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A REVIEW OF THE A. T. KEARNEY APPLICATION OF THE WHARTON EFA AUTOMOBILE DEMAND MODEL TO ASSESS THE IMPACT OF ENVIRONMENTAL REGULATIONS

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ABSTRACT

This paper reports a review on the use of the Wharton EFA Automobile Demand Model by A.T. Kearney, Inc. in its study of the economic impacts of environmental regulations on the automobile industry. This review is based on the Kearney draft final report to its sponsor, the Environmental Protection Agency (EPA); the Wharton EFA Automobile Demand Model documentation; and a previous analysis of the Wharton EFA auto model by the Highway Safety Research Institute (HSRI) of The University of Michigan.

This review examines Kearney's modifications and extensions of the Wharton EFA auto model, and how the use of that model affected the Kearney analysis. In addition, the model's simulation of the most probable regulatory scenario is briefly interpreted.

The findings of the review are:

- Kearney modified the Wharton EFA auto model to forecast the effects of EPA regulations on new car sales; size-class market shares; gasoline consumption; the profitability of AMC, Chrysler, Ford, and GM; and automobile industry employment.

- The Kearney analysis in its draft form contains an informative description of the motor vehicle transportation industry but it fails to adequately: (1) explain the Kearney modifications of the Wharton EFA auto model, (2) detail the limitations of the Wharton EFA auto model, and (3) interpret the forecasts of the Wharton-Kearney model simulations.

- The Kearney modifications to the Wharton EFA auto demand model did not correct any of the serious weaknesses of the original Wharton EFA auto model with regard to policy applications. Furthermore, the Kearney additions of the profitability and automobile industry employment equations have weaknesses that detract from the limited benefits achieved by the inclusion of those equations. Thus, the Wharton-Kearney model cannot be relied upon in policy analysis applications designed to estimate the economic impacts of environmental regulations.

1.0 INTRODUCTION

This paper is a brief review of how A. T. Kearney, Inc. used the Wharton Econometric Forecasting Associates Automobile Demand Model in studying the economic impacts of environmental regulations on the automotive industry (Kearney 1978). This review is based solely on an examination of the Kearney draft final report, since the program computer code and the program documentation were unavailable. This review, performed by the Policy Analysis Division of the Highway Safety Research Institute (HSRI) of The University of Michigan, was part of the study entitled, "Analytical Study of Mathematical Models: General Policy Studies." The reader will more easily understand this review if he is familiar with the Wharton EFA automobile model. Further information on that model is available in the original model documentation (Schink and Loxley 1977) and in an analysis of that model by Golomb, Luckey, Saalberg, Richardson, and Joscelyn (1979).

The Kearney study was sponsored by the U.S. Environmental Protection Agency (EPA). Its objective was to examine the economic impacts of various pollution standards on the automotive industry.

There are three parts to the Kearney Report. The first part describes the automotive manufacturers (American Motors Corporation !AMC1, Chrysler Corporation, Ford Motor Company, and General Motors Corporation !GM1, parts suppliers, and supporting service industries) and the characteristics of automobile demand, including abstracts of various automobile demand models. Part two presents the Kearney estimates of the incremental costs to both the automakers and their customers due to potential EPA emissions regulations in future years. Part three presents the Kearney estimates of economic impacts of the emissions abatement requirements.

The portion of the Kearney analysis relating to the impact of EPA passenger car regulation is based on simulations of the Kearney-modified

1977 version of the Wharton EFA Automobile Demand Model. This review addresses the effect of using the Wharton EFA automobile model in the Kearney analysis.

The Wharton EFA Automobile Demand Model was selected by Kearney as its major analytic tool, because its capabilities most closely matched the study needs. The Wharton EFA Automobile Demand Model was developed in 1976 under the sponsorship of the Transportation Systems Center (TSC) of the U.S. Department of Transportation. The project was initiated specifically to provide that federal agency and others with a better analytical tool for investigating the potential impacts of proposed policies and regulations on the motor vehicle industry and on the economy in general.

This paper is organized as follows: Section 2.0 describes the Kearney modifications to the Wharton EFA automobile model. Section 3.0 examines the impact of the use of the Wharton EFA Automobile Demand Model on the results of the Kearney analysis. Section 4.0 discusses the model's simulation results of the most probable regulatory scenario. Section 5.0 presents the findings of this review.

2.0 THE KEARNEY MODIFICATIONS TO THE WHARTON EFA AUTOMOBILE DEMAND MODEL

Kearney modified the Wharton EFA auto model so that it could simulate the effects of stationary-source and mobile-source pollution-abatement regulations. The objective was to estimate the impact of these regulations on gasoline consumption and auto industry employment and profitability. The two mobile-source regulatory scenarios simulated by Kearney were based on U.S. House of Representatives Bill 6161. They include alternative emissions standards for hydrocarbons, carbon monoxide, and oxides of nitrogen. These scenarios are presented in Table 2-1. Each of these regulatory scenarios is simulated under two assumptions concerning auto industry behavior: an optimal fuel-economy assumption and an optimal cost assumption. Kearney reports that the most probable scenario is Case A with an optimal fuel-economy assumption.

The Kearney analysis examines the impact of regulations on new car registrations, revenues of foreign and domestic automakers, average cost per mile, total gasoline consumption, U.S. auto industry employment, market shares of five size classes, total domestic market share, total regulatory cost per new car (including mobile-source costs as well as the effect of regulations on fuel economy), average fuel economy (both new and in total), and the gross operating margins for the Big Four domestic automakers. Since the original Wharton EFA auto model is not capable of forecasting these effects, Kearney modified the model.

The Kearney modifications to the Wharton EFA auto model do not alter its basic structure. The modifications are divided into two groups: (1) "Front end" modifications designed to input to the model the mobile and stationary source costs, maintenance cost changes, and fuel efficiency changes owing to the EPA regulations; and (2) "Back end" modifications that use the model's outputs to develop estimates of revenues,

TABLE 2-1

AIR POLLUTION CONTROL SCENARIOS
FOR LIGHT-DUTY MOTOR VEHICLES
HC/CO/NOx (grams/mile)

MODEL YEAR	CASE A ROGERS' BILL (H.R. 6161)	CASE B ROGERS' BILL (H.R. 6161)
1977	1.5/15/2.0	1.5/15/2.0
1978	1.5/15/2.0	1.5/15/2.0
1979	0.41/9/2.0	0.41/9/2.0
1980	0.41/9/2.0	0.41/9/2.0
1981	0.41/3.4/1.0	0.41/3.4/1.0
1982	0.41/3.4/1.0	0.41/3.4/1.0
1983	0.41/3.4/1.0	0.41/3.4/0.4
1984	0.41/3.4/1.0	0.41/3.4/0.4
1985	0.41/3.4/1.0	0.41/3.4/0.4

Notes:
1. Case A assumes that the EPA Administrator will decide in 1980 that more stringent NOx standards will not be required for cars produced in the 1983 model year and thereafter.
2. Case B assumes that the EPA Administrator will decide in 1980 that more stringent NOx standards will be required for cars produced in the 1983 model year and thereafter.
3. NOx standard would be subject to change at the discretion of the EPA Administrator, consistent with clean air quality.

Source: Kearney 1978, Part 2, pp. II-2.

profitability, employment, and gasoline consumption. These modifications are illustrated in Figure 2-1.

2.1 Front-End Modifications

1. **Fuel-Efficiency Change Factors**

   Fuel economies by size class of vehicle are calculated in the Wharton EFA auto model. Kearney develops projections of fuel economy changes resulting from emissions standards and incorporates them into the model through use of a multiplicative factor.

2. **Maintenance-Cost Change Factors**

   The increases in maintenance costs resulting from the EPA standards enter the model as additional repair costs. These costs, presented in current dollars, are the total costs over the life of the new automobile. These costs are appropriately discounted and deflated to constant-dollar terms to be consistent with the other costs in the Wharton EFA auto model.

3. **Emission Abatement Costs**

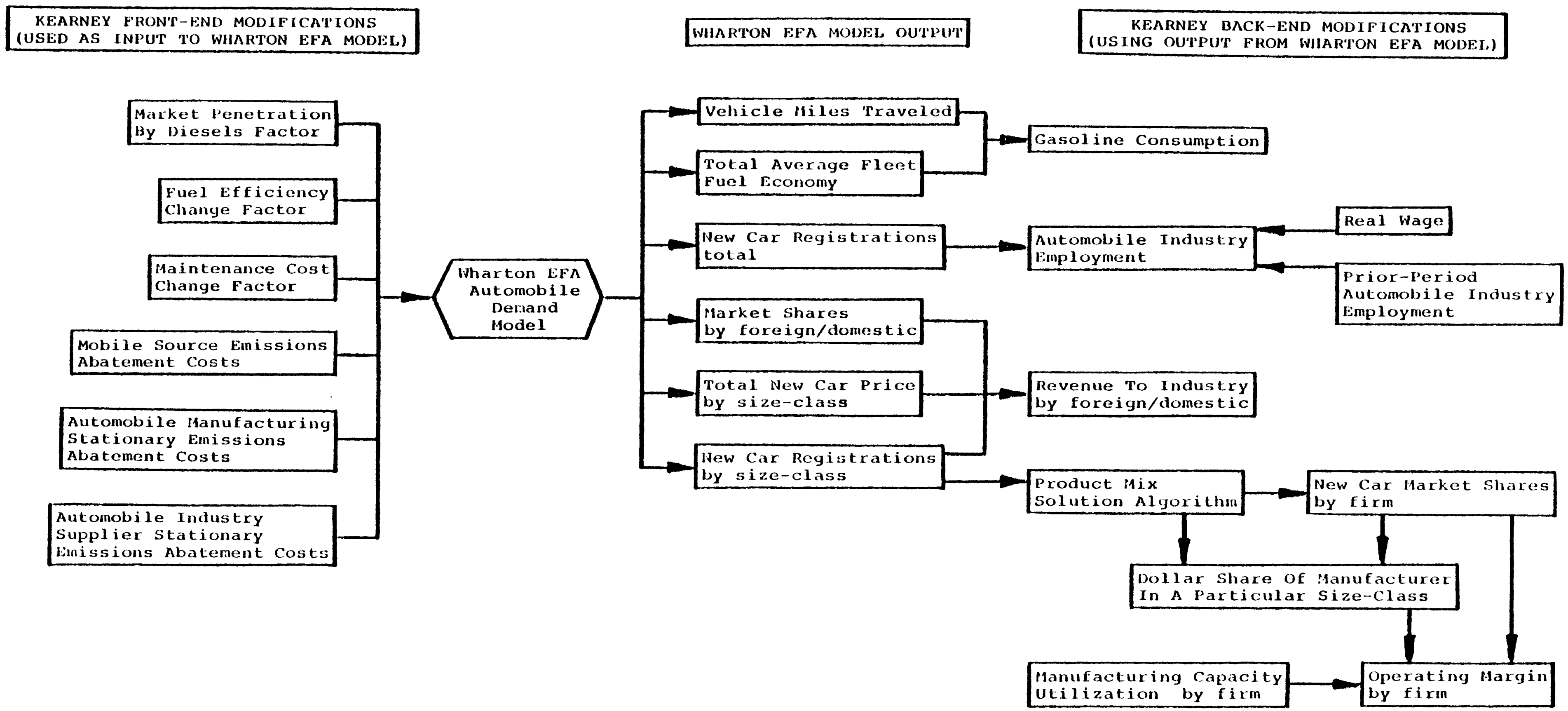
   The incremental costs resulting from the EPA regulations on mobile and stationary (both manufacturing and supplier facilities) sources of pollution are input to the Wharton EFA auto model by attaching three variables (one for each source) to each of the eight stripped (without options) base prices by size class. These costs are input in current dollars to be consistent with the Wharton EFA auto model. The mobile source costs are assumed to be passed along to the consumer without a markup. However, the cost of stationary-source pollution control is assumed to be passed along to the consumer with a fifty percent markup (Note: the Kearney documentation contained contradictory statements concerning this markup; an appendix stated no markup was used, while the text stated in several places that the markup was fifty percent).

4. **Diesel Penetration Factor**

   One of the sensitivity tests considered in the Kearney report is

FIGURE 2-1

KEARNEY MODIFICATION TO THE WHARTON EFA AUTO MODEL



the impact of the penetration of the use of diesel engines into the new automobile market. This test was regarded as an alternative to the regulatory scenarios (i.e., Cases A and B) simulated. This test simulates increased diesel penetration at the rate of five percentage points per year, beginning in 1981, up to a total of twenty-five percent of new car sales in 1985. The twenty-five percent figure is then held constant through 1990.

To perform this test, a variable containing the fraction of diesel penetration is attached to each of the eight base price-by-size-class equations to adjust the base prices for the higher initial costs of diesel-powered automobiles. In addition, diesel penetration is also made to affect maintenance costs and fuel economies. Gasoline consumption, under the high-diesel-penetration scenario, appears to include both gasoline and diesel fuels. Neither the price nor the consumption of diesel fuel are considered in the sensitivity test.

2.2 Back-End Modifications

1. **Gasoline Consumption**

   Kearney estimated gasoline consumption by dividing the forecast of total vehicle miles traveled by the average total fleet fuel economy. The gasoline consumption equation is, however, a relatively minor addition to the Wharton EFA auto model, since the independent variables are already part of the output.

2. **Profitability Equations**

   Kearney developed a profitability equation for each major domestic manufacturer: AMC, Chrysler, Ford, and GM. The dependent variables for the equation, as reported in the Kearney report, is gross operating margin. That is defined as operating earnings (before deduction of depreciation, depletion, interest, and income taxes) as a percentage of net sales (Kearney 1978, Part III, pg. v). However, the HSRI staff, using Kearney-supplied income statements for the automakers, determined that the data used for regression purposes has operating income after depreciation and amortization as a percentage of new sales. Net sales includes the sales of all products by the companies, not just automobile sales in the United States. Three of the five independent variables are the proportion of the manufacturers' sales in (1) the subcompact and compact submarket, (2) the intermediate submarket, and (3) the full-size and luxury submarket. The other independent variables are capacity utilization and the manufacturer's market share. Capacity utilization is the manufacturer's new registrations relative to a five-year moving average. This is a percentage. The market share variable is an index of the sales-weighted average of market shares in each size class. That is, the market share index values are calculated by multiplying a firm's market share in a size class times the fraction of the firm's dollar automobile sales comprised of that size class, and then summing over all size classes. The profitability equations were estimated using a generalized least-squares technique applied to annual data from 1947 to 1976. These results are shown in Table 2-2.

The estimated coefficients of sales shares support the general belief that Ford, GM, and Chrysler profit more from the sales of larger cars. The AMC estimated coefficients are an exception. However, AMC has become primarily a small car producer, and the estimated coefficients indicate that AMC profits more from small car sales than from the sales of larger cars.

Capacity utilization is expected to be positively related to profitability. The values of the coefficients and the corresponding t-statistics show that capacity utilization is significantly important in estimating the profitability of the automakers. The market share index is shown to be not significantly different from zero at the ten percent level.

The standard errors of regression are high when compared with the means of the automaker's operating margins over the historical period. Recalling that the dependent variables are percentages, these means are 15.46, 9.346, 4.715, and 1.35 for GM,

TABLE 2-2

REGRESSIONS TO EXPLAIN PROFITABILITY OF U.S. BIG FOUR AUTOMAKERS, 1947-1976

Firm	Sales Share of Subcompacts and Compacts	Sales Share of Inter-mediates	Sales Share of Full and Luxury	Capacity Utilization	Market Share Index	R^2	S.E.	RHO	D.W.	F-STAT
General Motors	-0.254 (-1.370)	0.056 (0.600)	0.123 (1.413)	0.133 (3.979)	0.145 (0.894)	0.59	2.621	0.62	1.86	8.99
Ford	-0.127 (-1.812)	0.079 (1.656)	0.135 (3.047)	0.130 (4.176)	0.083 (0.654)	0.67	2.22	0.30	1.95	12.68
Chrysler	-0.049 (-0.713)	-0.042 (-0.821)	0.100 (2.021)	0.111 (3.868)	0.097 (0.556)	0.49	2.64	0.52	2.20	6.00
American Motors	0.049 (2.056)	-0.012 (-0.440)	-0.168 (-2.771)	0.162 (2.701)	0.036 (0.656)	0.63	3.24	0.21	1.62	6.385

Note: Regressions estimated by generalized least squares with first-order autocorrelation parameter RHO.
t-statistics in parentheses.
Annual data, see Tables IV-1 through IV-6, 1949-1957; American Motors: 1956-1975.

Source: Part 1 - Industry Description and Financial Profile, Table IV-7, (Kearney 1978).

Ford, Chrysler, and AMC, respectively. This indicates that the forecast levels of operating margins for the automakers are likely to be quite far off the mark, particularly in the cases of Chrysler and AMC.

The profitability equations as specified by Kearney imply that the costs of the EPA regulations have only an indirect effect on the profitability of the automakers, that is, the costs are filtered through the independent variables of the equations. This may be true in some firms, but in other firms the regulations may impose direct and additional hardships. For example, a firm that lacks capital may have difficulty raising the additional funds for stationary pollution-control equipment, or a firm may have to shift key personnel into management of the pollution-control program. These types of profitability losses are assumed minor by Kearney.

The profitability equations have low R^2 statistics for time series. This may be caused by Kearney's estimating total profitability of the firm based on what occurs in the passenger car market. The major automakers, however, have significant interests in such areas as trucks, buses, tractors, glass, financing, locomotives, and replacement parts, plus overseas operations. Considering the breadth of those interests, it is not surprising that the R^2s and some of the t-statistics are low. These equations would be useful for estimating the effects of the changes in profitability resulting from changes in the auto market if the auto market profit source were independent of the other sources of profit. However, this is probably not the case. Events affecting profits from the sales of new cars will likely affect the automaker's other sources of profit. Therefore, the equation excludes relevant variables and produces biased estimates of the coefficients.

To link the outputs of the Wharton EFA model to the sales shares used by the profitability equation, Kearney developed a "solution algorithm." The solution algorithm produces product mixes (the fraction of a manufacturer's output in each class) given the firm's market shares (manufacturer's share of total industry output) and the size-class market shares. The size-class market shares are outputs of the Wharton-Kearney model. The firm's market shares are exogenous to the Wharton-Kearney model. The firms' market shares input to the Wharton-Kearney model are in Table 2-3.

3. Automobile Manufacturing Employment Equation

Based on a Cobb-Douglas production function and the hypothesis that employment demand in the short run will differ from its long-run equilibrium value, Kearney developed an automobile manufacturing employment equation. Kearney estimated that relationship to be in the following form:

$$\log(L_t) = \underset{(-1.4358)}{-2.64719} + \underset{(3.2854)}{.4395}\,[\log(L_{t-1})] + \underset{(3.7419)}{.43121}\,[\log(O_t)] - \underset{(-2.9238)}{.55910}\,[\log(w_t)]$$

$$R^2 = .507 \qquad S.E. = .0880 \qquad D.W. = 1.85$$

where

L_t = employment in period t

O_t = output in period t

w_t = real wage rate in period t

The output and real wage variables have the long-run effect on employment. The lagged employment variable moderates the short-run impacts of changes in the other independent variables.

The HSRI staff have the following observations and comments about the employment equation. First, the dependent variable as used for regression purposes is production worker employment in Standard Industrial Classification (SIC) 371. This class contains a substantial number of nonpassenger car production workers. SIC 371 includes workers producing trucks, buses, tractors, motor vehicle parts and accessories, and truck trailers. In 1974, parts and accessories production workers accounted for almost half of

TABLE 2-3

ASSUMPTION OF MARKET SHARES
OF BIG FOUR FIRMS
1975-1990

	GM	FORD	CHRYSLER	AMC
1975	.53	.282	.143	.045
1976-1990	.554	.262	.152	.03

Source: Kearney 1978, Part 3, Table D-1.

all SIC 371 production workers (U.S. Department of Labor 1976). Thus, assuming SIC 371 employment depends entirely on sales of new cars is a very rough approximation. Second, it should be observed that the only way that technological change (productivity) is accounted for in the equation is through the real wage variable. Third, the equation would be better specified if the dependent variable were worker-hours or the equivalent number of full-time workers, since the nature of the industry dictates overtime and cutbacks on an irregular basis.

The forecasts of the real wage rate (i.e., the future course of productivity) are based on a time-trend equation estimated over the period 1948 to 1976 and are assumed by Kearney to be determined exogenously to the Wharton EFA auto model. Therefore, the impacts of the EPA regulations are transmitted solely through changes in the output variable, which is new car registrations as forecast by the Wharton EFA auto model.

All the coefficients in the estimated equation are significantly different from zero, but the R^2 of .507 is relatively low for a time-series equation. The standard error of regression as a percentage of the mean of the dependent variable is 22.46%.

3.0 LIMITATIONS IMPOSED ON THE ANALYSIS BECAUSE OF USE OF THE WHARTON EFA AUTOMOBILE DEMAND MODEL

An analysis based on an econometric model is subject to the model's limitations. Thus, the conclusions from the Kearney study of the impact of passenger car regulations are dependent on the characteristics of the Wharton EFA auto model.

3.1 The Wharton EFA Auto Model as a Policy Tool

Golomb et al. (1979) found the Wharton EFA auto model to be generally insensitive to changes in new car prices, automobile use costs, and production input costs. This insensitivity may be reasonable in the case of changes in some costs such as insurance, parking and tolls, and possibly repair costs, but inappropriate in other cases such as purchase price and fuel costs. They note that this insensitivity is particularly true in the long run.

The source of these insensitivities lies in Wharton's methodology. Golomb et al. (1979) conclude:

> A fundamental weakness of the model involves the price elasticities in the desired stock and share equations. Desired stock and desired stock shares by vehicle class are critical to the operation of the model either in long-term forecasting or policy analysis. Yet these critical equations are estimated over a 1972 cross-section of state data. The cost of owning and operating a car will vary minimally across states, and the variation that does exist will not be due to fundamental differences in the price of a car, the level of federal taxes, and so on. In these circumstances, one can have very little confidence in the estimated cost or price elasticities. They simply do not reflect responses to price variations that would be observed over time as the result of changes in policy. In effect, this rules out the possibility of using the model with any confidence in a number of interesting policy simulation experiments. (p. 205.)

In addition, the Wharton EFA auto model's new-car-sales-demand equation specification has demand as a function of the ratio of current-year prices to the prior-year prices. This specification produces large first-year impacts due to price changes but no long-run impact. The long-run impact of the price changes occurs as a result of changes in the desired stock due to changes in the capitalized cost per mile. The round-about route produces small long-run impacts of price changes.

3.2 The Effect of Using Wharton EFA Automobile Model Outputs

Given the problems mentioned in the previous section, the reliability of the specific Wharton output used by Kearney is questionable. Table 3-1 lists the Wharton model outputs used by Kearney, along with the respective error statistics that were produced by HSRI staff when they exercised the model over the period 1960-1974. The interpretation of the error statistics is straightforward. The forecasts of new car sales, VMT, and average MPG are reasonably accurate. The relatively high errors for market shares indicate that the Wharton EFA auto model inadequately represents the determinants of new car registrations by size-class market shares.

These statistics and other conclusions reported by Golomb et al. have implications for the reliability of the Kearney simulation results. These implications as well as the HSRI staff's analysis of the particular requirements of the Kearney study are discussed below.

1. **Impact of Fuel Efficiency Changes on Wharton-Kearney Model Outputs**

   The impacts of EPA-caused fuel economy changes on the model's output variables are transmitted through the capitalized cost per mile variable. Capitalized cost per mile is a critical variable in the Wharton EFA auto model. It includes finance charges, gasoline, insurance, tire, parking and tolls, and motor oil costs as well as the purchase price of new cars (including taxes). Capitalized cost per mile is a determinant of the desired automobile stock and desired market shares by size class of new car sales. These latter two in turn are determinants of new car sales, both in total and by size-class market share.

The point of this discussion is that changes in fuel efficiency, both in the short and long runs, will have minimal impact on the model's output variables due to the structure of the model. That is, the importance of changes in fuel economy in the purchase decision is not high.

2. **Profitability Forecasts**

As noted in the previous section, the profitability forecasts are dependent on the size-class market shares as estimated by the Wharton EFA auto model. The error statistics presented in Table 3-1 indicate that the Wharton EFA auto model produces relatively inaccurate and unreliable estimates of size-class market shares. Since the Wharton EFA auto model inadequately represents the determinants of market shares, any use of these forecasts for policy analysis purposes is likely to produce incorrect conclusions.

Profitability changes due to shifts in size class composition of sales caused by EPA regulations cannot be regarded as reliable if the model does not (a) represent what determines market shares and (b) have reasonable estimated cost or price elasticities.

3. **Gasoline Consumption**

Kearney forecasts gasoline consumption by dividing total VMT by average fleet fuel economy, both as generated by the Wharton EFA auto model.

Average fuel economy is critically dependent on the stock of cars by class and vintage. Since the number of cars added to the stock in any given year is relatively small, average fuel economy as forecast by the model in the short run is dominated by the stock of cars already in existence. However, in the long run, forecasts of average fuel economy will be dependent on the stock of cars as forecast by the Wharton EFA auto model. Since the model forecasts new car size-class market shares with poor reliability, long-run forecasts of average fleet fuel economy are equally unreliable.

TABLE 3-1

ERROR STATISTICS
WHARTON EFA AUTOMOBILE DEMAND MODEL
SIMULATION OVER THE WITHIN-SAMPLE PERIOD 1960-1974

VARIABLE	MEAN	RMSE[1]	% RMSE[2]
VMT/Family Unit	12.38	0.6358	5.134
Average Fleet Fuel Economy	14.00	0.5068	3.620
New Car Registrations	8.693	0.8234	9.47
Market Shares[3]			
Subcompact	0.1339	0.1300	97.08
Compact	0.1697	0.0572	33.68
Midsize	0.2520	0.1356	53.81
Full	0.3628	0.1294	35.66
Luxury	0.814	0.0113	13.90
Subcompact and Compact	0.3036	0.0966	31.82
Midsize	0.2520	0.1356	53.81
Full and Luxury	0.4442	0.1310	29.49

Notes: 1. RMSE is the average error of the predicted values and indicates the accuracy of the forecast.

2. % RMSE is the RMSE as a percentage of the mean of the actual values of the variables over the forecast period, i.e., 100 x RMSE/Mean.

3. While the Wharton EFA Auto Model forecasts five size-class market shares, the Wharton-Kearney version combines the subcompact and compact shares, and the full and luxury shares for use in the profitability equations. Combining the shares reduces the error levels considerably.

Forecasts of VMT are dependent on forecasts of size-class market shares, for the VMT equation reflects variations in mileage due to changes in the age composition of the automobile stock. The VMT estimate is also dependent on the average fuel economy as forecast by the model. In the short run, VMT is relatively insensitive to the policies simulated by Kearney, since those policies are transmitted through the model by changes in size-class market shares. But, as with fuel economy, the prediction of VMT in the long run is critically dependent on the poor estimates of market shares generated by the Wharton EFA auto model.

To summarize, both VMT and average total fuel economy as estimated by the Wharton EFA auto model are insensitive in the short run to the policies simulated by Kearney. In the long run, the policies' effectiveness is transmitted to the gasoline consumption estimates through the market shares and new car sales forecasts. Since the size-class market shares forecasts are unreliable, the policies' impact on gasoline consumption cannot be accurately measured.

4. **Automobile Industry Employment**

In forecasting the employment effects, the only Wharton EFA auto model output used by Kearney is the new car sales (registrations). Over the historical period, it has been shown by Golomb et al. that new car sales is forecast with an RMSE of 820,000 units or a percentage error of 9.5%. The trends of new car sales (i.e., the upturns and downturns of sales) are predicted fairly well. However, the other important requirement is that the cost and price elasticities reflect reality. As indicated previously, these elasticities are estimated over a questionable data set, i.e., cross-section data across states. Thus, use of the Wharton-Kearney model for policy simulations that affect prices or costs are likely to produce inaccurate results.

5. **Foreign and Domestic Revenues**

The Wharton-Kearney model forecasts both domestic and foreign revenues from the sales of cars in the U.S. As Kearney notes in its report, the foreign/domestic split is exogenous to the version of the Wharton EFA auto model used, and this limitation must be considered when evaluating the effects of various policies.

In the Wharton EFA auto model, foreign makes compete in the subcompact, compact, and luxury car submarkets. The Kearney foreign share of those size classes are 51%, 5%, and 90%, respectively. However, it should be noted that Schink and Loxley (1977) report these foreign shares to be 52%, 7%, and 12% respectively for the period 1976-2000. Thus, it appears that Kearney has either changed the values of the split parameters substantially or else has some typographical errors in its report.

Kearney performed sensitivity tests on these externally set parameters by simulating a regulatory scenario under three groups of parameters. These groups are (1) original Wharton EFA auto model parameters noted previously, (2) original parameters increased by 10%, and (3) original parameters decreased by 10%. Changing these parameters by 10% does not imply that the foreign manufacturers' share of the U.S. market changes by 10% since the foreign manufacturers are assumed by Wharton EFA to have no entries in the intermediate and full-size classes. The test results showed that the model's forecasts are changed by insignificantly small amounts. However, a conclusion that the foreign/domestic split has only insignificant impact on the Wharton-Kearney outputs variables, including profitability, cannot be considered reliable without additional information.

In addition, it should be noted that the import car market has been changing substantially in recent years. There is now foreign car penetration in the mid-size class market. This is not considered in the Wharton EFA auto model, and adds to the uncertainty of the Wharton-Kearney results.

4.0 DISCUSSION OF A SELECTED WHARTON-KEARNEY MODEL SIMULATION

To facilitate an understanding of the issues raised in previous sections, this section presents a brief discussion of the results of a simulation of regulatory scenario A under the assumption of optimal fuel economy. The simulation discussed here is one of many reported by Kearney and is indicative of other simulations. Table 4-1 contains the simulation results. The upper portion of the table shows the simulation values of the output variables. The lower half of Table 4-1 indicates (in unit or percentage terms) the impact of the regulations on a baseline case involving no additional abatement costs. The major results are discussed below.

1. **New Car Sales**

   As expected, the impact on new car sales of the changes in price are most dramatic in the year the price increases occur. However, once the price stops rising (1982), sales return to close to normal. The positive sales increase over the baseline in 1982 is counterintuitive, given that buyers that year are faced with pollution abatement costs $300 higher than in the baseline case.

2. **Domestic and Foreign Revenues**

   In evaluating these values, recall that the foreign shares of three size classes are set exogenously. The increases in revenues are a result of the increases in the prices of automobiles due to the pollution control equipment.

3. **Employment - Auto Industry**

   The employment forecasts reflect the construction of the employment equation (the prior-period employment variable) and the forecasts of new car sales. In 1980, only a partial impact of the sales decrease occurs. In 1981, the second consecutive year of depressed sales, employment drops even further. In 1982, the prior-period employment variable shows its effect as employment

TABLE 4-1: SUMMARY IMPACTS OF CASE A, OPTIMAL FUEL ECONOMY (CASE AOM)

SIMULATION VALUES FOR AOM

	1980	1981	1982	1983	1984	1985	1990*
NEW CAR SALES (MILL)	11.860	11.991	12.943	12.311	12.499	12.379	12.983
DOMESTIC REVENUES (BILL 77-I $)	47.681	49.727	53.862	51.347	52.343	51.990	54.676
FOREIGN REVENUES (BILL 77-I $)	6.422	6.445	6.925	6.657	6.714	6.642	7.113
AVG. COST-PER-MILE (77-I $)	0.219	0.223	0.224	0.224	0.224	0.225	0.229
TOTAL GAS CONSUMPTION (BILL GAL)	80.294	79.064	77.681	76.835	75.399	73.908	66.531
EMPLOYMENT--AUTO INDUSTRY (THOU)	665.313	663.943	680.232	667.211	660.605	649.681	618.605
SUBCOMPACT SHARE	0.193	0.186	0.184	0.187	0.185	0.185	0.194
COMPACT SHARE	0.195	0.212	0.210	0.210	0.208	0.206	0.198
MID-SIZE SHARE	0.264	0.263	0.260	0.258	0.257	0.255	0.260
FULL-SIZE SHARE	0.252	0.241	0.247	0.245	0.240	0.251	0.233
LUXURY SHARE	0.096	0.098	0.099	0.100	0.101	0.102	0.107
TOTAL DOMESTIC SHARE	0.800	0.806	0.807	0.805	0.806	0.806	0.802
MOBILE SOURCE COST/NEW CAR (77-I $)	111.425	259.155	259.308	259.202	259.417	259.545	241.512
INC. GASOLINE COST/NEW CAR (77-I $)	-78.194	-79.347	-77.841	-75.770	-74.112	-72.671	-70.345
TOT. ABATEMENT COST/NEW CAR(77-I $)	85.413	295.756	300.475	305.026	311.665	314.293	290.404
TOTAL FLEET IN-USE MPG	13.946	14.476	15.077	15.738	16.422	17.130	20.609
DOMESTIC NEW FLEET EPA MPG	21.043	22.022	22.907	23.884	24.877	25.775	29.162
GM GROSS OPERATING MARGIN	9.938	8.890	9.857	8.982	9.190	9.256	9.206
FORD GROSS OPERATING MARGIN	3.803	3.600	4.564	3.694	3.901	3.959	3.844
CHRYSLER GROSS OPERATING MARGIN	-0.527	-0.365	0.433	-0.271	-0.131	-0.094	-0.223
AM GROSS OPERATING MARGIN	3.444	3.903	4.964	3.953	4.094	4.083	3.936

PERCENTAGE OR UNIT DIFFERENCE OF AOM FROM BASELINE

	1980	1981	1982	1983	1984	1985	1990*
PERCENTAGE DIFFERENCE							
NEW CAR SALES	-3.241	-3.977	0.372	-0.007	-0.090	0.150	-0.636
DOMESTIC REVENUES	-0.810	1.012	5.611	5.221	5.190	5.450	4.254
FOREIGN REVENUES	-0.606	1.486	6.234	5.902	6.042	6.350	5.245
AVG. COST-PER-MILE	0.796	2.231	2.255	2.282	2.323	2.339	2.191
TOTAL GAS CONSUMPTION	-0.217	-0.819	-1.361	-1.452	-1.560	-1.724	-1.847
EMPLOYMENT--AUTO INDUSTRY	-1.496	-2.433	-1.002	-0.501	-0.308	-0.118	-0.432
UNIT DIFFERENCE							
SUBCOMPACT SHARE	-0.000	-0.000	0.000	0.000	0.001	0.001	0.001
COMPACT SHARE	0.005	0.009	0.008	0.008	0.007	0.007	0.006
MID-SIZE SHARE	0.000	-0.000	0.000	0.000	0.000	0.000	0.003
FULL-SIZE SHARE	-0.005	-0.009	-0.009	-0.008	-0.008	-0.008	-0.009
LUXURY SHARE	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL DOMESTIC SHARE	-0.000	-0.000	-0.000	-0.001	-0.001	-0.001	-0.001
MOBILE SOURCE COST/NEW CAR (77-I $)	111.425	259.155	259.308	259.202	259.417	259.545	241.512
INC. GASOLINE COST/NEW CAR (77-I $)	-78.194	-79.347	-77.841	-75.770	-74.112	-72.671	-70.345
TOT. ABATEMENT COST/NEW CAR(77-I $)	85.413	295.756	300.475	305.026	311.665	314.293	290.404
TOTAL FLEET IN-USE MPG	0.000	0.034	0.068	0.110	0.166	0.216	0.405
DOMESTIC NEW FLEET EPA MPG	0.410	0.453	0.471	0.491	0.511	0.520	0.602
GM GROSS OPERATING MARGIN	-0.301	-0.657	-0.057	-0.190	-0.320	-0.266	-0.209
FORD GROSS OPERATING MARGIN	-0.397	-0.600	-0.025	-0.167	-0.290	-0.239	-0.260
CHRYSLER GROSS OPERATING MARGIN	-0.272	-0.416	0.000	-0.043	-0.151	-0.111	-0.133
AM GROSS OPERATING MARGIN	-0.298	-0.399	0.320	0.133	-0.027	0.026	0.007

*1990 VALUES OF GROSS OPERATING MARGINS ARE IN ACTUALITY 1988 VALUES.

Source: Kearney 1978, Part III, Table E-2 drops to 1.0% below the baseline case, even though sales are .4% higher than the baseline case. After 1982, the long-run impact of new car sales dominates the employment forecasts and is relatively minor.

4. **Size-class Market Shares**

Trading down occurs as the capitalized cost per mile increases. The extent of the trading down is minor; at the most the shares change by .9 percentage points, or less than 5%. The reasonability of such minor changes is difficult to evaluate. However, as noted previously, the reliability of the market shares forecasts is not high, which leads the HSRI staff to have serious reservations about these results.

5. **Total Fleet In-Use MPG**

As expected, the impact of the regulatory scenario on MPG is very gradual and increases over the long run due to both the absorption of new cars with higher MPG than the baseline and the trading down that occurs relative to the baseline. The impact in the long run is again dependent on the size-class market shares forecasts.

6. **Operating Margins of Firms**

The impact of regulations on profitability margins is minor. AMC is shown to have some slight profitability increases due to the regulations, while Chrysler is shown to have negative profitability margins in 1981, 1984, and 1985 because of the EPA regulations. Conclusions drawn on these results are subject to error. In addition to misspecification, the profitability equations as estimated by Kearney have relatively high standard errors of regression. This indicates that the levels of profitability as forecast by the Wharton-Kearney model are not precise. Therefore, the conclusion that a firm may be in a loss situation because of the regulations could be drawn, but it would be unwarranted. On the other hand, a firm forecast to be earning a profit may actually be in a loss situation. This is not well explained in the Kearney report.

5.0 FINDINGS

The HSRI review of a portion of the A. T. Kearney analysis that was based on exercising the Wharton-Kearney model produced the following major findings.

- Kearney modified the Wharton EFA auto model to forecast the effects of EPA regulations on new car sales, size-class market shares, gasoline consumption, the profitability of AMC, Chrysler, Ford, and GM, and automobile industry employment. These modifications provided innovative additional capabilities to the Wharton EFA auto model. However, the Kearney's profitability and employment equations were poorly specified as a result of simplifying assumptions.
- While the Kearney analysis in its draft form contains an informative description of the motor vehicle transportation industry, it fails to adequately (1) explain the Kearney modifications of the Wharton EFA auto model, (2) detail the limitations of the Wharton EFA auto model, and (3) interpret the forecasts of the Wharton-Kearney model simulations.
- The Kearney modifications to the Wharton EFA auto demand model did not correct any of the serious weaknesses of the original Wharton EFA auto model with regard to policy applications. Furthermore, the Kearney additions of the profitability and automobile industry employment equations have weaknesses that detract from the limited benefits achieved by the inclusion of those equations. This policy application of the Wharton EFA auto model relies heavily upon that model's cost and price elasticities and its representation of the determinants of market shares. However, these characteristics of the Wharton EFA auto model are its major deficiency in policy applications. Therefore, the Wharton-Kearney model cannot be relied upon in policy analysis applications designed to estimate the economic impacts of environmental regulations.

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