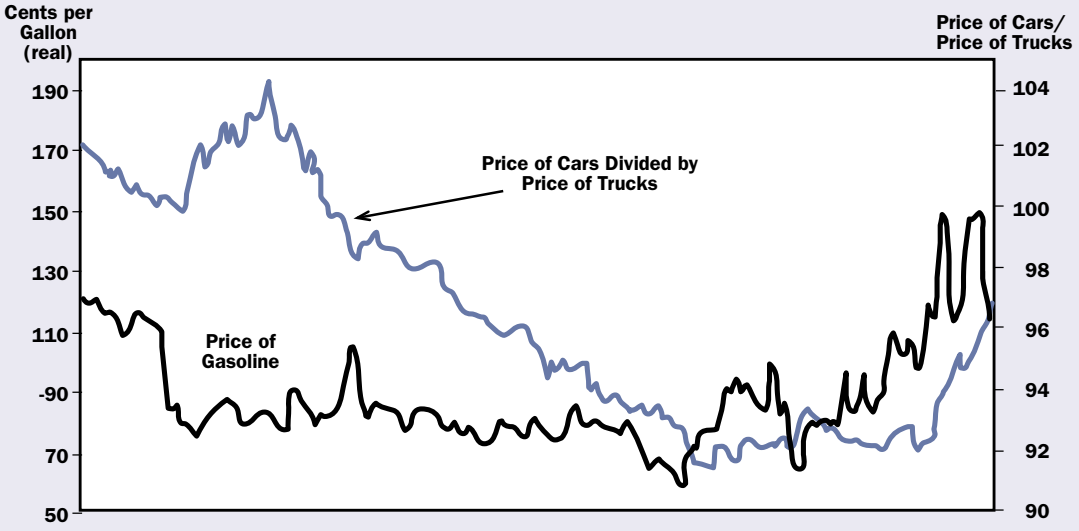
The term $\beta_3 \left(\frac{\pi_o}{f_i}\right)$ in the hedonic equation measures the present discounted value of the vehicle's expected fuel cost over its useful life. The calculation assumes that fuel economy is constant over the life of a vehicle, but not annual miles driven. The price of fuel could also change over time, and the calculation defines the consumer's expectations about future fuel prices and miles driven as simple annual rates of change.

Expected annual miles driven fall with a vehicle's age for two reasons: (1) not all vehicles survive from one year to the next, and the survival probability is incorporated in expectations; and (2) many older vehicles become second or third vehicles in multi-vehicle households and are driven less. The miles a vehicle is driven at a specific age and year in the future could also be inversely related to the fuel cost per mile (p/f) that holds then. Rational consumers would incorporate this "rebound" effect (lower fuel costs per mile increase the demand for miles; higher fuel costs per mile reduce the demand for miles) into their expectations.

What happens to the relative value of two vehicles when the expected future prices of fuel increase? The answer obviously depends on the vehicles' relative fuel economies—the cost of operating both vehicles would rise, but the cost of operating the vehicle with lower fuel economy would rise relative to the cost of operating the more fuel-efficient vehicle. All else equal, this would increase the demand for the more fuel-efficient vehicle relative to that of the less fuel-efficient vehicle. In the hedonic model, the increased demand for fuel-efficient vehicles is expressed as a higher purchase price that consumers are willing to pay.

FIGURE 2

THE REAL PRICE OF GASOLINE AND THE PRICE OF CARS RELATIVE TO THE PRICE OF TRUCKS



Source: U.S. Bureau of Labor Statistics

This simple hedonic model predicts a positive relationship between fuel price and demand for more fuel-efficient vehicles (a negative relationship between fuel prices and demand for less fuel-efficient vehicles). If manufacturers do not want to accept lower sales volumes of less fuel-efficient vehicles when fuel prices rise, then they can accept lower prices and maintain sales units. The next sections of the paper describe the empirical tests we performed of the model's prediction (one using monthly data--Jan-84 to Oct-06--for aggregated products and the other using disaggregated data on hundreds of vehicles over four years). Both provide compelling evidence of a direct connection between fuel prices and sales of vehicles with different fuel economy.

TABLE 2

REAL RETAIL TRANSACTION PRICE REGRESSION

	COEFFICEINT	ELASTICITY
Constant	-69,165.53	
	(4.73)**	
Real Disposable Income per Capita ($)	0.245	0.190
	-0.55	
Horsepower per ton	630.607	1.886
	(23.67)**	
Curb Weight (lb)	10.501	1.090
	(15.00)**	
FuelPrice/MPG	-768.002	-0.161
	(4.82)**	
Observations	1468	
No. individual vehicle models	445	

Absolute value of z statistics in parantheses

*significant at 5%; ** significant at 1%

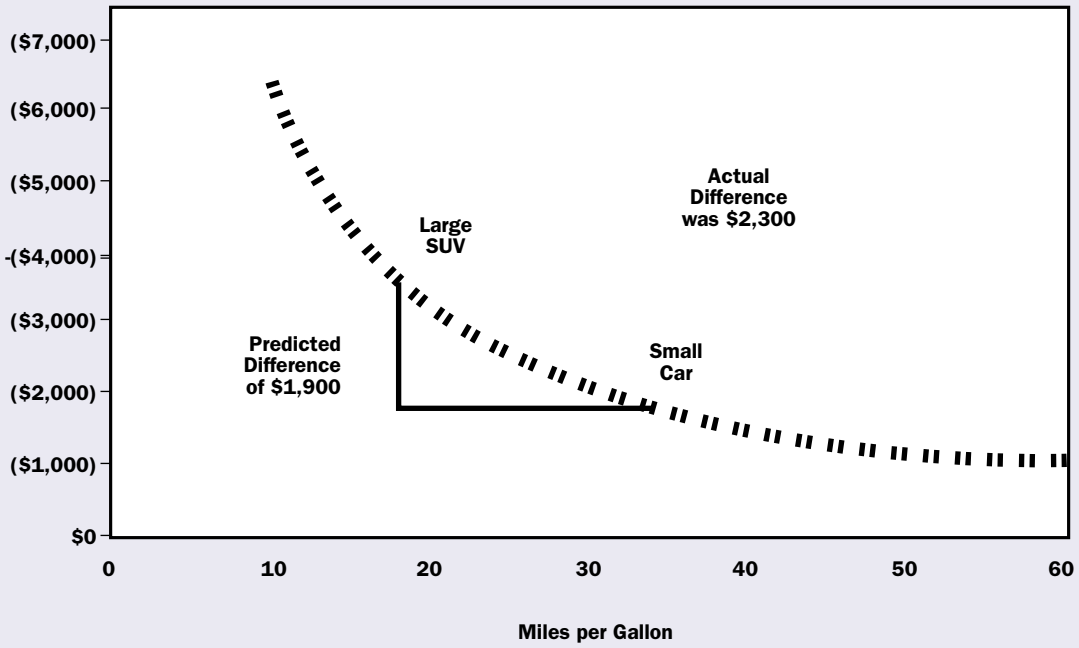
Dummy variables to represent individual brands are not shown.

Evidence from Aggregate Data

Our first test of whether fuel prices influence the relative prices of vehicles as predicted by our simple model (a rise in fuel prices induces a rise in the relative price of more fuel-efficient vehicles) uses highly aggregated data from the Bureau of Labor Statistics' Consumer Price Index. The Bureau publishes monthly observations on the average price of a gallon of unleaded regular gasoline and on price indices for cars, trucks, and all items. Overall, cars have higher fuel economy than trucks do, so we expect fuel prices to be positively related to the car/truck price ratio. It is worth noting, however, that the vehicles classified as trucks are highly diverse, ranging from large SUVs that have very low fuel economy to small crossover vehicles that look like SUVs but are based on cars and have very high fuel economy. We should not be surprised if the effect we are looking for is small. Nonetheless, Figure 2, which plots the data on the real price of gasoline

FIGURE 3

THE IMPACT ON VEHICLE PRICE OF THE RISE IN GASOLINE PRICE FROM 2002 ($1.46/GAL) TO 2005 ($2.27/GAL)



and the price of cars divided by the price of trucks, seems to have the predicted positive correlation, certainly since 1999. However, given the variety of offerings in the light vehicle market, aggregate data are not definitive; and the best approach to capturing the effect of fuel prices on automobile prices would seem to be a combination of cross-section and time-series data that take into account those characteristics that vary across brands.

Evidence from Cross-Section Time-Series Data

The second test of the link between fuel prices and vehicle prices uses data covering 445 vehicles for 2002-05. The cross-section (vehicle level) data include the retail transaction price, performance (horsepower/ton), size (curb weight), and fuel economy. The time-series (year level) data include the real price of gasoline and the real disposable income per capita. The transaction prices came from several sources, including Edmunds.com, Power Information Network, and the National Automobile Dealers Association. The vehicle attributes came from NHTSA fuel economy records.

The hedonic regression parameter estimates, based on equation 1, are shown in Table 3. An issue that arises with time-series cross-section data is whether the error term, ε_{it} is made up of random effects or fixed effects (fixed effects would be equivalent to having a dummy variable for each vehicle). The Breusch and Pagan (1980) Lagrangian multiplier test for random effects rejected the hypothesis that the variances within vehicle are zero in favor of the random effects model. Thus, dummy variables were introduced to represent each brand. The hedonic regression is also adjusted for autocorrelation in the residuals within vehicles.

The coefficients have the predicted signs. More horsepower per ton and more curb weight are associated with a higher vehicle price, and higher fuel cost per mile is associated with a lower vehicle price. The link between fuel prices and vehicle prices is confirmed. The impact of fuel prices on vehicle prices depends on fuel economy—the lower the fuel economy the greater the impact of a specific change in fuel price on the vehicle price. The implications for large SUVs and small cars are shown in Figure 3. From 2002 to 2005 the price of fuel rose from $1.46/gal to $2.27/gal (real 2005 dollars). Based on the hedonic estimates, the negative impact of this fuel price increase on the average large SUV price would be $1,900 greater than its impact on the average small car price, given their very different fuel economy levels. In fact, the average large SUV price fell $2,300 more between 2002 and 2005 than the average small car price did.

Summary and Recommendations

At the time of the 9/11 terrorist attacks on the United States, the real prices of cars and trucks had been falling for almost six years at an accelerating rate. Data collected by the government for the Consumer Price Index (CPI) suggest that in the four years since 9/11 car and truck prices continued to fall, but no longer at an increasing rate. However, the CPI does not measure the effects of

incentives in the form of zero- and low-interest loans, which the automakers turned to after 9/11, in addition to cash rebates, to stimulate sales. When all forms of incentives are taken into account, it is clear that the CPI statistics do not represent the buyers' costs of purchasing new vehicles, and that real car and truck prices continued to fall at an increasing rate through 2005. Automakers have been engaged in very fierce price competition for almost a decade, and the data suggest that the competition has become fiercer over time.

We presented evidence that a significant portion of changes in vehicle prices can be explained by changes in fuel prices. In highly aggregated monthly data (1/84-10/06) on car and truck prices, this paper shows that rising fuel prices lower prices of both cars and trucks. Moreover, they lower the prices of trucks more than the prices of cars. In disaggregate data on 445 individual vehicles for 2002 to 2005, we showed that the negative impact of rising fuel prices on vehicle prices is greater for less fuel efficient vehicles than for more fuel efficient vehicles.

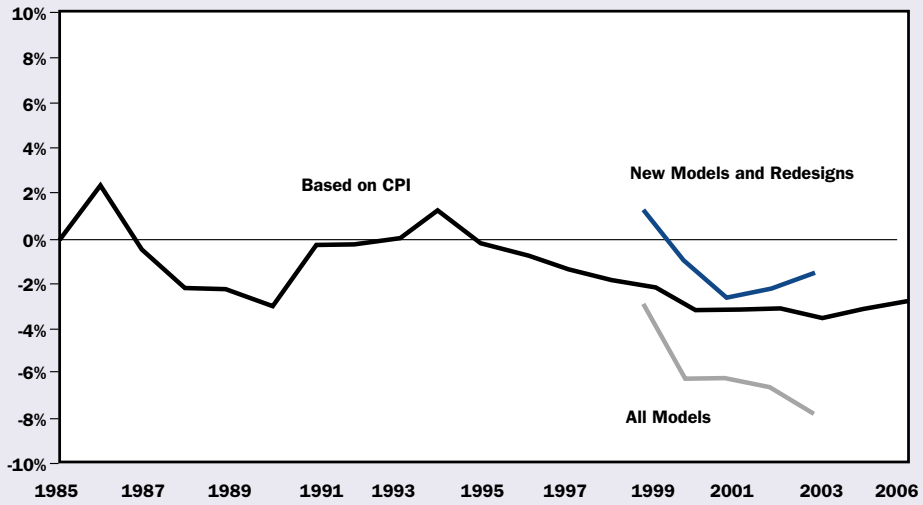
Detroit maintained well into 2005 that rising fuel prices were not having an impact on sales of less fuel-efficient, more profitable SUVs. It is difficult to explain this lapse in sound economic analysis. Perhaps public statements concerning sales forecasting and sales reporting have become more public relations than economics, and the denial of a link between fuel prices and sales was helpful in justifying decisions that had already been made. Perhaps the practice of defining "sales" as the crude count of units sold, which may be appropriate for production planning but not marketing, meant that economists spent too much time explaining differences in unit sales and thus missed the impact of the actual changes in prices. Perhaps the weight of Detroit's challenge to slow the ongoing loss of market share to Japan and Europe (and the fact that whenever Detroit's incentives slowed so did Detroit's sales) made digging into the details a low priority.

Whatever the reasons, Detroit did not accept or publicly admit the link between fuel prices and vehicle demand until it was impossible to ignore. The industry would have benefited from a greater adherence to the principles of economics. What should business economists in other industries do to help avoid the mistakes of the auto industry? Here are a few principles that should help.

1. Report the brutal facts to management, investors, the media, and the public. Economists should be trying to inform their audiences, not trying to form their audiences' opinions.
2. Let economic theory guide analysis; maintain a healthy skepticism about conventional wisdom.
3. Track unit sales, prices of your industry's products, and the prices of other goods that influence your industry. In doing this economists will be doing their part to ensure that there are no (economic) surprises to management. Economists should have been the first to identify the impact of fuel prices.
4. Forecast defensively. If there are factors that can have good or bad effects on your market, then you should report your forecast in a range.
5. Forecast realistically. If management insists on a point estimate, then teach them about risk and uncertainty. Failing that, your point estimate should be on the "bad effects" side.

FIGURE 4

ANNUAL YEAR/YEAR CHANGES IN REAL PRICES OF LIGHT VEHICLES



Appendix: Correcting Prices for Incentives

Figure 4 shows the annual changes in real vehicle prices measured by the CPI along with Corrado et al's. (2006) estimates of changes in real vehicle prices from transaction-level information from Power Information. Corrado et al. matched products year to year to measure real price changed. The

upper and lower limits depend on what is treated as a new product. The upper limit treats redesigns and new entries as new products; the lower limit treats all models as new products each year. The lower limit is further away from the CPI than the upper limit is, suggesting that the CPI should be pulled down to reflect the impact of incentives in the form of low-rate financing.

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