3. The postal service would be required to provide a standard set of services in competition with a set of diverse and unstandardized offerings by other firms.

Considering factors such as these, it seems that a cooperative, rather than competitive, environment between government and the private sector would be the most appropriate solution.

As a general statement, however, the success of the system will depend ultimately on how readily society accepts it. While the system itself could bring about tremendous changes in the habits of people, businesses can be expected to be early adopters due to the greater value they place on the prompt communication of information. When a considerable number of private persons and businesses do not consider an electronic letter to be a proper substitute for a regular letter, the simultaneous existence of two parallel systems of communication might result. The likely impacts would be an increase in the cost and a reduction in the efficiency of regular letter-mail service.

Lee and Meyburg have mentioned a number of other important implications of the transportation-communications trade-off--specifically, the issues of privacy, liability, and capital-labor substitution. Among these, the issue of privacy might have the greatest impact on the implementation of the technology. Business and private persons might not readily accept human handling of their uncovered private letters. This problem could be alleviated by a high degree of automation in the handling of letters and by technological development that would ensure that only authorized persons would have access to the information contained in the letter. We will look forward to learning of future developments in this area.

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Abridgment

Estimation of Gasoline Price Elasticities for New Jersey

JOHN G. J. DeJONG

Gasoline price elasticities are useful in projecting vehicle miles of travel, gasoline use, and gasoline tax revenues. The two objectives of the study were (a) to develop a method for the estimation of two types of price elasticities of demand for travel by automobiles and (b) to arrive at empirical elasticities for a state. One-year and medium-term elasticities were estimated for New Jersey. Travel counts and real gasoline prices from 1972 to 1979 were correlated to determine the one-year and medium-term elasticity for New Jersey. The elasticities that resulted out of this correlation were compared with other elasticities in the literature. The estimated four-year elasticity conforms very well with the medium-term elasticities in the literature. Four scenario adjustments were used to represent the growth rate in travel as caused by factors other than the real gasoline price. The first scenario resulted in elasticity estimates that conformed to the best of those in the literature: a four-year elasticity of -0.28 and a one-year elasticity of -0.14.

The purpose of the study was to develop a one-year and a four-year elasticity of demand for travel by automobiles. A price elasticity of demand for travel is defined as the change in the quantity of automobile miles demanded in response to a change in the gasoline price. Vehicle travel counts and real gasoline prices in New Jersey for each month from 1972 to 1979 were correlated to determine a one-year and a four-year elasticity for New Jersey. By comparing two of the same months with four years in between, or two of the same months in two consecutive years, a large number of elasticity estimates were arrived at and can be used in calculating an average elasticity estimate.

Four travel growth scenarios were used to adjust for the factors, other than the gasoline price, that affect miles of travel. An adjustment was made to determine how the quantity of miles traveled is affected by price changes only. A scenario approach was taken because it is not exactly known how much of the growth in vehicle miles of travel (VMT) is caused by factors other than a changing real gasoline price.

This paper will focus mainly on the methods used to estimate the one-year and the medium-term elasticities.

METHODOLOGY

Traffic volumes of 30 permanent counting stations on the major highways of New Jersey were used as a measure for VMT on these highways. Miles traveled by diesel-powered vehicles were not subtracted from the vehicle volume data. It was felt that the subtraction of vehicle counts for diesel-powered vehicles is not very relevant in developing an estimate for a price elasticity because most diesel vehicles are trucks and truck use is not significantly affected by fuel price increases. This means, however, that the elasticity estimates arrived at in this paper are probably somewhat low in absolute terms because the percentage change in quantity is somewhat larger when truck travel is taken out.

Monthly vehicle-volume data of 30 permanent counting stations were taken out of the Annual Traffic Count Summaries for 1972 through 1979, which are published by the New Jersey Department of Transportation (NJDOT).

The calculations for the individual elasticity estimates were done by computer. A price elasticity of demand represents the reaction of consumers to a change in price in the form of a change in the quantity demanded. The basic formula for a price elasticity is the change in quantity divided by the change in price. If the period in between the two quantities and the two prices is one year, it is a one-year elasticity. During one year, the fleet miles per gallon cannot change very much so that the price elasticity of demand for travel is equal to the price elasticity of demand for fuel.

The basic formula was adjusted to take into consideration the factors that historically have increased travel on major highways in New Jersey (e.g., increasing real per capita income, population, and supply of road facilities). A similar type of adjustment was made when Curry, Scott, Piske, and Scardino (1) calculated their expected quantity. They defined expected quantity as the quantity of travel that would have taken place if there would not have been an oil-supply crisis. The adjusted formula is

$$[(q_2 - q_1)/(q_1) - (\text{adjustment})]/(P_2 - P_1)/(P_1) \quad (1)$$

where q is the quantity of travel and p is the real price of gasoline.

The variable adjustment was made in the form of scenarios so that they can be evaluated by the reader. An upper limit for the adjustment was arrived at by calculating the average annual rate of change in VMT (VMT as a proxy for traffic counts) on New Jersey's highways from 1957 through 1972: 4.55 percent annual growth (as calculated by the NJDOT Bureau of Data Resources). This is an upper limit because one of the factors that has increased travel from 1957 through 1972 is a declining real price of gasoline. The lower limit of a 3 percent adjustment is arrived at by following the rule of thumb that total VMT on all roads is increased by about 3 percent up until 1972. This was an attempt to quantify the relation between real price and automobile travel; thus, all extraneous factors, other than a changing gasoline price, that have historically increased miles of automobile travel were deleted. Four scenarios, with 0.03, 0.035, 0.04, and 0.045 as adjustments, were used to calculate four different one-year elasticity estimates. Three four-year elasticity estimates were calculated with the three scenarios of a 0.03, 0.035, and 0.04 adjustment.

The effect of gasoline availability problems has to be taken out in an analysis that quantifies the relation between price and the quantity demanded. For this reason, months in which the governor of New Jersey had announced gasoline rationing (by means of odd and even license numbers) were eliminated. Odd-even rationing started officially on February 11, 1974, and ended in March. To take into consideration the possibility that the governor reacted late in imposing rationing and to take out the effect of an after shock of the oil crunch on fuel use, data for the months of October 1973 through June 1974 were eliminated. Similarly, data from March through October 1979 were eliminated.

AVERAGE FOUR-YEAR ELASTICITY ESTIMATE

After estimating the individual elasticities it was found that the four-year estimates were distributed closely together, while the one-year estimates had several outliers in the tails of a normal distribution graph. A moving average in calculating the four-year elasticity estimates was used with the thought that the moving average would take away minor fluctuations and would arrive at an underlying trend in the elasticity estimates (based on data from 1972 to 1979). An average four-year elasticity was calculated by using a three-month moving average. For example, the quantity of vehicles counted during January, February, and March 1976 was compared with the quantity during January, February, and March 1972.

AVERAGE ONE-YEAR ELASTICITY ESTIMATE

Another method was used to estimate the average one-year elasticity. Because the use of a moving average would create interdependencies among the individual elasticity estimates, which would prevent the use of a statistical method to exclude outliers, straight elasticities were used to calculate an average one-year elasticity estimate. Straight means that the quantity and price of a particular month were compared with the quantity and price of the same month in the next year. In contrast to the price changes during four years, the price changes during one year were sometimes very small. It might be that the price data that are used in the denominator are not expressed at the right level of precision. Price data have one decimal place, while quantity is in tens of thousands of vehicles. Sometimes, the resulting elasticity estimates are very large in absolute terms because of the very small price changes, even though the quantity change is moderate.

The average one-year elasticity estimate is calculated by adding a number of individual elasticities. Then it is divided by that number of elasticities.

If the frequency distribution for the individual elasticity estimates is plotted, an approximately normal distribution is produced: There is a central tendency about the mean and a portion of the values falls into the two tails. An average elasticity that includes observations in these tails may be unduly influenced by the magnitude of these relative infrequent tail values. The primary reason that

Figure 1. Total frequency distribution for individual one-year elasticity estimates in 0.03 travel growth scenario.

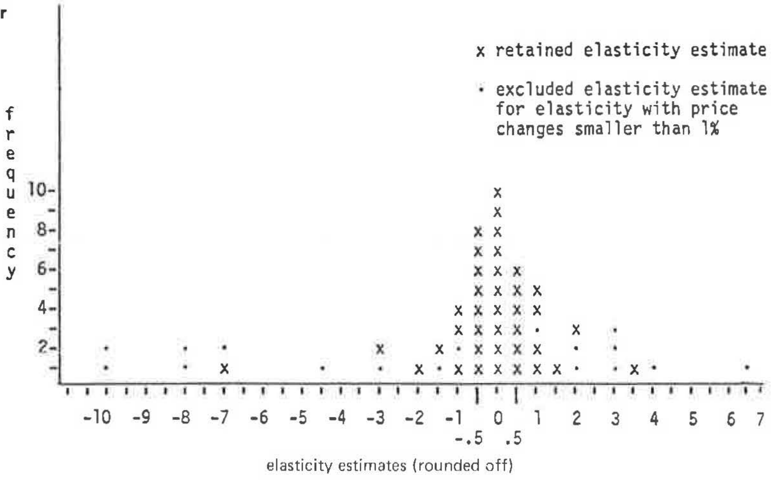

Table 1. One-year elasticity estimates based on four scenarios for background growth in miles traveled.

Adjustment Scenario	No. of Elasticities	No. of Elasticities Between -0.35 and -0.15	Range of Elasticity Estimates Without Screening	Average One-Year Elasticity Estimate
0.03	36	6	-10.17 to 6.53	(-4.988/32) = -0.14
0.035	33	7	-4.53 to 14.77	0.165
0.04	32	5	-5.36 to 16.83	(4.103/32) = 0.128
0.045	31	5	-6.2 to 18.8	0.084

Table 2. Four-year elasticity estimates based on three different scenarios for background growth adjustment.

Adjustment Scenario	No. of Elasticities	No. of Elasticities Between -0.45 and -0.25	Range of Elasticity Estimates	Average Elasticity Estimate
0.03	29	5	-1.72 to 0.217	-0.284
0.035	29	11	-6.57 to 1.14	-0.431
0.04	29	7	-11.77 to 3.38	-0.590

these values exist is attributable to the characteristic of a quotient and the fact that there are a number of one-year elasticity estimates with a very small price change. For this reason elasticity estimates with a price change smaller than 1 percent were excluded in estimating the average one-year elasticity. After excluding these elasticity estimates, there were still some suspect tail values.

The following might help the reader to appreciate the sensitivity of the elasticity ratios and further explain why a judgmental procedure was followed to exclude more quotients. The elasticity estimates are actually variables that are used to estimate the true value of the population elasticity parameters. These estimates have a distribution about the true population parameter; this suggests that a statistical technique could be used to detect the presence of outliers. In fact, direct analytical outlier detection of a ratio distribution must be approximated and can only be done if both numerator and denominator have a small coefficient of variation, i.e., if the standard deviation of the denominator (or numerator) is small relative to the mean (2). This requirement was not met by the data on hand, so an alternative, but more judgmental, procedure was followed. Because a statistical method, like a confidence interval analysis, could not be used, all elasticities of an absolute magnitude of 3.0 or more were excluded as outliers. Real-world observations of New Jersey drivers tend to support this exclusion since their reaction as a group was not very strong to gasoline price changes in the short term. A final common-sense reason for the latter exclusion is that, if the few large quotients are included in the calculation of the average elasticity estimate, they would totally overshadow the majority of the elasticity estimates that are in between -1.5 and +1.5.

As shown in Figure 1, the primary cause for excluding some estimated values was a very small change in the reported prices. Table 1 presents information about the individual elasticities used in the estimation of the average one-year elasticity.

RESULTS

One-year elasticities are expected to be lower in absolute terms than medium-term price elasticities of demand because people have had more time to react to the price change. The estimates for the one-year elasticities are presented in Table 1.

The change in sign of the average elasticity estimate going from the 0.03 scenario to the 0.035 scenario is a result of having a quantity change that becomes negative while the real price change is negative in both the 0.03 and the 0.035 scenarios. A declining quantity correlated to a declining real gasoline price results in a positive individual and sometimes positive average elasticity estimate.

Not one of the four elasticity estimates in column 5 of Table 1 conforms perfectly to the elasticities in the literature. Brookhaven National Laboratory reports that the estimates for a three-month gasoline price elasticity of demand for gasoline is in the range of -0.07 to -0.14 (3). One-year elasticities can be expected to be higher. Altshuler reviewed the literature and found that the range for one-year price elasticities of demand for gasoline is -0.2 to -0.3 (4).

The four-year elasticity estimates conformed very well to the elasticities in the literature (see Table 2). The reader can choose the most reasonable scenario from the three that follow.

Medium-term elasticities are expected to be larger in absolute terms than one-year elasticities. Column 5 of Table 2 conforms to this expectation. Green of Oak Ridge National Laboratory studied 1966-through-1975 gasoline consumption and estimated the medium-term gasoline price elasticity to be -0.34 (5).

Both the one-year and the four-year elasticity estimates of scenario one conform the best to the findings in the literature. The four-year elasticity for New Jersey appears to be on a better methodological base than the one-year elasticity estimate. The four-year elasticity estimate of -0.28 means that with a 10 percent increase in the real price, automobile travel in New Jersey decreases by 2.8 percent.

FUTURE RESEARCH

Further research on the question of how the estimation method of this type of one-year elasticity can be improved is desirable. As noted above, taking out truck travel will result in a more correct and higher elasticity estimate in absolute terms.

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Land Use and Energy Intensity

HERBERT S. LEVINSON AND HARRY E. STRATE

This paper summarizes the energy implications of urban land use in the metropolitan Toronto area. It identifies the transportation and nontransportation energy intensities of various land uses, assesses the effects of population density on energy consumption, and suggests measures to improve energy efficiency. The annual energy requirements of various land uses, including transportation energy, were manufacturing, 40 percent; residential, 35 percent; commercial, 19 percent; and other, 6 percent. The total annual energy consumption of various types of residential development was computed by adding the annual transportation energy consumed to the annual energy required to build and operate buildings. Composite annual energy requirements were single-family attached—504 000 MJ/unit; single-family detached—376 000 MJ/unit; walk-up apartment—284 000 MJ/unit; and high-rise apartment—216 000 MJ/unit. Single-family residences consumed 50 percent more energy than did apartments on a per-unit basis. However, on a per-capita basis, apartments were found to be only 15 percent more efficient. Better land use planning to encourage compact urban development, increase residential densities, balance jobs and people, expand transit ridership, encourage ridesharing, and reduce per-capita space requirements would improve energy efficiency. These are desirable actions, especially in rapidly growing metropolitan areas. However, they appear difficult to achieve in view of public preferences and the incremental nature of implementing land use plans. Consequently, the greatest near-term gain in energy conservation probably will come from improving the operating energy efficiency of existing and new buildings and from improving transportation energy efficiency.

This paper summarizes the energy implications of urban land use in the metropolitan Toronto area (1). It overviews the state of the art, identifies the direct and indirect transportation and nontransportation energy intensities of various land uses, assesses the effects of population density on energy consumption patterns, and suggests measures to improve energy efficiency. It is based on a review of travel behavior and energy data for both Canada and the United States.

Much has been written on urban form, transportation, energy, and density; yet, many key parameters have not been quantified. There are differences of opinion among analysts regarding the effects of development density on energy consumption. Accordingly, the paper addresses two basic areas: (a) What are the energy requirements of various types of urban land? and (b) how does development density affect both transportation and nontransportation energy consumption?

STATE OF THE ART

The specific building factors that influence energy consumption include construction techniques, exposed surfaces, exposed surface-to-volume ratio, heating and cooling systems, insulation and fenestration, and climatological characteristics. However, most studies relate energy consumption to building types, age, and density, which may obscure many valid causative relationships. For example, a poorly insulated high-rise luxury apartment with spacious units may consume more energy per dwelling unit, per capita, or even per square foot, than a medium-density development of the same number of units per acre (2).

More study has been done of patterns of residential energy consumption than any other land use segment, and many of these findings are applicable to other land uses, such as commercial. For example, the cube minimizes the surface-to-volume ratio, thereby reducing heat-transfer potential; another example, shared walls, can reduce per unit energy