UCI-ITS-WP-79-2

Sales of Imported Cars: A Model of State-to-State Variation

UCI-ITS-WP-79-2

Charles A. Lave
Joan Bradley
Joseph Gawzner
Jill Horikawa
Robert Steel
Robert Stratton
James Walker
Gregory Wetterson

School of Social Sciences and
Institute of Transportation Studies
University of California, Irvine

July 1979

Institute of Transportation Studies
University of California, Irvine
Irvine, CA 92697-3600, U.S.A.
http://www.its.uci.edu

SALES OF IMPORTED CARS: A MODEL OF STATE-TO-STATE VARIATION

Charles Lave, Joan Bradley,
Joseph Gawzner, Jill Horikawa, Robert Steel,
Robert Stratton, James Walker, and Gregory Wettersten*
School of Social Sciences
University of California
Irvine, CA 92717

May 1979

INTRODUCTION

Given our current shortage of petroleum there is a great deal of interest in conservation. It has been argued elsewhere that the single most effective means of reducing gasoline consumption is the promotion of fuel-efficient cars (Lave, 1 and 3). What are the factors which determine the sales of such fuel-efficient cars? For most of our recent history, "fuel efficient cars" and "imported cars" have been almost totally overlapping categories; hence a model of the relative market-share of imported cars, across states, can potentially tell us a good deal about ways of increasing the sales of fuel-efficient cars, whether they are imported or domestic in orgin.

This paper explains the market penetration of imported cars in the 1975 new car market; variables are the demographic and geographic characteristics of the state. Our model explains 92% of the variation in

---

*Research for this project was supported, in part, by a grant from Oak Ridge National Laboratory.

market shares across states, and all of the regression coefficients are significant and have the expected signs. The largest single explanatory factor appears to be variation in marketing effort by the import manufacturers. The next most important factor, though considerably less powerful, is the relative education level in the state. Both factors, marketing effort and education, have strong positive effects on market share.

THE INITIAL MODEL

Our initial model is summarized in Figure 1. The signs indicate the expected slope of the relationship.

Family Size: We know from the previous literature on automobile choice that family size ought to have a negative relationship to the demand for imported cars--the average import is a small car, and large families need more carrying capacity.

Education: Education has an indirect effect on car choice through its effect on income. We also expected a positive direct effect because of the effect that education has on people's values. The year we are looking at is 1975, shortly after the OPEC oil embargo, and the resultant emphasis on declining energy supplies. We would expect that educated people would be most aware of these ideas, and also that the major constituency for the environmental movement lies among the most educated portion of the population. Hence we expect that increased education would increase the odds of buying a small, fuel-efficient imported car.

We also know that people often buy possessions as a symbol of their political attitudes, and an automobile is one of the most visible of all symbols. Since there is some tendency for education to lead to anti-establishment sentiments, it seems possible that this might raise the odds of an educated person buying a foreign car. We are not saying that all educated people are anti-establishment, or pro-environmental, or concerned about energy problems. What we are saying is that, holding the income consequences of education constant, there is a tendency for these kinds of values to go along with increased education and hence to increase the odds of buying a foreign car. (The disaggregate auto-choice model of Lave and Train, 2, showed a very strong negative relationship between education and the size of the car purchased.)

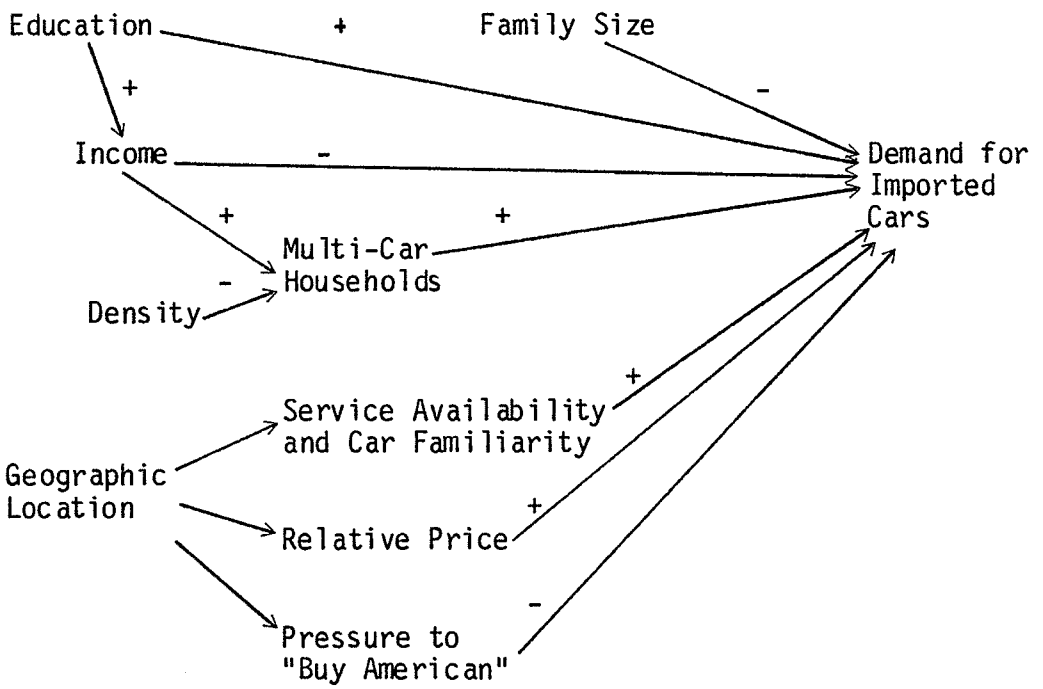


Figure 1: Determinants of Import Demand

Income: We expect income to have a negative direct effect and a positive indirect effect on the chances of purchasing an imported car. The negative direct effect is simply a reflection of the lower price of imported cars, in 1975, relative to domestic cars. All imported cars were not inexpensive, but the average new foreign car was cheaper than the average new domestic car. The positive indirect effect comes about because higher incomes tend to lead to a greater number of cars per household.

Multi-Car Households: The positive relationship between cars per household and the chances of buying a small car has been supported empirically by Lave and Train (2), and by Leape (4). And the theoretical reasoning behind the relationship is straightforward: a family uses a car for a variety of hauling tasks, if it has only one car then it must be a car large enough to take care of the largest hauling task the family generates, but if the family has many cars it can afford to buy some special purpose vehicles, e.g., a car to carry one person to work or shop. That is, a one-car household must own a general purpose, utility vehicle; a multi-car household has the option of buying cars to serve more specialized purposes. Hence, other factors being equal, the more cars per household the greater the chance they will buy a small car, and this increases their chance of buying an imported car.

Density: We refer here to population density, and we expect to find a negative effect between population density and the number of cars per household for two reasons: 1. dense cities tend to have good transit service. In turn, this means that the necessity for a family to purchase

a second or third car is reduced. 2. The increased difficulty and expense of parking in dense cities make extra cars less desirable.

Geographic Location: A family's gross geographic location, the state where they live, has important consequences for the kind of car they will buy. Location affects the relative price of imported cars, the relative availability of service for the car, and even the social pressure to buy a particular kind of car. We take up these factors below.

Service Availability, and Car Familiarity: Imagine that you were a Volkswagen dealer in 1955. People won't buy your car because it represents a new concept ("tiny car"), an unknown manufacturer, unknown reliability problems, and potential service problems if it breaks down far from your dealership. Thus, you cannot sell cars easily until you have sold enough of them: the first sales are very tough but they become progressively easier because your product becomes familiar and service availability spreads.

Hence, opening a new geographic market is very expensive for an importer and, once opened, the marginal return from a dollar's worth of extra effort will be higher in the existing location than in a new one. The end result is a concentration of imported car dealerships in coastal areas, and a greater probability of someone buying an imported car in these areas.

Relative Price: Destination charges on domestic cars tend to be low in the middle part of the U.S. and high on the coasts. Destination charges for imported cars tend to be low on the coast and become higher toward the center of the U.S. Thus the relative purchase price is a function of location and, in particular, imported cars enjoy a relative

price advantage on the coast, and hence we would expect to find a greater market share for them on the coast.

Pressure to "Buy American": We reasoned that there was likely to be more social pressure to buy domestic cars in those states where the auto industry played an important role in the state's economy, and this pressure will in turn decrease the market share of imports in those states.

OPERATIONALIZING THE MODEL

Table 1 shows the means and correlations of he variables used in the model.

%IMPS is the sales of new imported cars divided by the sales of all new cars, for each state, in 1975.

ECOAST and WCOAST are geographic location variables. They are coded as 1 for coastal states, 2 for the next inside tier of states, 3 for the tier inside of that, and 4 for all other states. Table 3 gives the details of the coding.

%CLLEGE is the percentage of people with at least one year of college education in the state. We reasoned that the effects of education are highly non-linear and that one year's worth of college was sufficient to produce most of the expected effects.

%C.A/P is the percentage of U.S.-built cars assembled in the state, divided by the state population. The numerator is a rough measure of the value of auto production in that state, and dividing by population standardizes this number to give a better idea of the importance of auto production to the state's economy. This operationalization is somewhat rough since a percentage point of auto-assembly in Michigan involves much

STATISTICS FOR CASES TO BE USED IN REGRESSION

VARIABLE		MEAN	STD DEV (%MEAN)	MINIMUM VALUE	MAXIMUM VALUE
%IMPS	1	.1954	41.	.6436E-01	.3888
ECOAST	2	2.720	50.	1.000	4.000
WCOAST	3	3.460	28.	1.000	4.000
%CLLGE	4	21.76	21.	14.00	32.00
%C.A/P	5	.4104E-02	265.	.0000	.6364E-01
$/PER	6	5665.	16.	4041.	8815.
$/PER2	7	.3291E 08	34.	.1633E 08	.7770E 08
%P<5.5	8	7.722	12.	6.300	11.20
%2+3.C	9	.3111	17.	.1170	.4069
POP%UR	10	36.44	45.	9.000	100.0

CORRELATION MATRIX

%IMPS	1	1.00								
ECOAST	2	.06	1.00							
WCOAST	3	-.79	-.53	1.00						
%CLLGE	4	.71	.29	-.64	1.00					
%C.A/P	5	-.26	-.13	.19	-.07	1.00				
$/PER	6	.29	-.06	-.23	.51	.21	1.00			
$/PER2	7	.30	-.05	-.25	.50	.19	.99	1.00		
%P<5.5	8	.13	.40	-.39	.16	-.11	-.30	-.23	1.00	
%2+3.C	9	.12	.26	-.23	.07	.23	-.13	-.18	.05	1.00
POP%UR	10	-.01	.05	-.08	.28	-.07	.38	.35	-.23	-.11	1.00
		1 %IMPS	2 ECOAST	3 WCOAST	4 %CLLGE	5 %C.A/P	6 $/PER	7 $/PER2	8 %P<5.5	9 %2+3.C	10 POP%UR

TABLE 1: Means and Correlations of the Data

Coding For "ECOAST" Variable

"1"	"2"	"3"	"4"	"4"
Maine	W. Virginia	Michigan	Washington	Oregon
Vermont	Kentucky	Indiana	California	Alaska
N. Hamp.	Kentucky	Ohio	Nevada	Idaho
Mass.	Alabama	Wisconsin	Utah	Arizona
Rhode I.	Tennessee	Illinois	Montana	Wyoming
New York		Mississippi	Colorado	N. Mexico
Penn.			N. Dakota	S. Dakota
Conn.			Nebraska	Kansas
N. Jersey			Oklahoma	Texas
Delaware			Minn.	Iowa
D.C.			Arkansas	Louisiana
Virginia			Missouri	
N. Carol.				
S. Carol.				
Georgia				
Florida				
Maryland				

Coding For "WCOAST" Variable

"1"	"2"	"3"	"4"	"4"
Washington	Idaho	Montana	Alabama	Arkansas
Oregon	Nevada	Wyoming	Conn.	Delaware
California	Utah	N. Mexico	D.C.	Florida
Alaska	Arizona	Texas	Georgia	Illinois
	Colorado		Indiana	Iowa
			Kansas	Kentucky
			Louisiana	Maine
			Maryland	Mass.
			Michigan	Minn.
			Miss.	Missouri
			Nebraska	N. Hamp.
			N. Jersey	New York
			N. Carol.	S. Carol.
			N. Dakota	S. Dakota
			Ohio	Oklahoma
			Penn.	R. Island
			Tennessee	Vermont
			Virginia	W. Virginia
			Wisconsin	

TABLE 2: Coding of Coastal Variables

more value-added than a percentage point of auto-assembly in, say, California. (The parts to be assembled in California were mostly manufactured in Michigan.) Hence this variable will understate the relative importance of auto assembly to Michigan.

$/PER is state income divided by state population.

$/PER2 is (income/person)^2; and will be used to fit a non-linear relationship.

%P<5 is the percentage of the state's population which is less than five years old; and is used as a measure of family size.

%2+3.C is the percentage of families in the state that own at least 2 cars.

POP%UR is a measure of urban density. It is the number of people who live in cities larger than 25,000 people, divided by total population. We would have preferred some kind of measure of average central city density, but this was the closest we could come to it. However, since the large cities will dominate the average population, this variable will essentially measure the proportion of the population that lives in large cities.

We decided to eliminate Hawaii from the sample; it is quite different from the other states and we do not have any variables that might standardize for the difference. For example, all cars must come to Hawaii via boat, hence the relative price of domestics to imports will be quite different than the relative price elsewhere in the U.S. Furthermore, since the general history and customs of the area are quite different, it

seems reasonable to expect that Hawaiians would be more favorable to foreign cars.

After some experimentation with the exact specification of the variables, we fitted the regression shown below. The overall fit, corrected for degrees of freedom, shows that we explained 92% of the variance in import shares among states, and the coefficients are reasonable. (The column "Regresn Coeff." shows the ordinary regression coefficients; "Beta" shows the standardized coefficients, which are a measure of relative importance; and "T Ratio" is the regression coefficient divided by its standard error and hence a t-value of 2.0 or greater is sufficient for customary significance levels.)

R.SQ= .920 DEP.VAR= 1, %IMPS

	VARIABLE	REGRESN COEFF.	"T" RATIO	BETA
2	ECOAST	-.247E-01	8.2	.42
3	WCOAST	-.633E-01	11.5	.77
4	%CLLGE	.905E-02	7.5	.51
5	%C.A/P	-.971	2.8	.13
6	$/PER	-.189E-03	3.4	2.15
7	$/PER2	.144E-07	3.3	2.00
8	%P<5.5	-.285E-01	4.5	.33
9	%2+3.C	.196	2.3	.13
10	POP%UR	-.672E-03	2.9	.14

CONSTANT= 1.07 STD.ERR.EST.= .226E-01

All of the regression coefficients have the theoretically expected signs, all are statistically significant, and we were able to fit an

unusually detailed model. If we look at the beta coefficients we can see that the two coastal variables have the greatest influence on import shares, followed by the education variable. (The very large betas associated with income must be taken together since they come from two versions of the same variable. One is for a negative coefficient, and one is positive: if we add them together, -2.15 + 2.00, we get a net beta of .15.)

Conceptually, we might classify the variables into geographic factors (the coastal variables) and demographic factors (the other variables); and it is interesting to measure the relative strength of these two groups. Table 3 shows the results of using only one group of variables at a time. R^2 with the coastal variables alone was .794, and R^2 with the demographic variables alone was .636, thus indicating the importance of the geographic variables.

The Coastal Variables

The relative strength of the coastal variables came as a surprise and so we did a number of additional things to clarify this result. First we computed one further measure of relative importance, as follows. We created a single variable, GEOG, to combine the effects of both coastal variables by using the fitted regression weights, thus GEOG = -.0247(ECOAST) -.0633(WCOAST). And we also created a variable, DEMOG, using the fitted regression weights for the demographic variables. A regression of %IMPS on GEOG and DEMOG is then statistically identical to the original equation, but there will only be two betas (each summarizing the effect of many variables) and they can be compared directly.

EQUATION					*OTHER VARIABLES*					
R.SQ= .794 DEP.VAR= 1, %IMPS										
VARIABLE	REGRESN COEFF.	"T" RATIO	BETA		VARIABLE	"T" IF IN EQ.		VARIABLE	"T" IF IN EQ.	
2 ECOAST	-.290E-01	6.5	.49		4 %CLLGE	4.1		5 %C.A/P	-2.0	
					6 $/PER	.3		7 $/PER2	.3	
3 WCOAST	-.869E-01	13.8	1.05		8 %P<5.5	-1.4		9 %2+3.C	.0	
					10 POP%UR	-1.1				
CONSTANT= .575		STD.ERR.EST.= .364E-01								

GEOGRAPHIC FACTORS ALONE

EQUATION					*OTHER VARIABLES*					
R.SQ= .636 DEP.VAR= 1, %IMPS										
VARIABLE	REGRESN COEFF.	"T" RATIO	BETA		VARIABLE	"T" IF IN EQ.		VARIABLE	"T" IF IN EQ.	
4 %CLLGE	.156E-01	7.0	.87		2 ECOAST	-2.2		3 WCOAST	-5.7	
5 %C.A/P	-1.55	2.2	.21							
6 $/PER	-.363E-03	3.2	4.14							
7 $/PER2	.290E-07	3.2	4.03							
8 %P<5.5	-.363E-01	2.8	.42							
9 %2+3.C	.458	2.7	.29							
10 POP%UR	-.780E-03	1.6	.16							
CONSTANT= 1.13		STD.ERR.EST.= .484E-01								

DEMOGRAPHIC FACTORS ALONE

TABLE 3: Relative Explanatory Power of Variables

GEOG gets a beta of .65 and DEMOG gets a beta of .44, which is another indicator of the relative importance of the coastal variables.

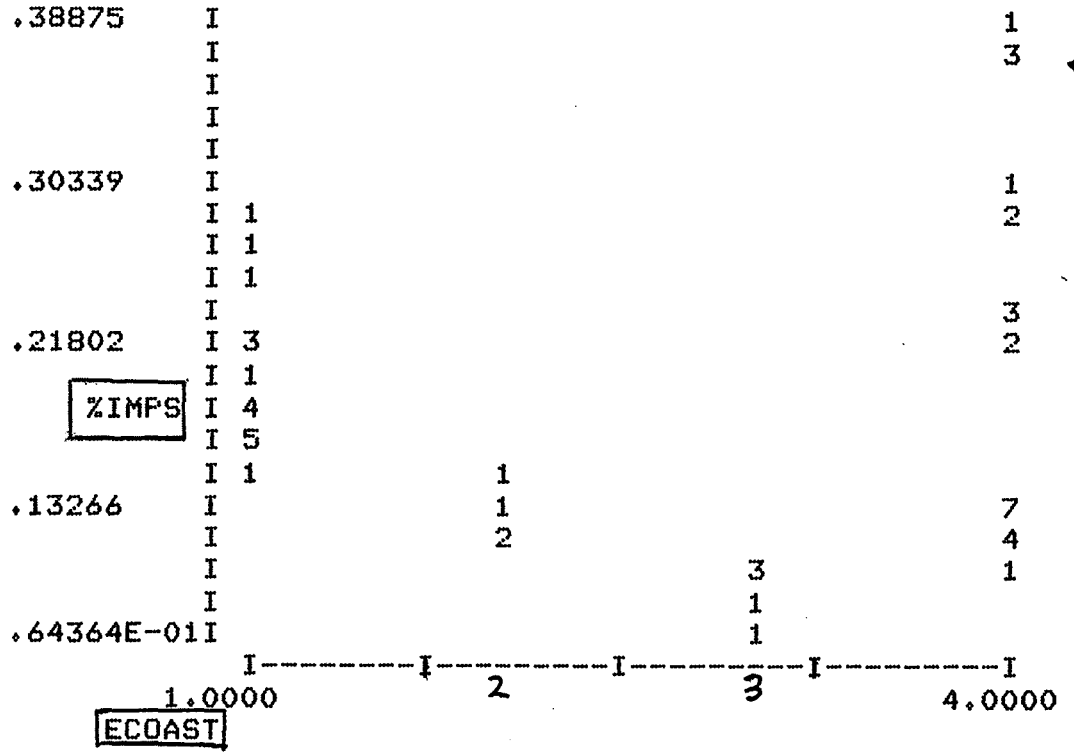
The estimated correlation coefficient between GEOG and DEMOG is .54, which is relatively high. Hence one reason that a regression based on the coastal variables alone can achieve an R^2 of .794 is that there is a good deal of correlation between the two sets of variables, and one set can partially substitute for the other.

Figure 2 plots the coastal variable against import market share. In both plots the strong linear relationship between %IMPS and the first three levels of the coastal variable is quite striking. (Level 4 of each coastal variable represents all the states that are more than three states distant from the coastline; thus some of the level 4 states in the ECOAST variable become level 1 states in the WCOAST variable, and vice versa.)

Why does the coastal variable play such an important role in the model? Figure 1 showed three possible factors that this variable might be modeling: relative prices of imports to domestics, pressure to buy American, and the effects of product familiarity and service availability.

The variable Percent-Autos-Assembled divided by Population was used as a proxy measure of the buy American factor and, to the extent that it is a reasonable proxy, it will hold this bottom path constant. Hence we believe that the strong effect of the coastal variables is not coming about through that source.

Perhaps it is the relative price effect which produces the strong coastal variable. If imports were much cheaper on the coast, and



"1 3" MEANS THERE ARE 3 STATES AT THIS POINT ON THE PLOT

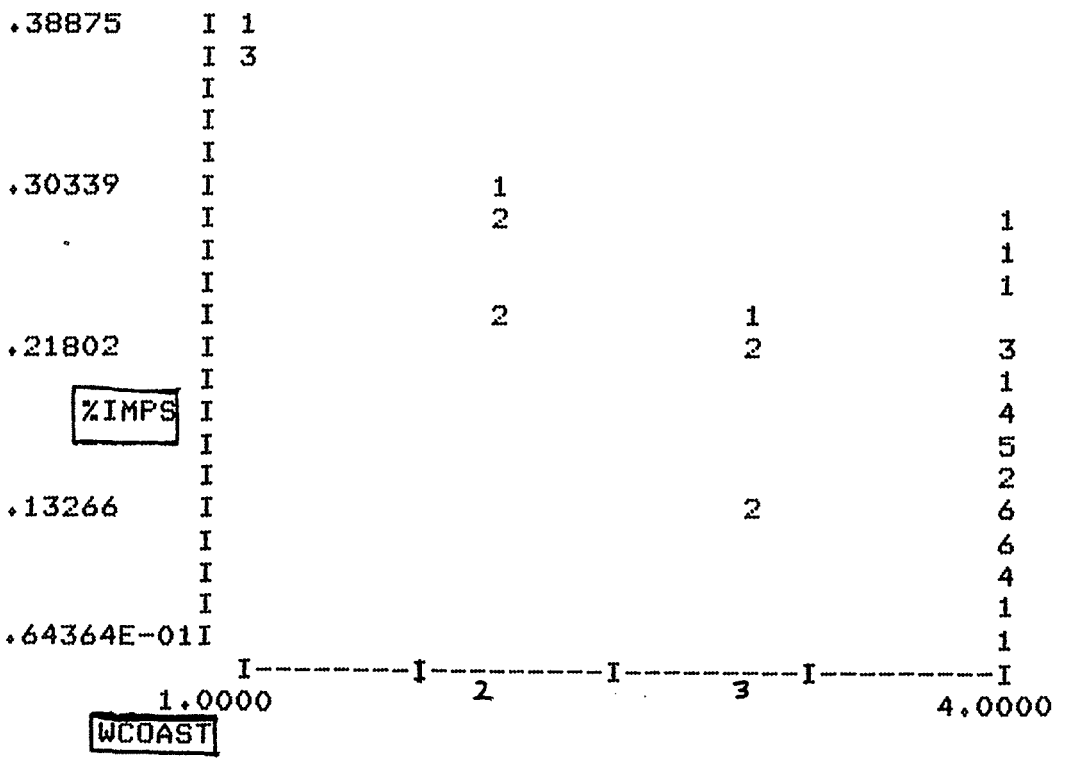


FIGURE 2: %IMPS Versus the Coastal Variables

domestics were much cheaper in the mid-west, then we would get a result like this. So we investigated actual destination charge patterns and found that domestic-compact cars are about a hundred dollars cheaper in the midwest than they are on the coast; while the most popular imports have an essentially flat price pattern across the country. Thus although the relative price profile does actually correspond to our hypothesis, it is difficult to believe that a difference this small could be a major factor in accounting for the strength of the coastal variables.

One might also hypothesize that what is really going on is that the people who live on the coasts have a higher level of international consciousness, are less insulated, etc. To get a rough test of this idea we constructed a new variable, GULF, which takes on the value 1 for gulf coast states and is 0 otherwise. If the Atlantic Coast and Pacific Coast variables were only working because of the side effects of international shipping, then the GULF variable would be expected to be significant also. It was not, and never obtained a t-value greater than .5, either by itself, or in the existing model, or in any modifications of the existing model.

Thus our explanation for the strength of the coastal variables comes down to: relative import shares are higher on the coasts because that is where the marketing effort has been concentrated. This will probably come as no surprise to those people who have a self-interest in marketing, but it certainly does surprise us. Further work on this question is clearly necessary. What we need is data on comparative advertising expenditures and number of dealers, by state, over time, so that this explanation might be checked in a more direct manner.

Non-Linear Income Variable

The final version of the model includes both \$/PER and $(\$/PER)^2$ with opposite signs. Figure 3 shows a plot of the resultant quadratic function. The vertical axis shows the probability of buying an imported car as a function of income per person. (It is calculated from the fitted regression weights, $P(Imp.) = -.000189(\$/PER) + .0000000144(\$/PER)^2$.) The great majority of the points lie along the negative sloping portion of the curve as we hypothesized; but two states lie along the portion of the curve which turns positive.

Why might the curve be turned upwards for these two states? What is different about them, aside from the fact that they have the highest incomes? Alaska has a very high import market share (only 1% less than California) and it is possible that the relative price explanation may actually be the relevant factor there. We do not have destination charge data for Alaska but it seems reasonable to expect that the destination charges on domestic cars would be much higher, while the destination charge on imported cars would be about the same as the rest of the west coast. Thus relative prices would be quite different and since this factor is not explicitly included in the model, the burden of compensation falls on the income variable.

For the District of Columbia it may be that the high income, itself, provides the relevant explanation. We predicted a negative relationship with income because imported cars were less expensive cars (in 1975), but there are also luxury imported cars that serve as status symbols. It is possible that the combination of the international population and high income lead to a disproportionate purchase of luxury imports in Washington.

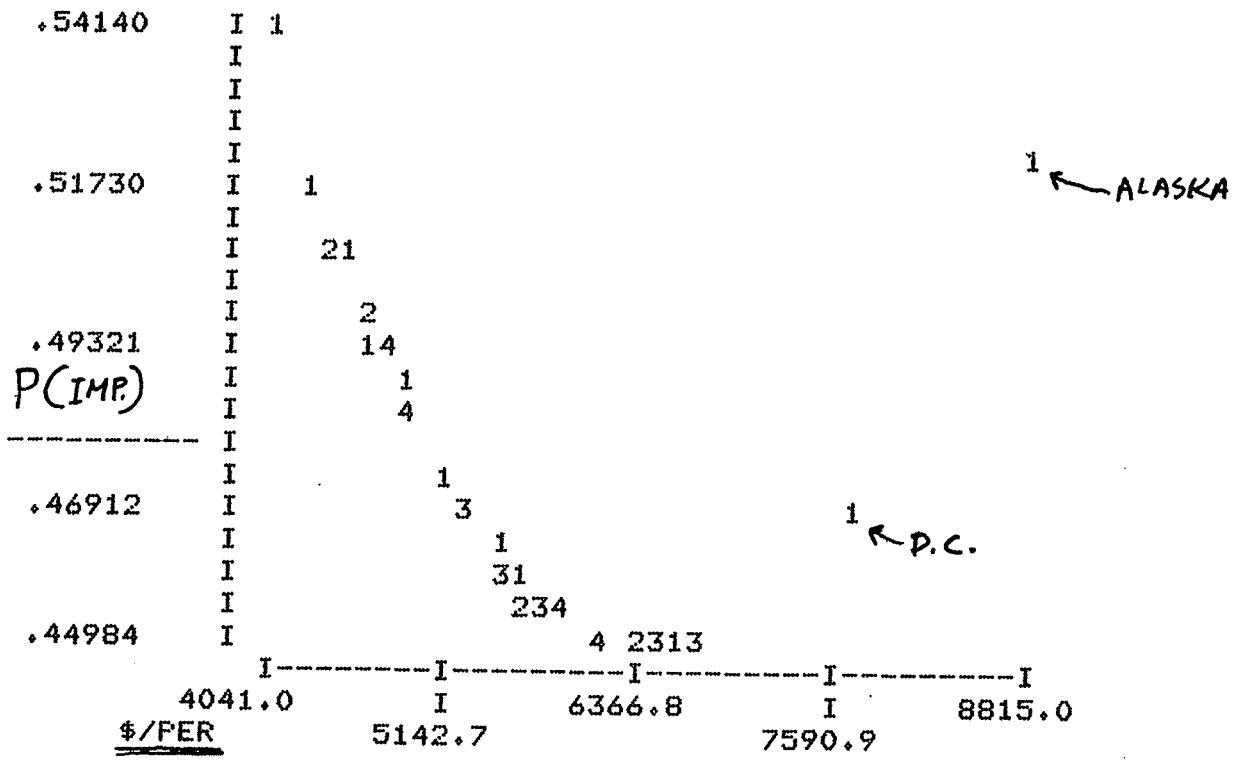


FIGURE 3: Probability of Purchasing-an-Import Versus Income

Of the two deviant states, our explanation of Alaska seems a good deal less ad hoc. In any event, there are some obvious data which would test our explanations: the actual destination charges of imports and domestic cars in Alaska, and the composition of the types of imported cars in Washington.

CONCLUSION

We have been able to fit an unusually detailed model, and we have explained a very high proportion of the variance in market shares. All of the variables had the theoretically expected signs and were statistically significant.

The two most important factors turned out to be the coastal variable (relative marketing-effort) and education, both of which had strong positive effects.

We queried executives at Datsun and Toyota to ask their explanation of why they sold so few cars in the middle part of the country, and their responses all boiled down to, "People in the mid-west seem to prefer large cars." We are skeptical of this explanation since the same thing could have been said about Californians twenty-five years ago, yet their preferences have changed. This paper has tentatively developed the concept of relative-marketing-effort to explain the observed differences. It is only an inference, since we lack the data to make a direct test of this idea.

However, if our tentative explanation is correct, it has a number of important consequences. First, it implies that if the importers were to make a substantial marketing effort in the mid-west, they would soon be

able to steal a major share of the market away from the domestic manufacturers. Second, it implies that a major marketing effort toward small cars by the domestic manufacturers would probably work.

If our analysis is correct, why haven't the importers undertaken such a marketing effort? There are a number of possible reasons: they may be reluctant to greatly increase their volume of imports to the U.S. because of political considerations; they may be reluctant to commit money to a major new marketing effort when the payoff to such investment is probably higher in the already developed areas; and they may be reluctant to undertake the risk of such an investment at a time when the domestic manufacturers are preparing a major small car effort of their own. As to the historical reluctance of the domestic manufacturers: first, there was initially the problem of developing a competitive car for a very small piece of the market (the payoff did not warrant the expense); and second, there was also the reluctance to undercut their own sales of full size cars, which are much more profitable; however all this may change given the need of the domestic manufacturers to meet the federally mandated Corporate Average Fuel Economy targets.

REFERENCES

1. Lave, Charles A. "Transportation and Energy: Some Current Myths." Policy Analysis, 4:3, Summer 1978.
2. Lave, Charles A. and Kenneth Train. "A Disaggregate Model of Auto-Type Choice." Transportation Research, 13a, February 1979.
3. Lave, Charles A. "Conservation of Energy in the Urban Passenger Sector: A General Principle and Some Proposals." In press for Transportation Research.
4. Leape, James. "An Analysis of the Demand for Automobiles." Unpublished honors thesis, Economics Department, Harvard University, August 1977.