Transport Gasoline Demand In Canada

By M. Nagy Eltony*

1. Introduction

Few studies have estimated gasoline demand in Canada. Most of these studies have either failed to recognise all the ways in which consumers can react to gasoline price changes or have implemented pre-1973 data which did not provide good estimates of price elasticities (Dewees et al., 1975; Dahl, 1978; Shalaby and Waghmare, 1980).

Some models attempt to estimate the components of gasoline demand using aggregated data (Gallini 1983; Dahl 1982). The problem with these models is that they do not identify the relationship between the household decisions on vehicle holdings and on usage. These two decisions are likely to be dependent; the use of a vehicle depends on its type and the type of vehicle chosen depends on its expected use. Since these decisions are made within the household, household data should be used for estimating the various components of gasoline demand.

This paper provides an estimate of household gasoline demand in Canada by applying a detailed model to pooled time-series (1969-1988) and cross-sectional provincial data. The model recognises three major behavioural changes that households can make in response to gasoline price changes: drive fewer miles, purchase fewer cars, and buy more fuel-efficient vehicles.

In the model, fuel economy is treated in considerable detail. The two components of the fuel economy of new cars sold — the technical fuel efficiency of various classes of cars and the distribution of new car sales according to their interior volume rather than their weight — are estimated as functions of economic variables. Car manufacturers are assumed to improve the technical fuel economy according to their expectation of consumers’ response to future changes in gasoline prices and general economic conditions.

The next three sections of this paper discuss the model, the data, and the estimation results respectively. The conclusions are presented in the final section.

2. The Model

The model presented in this study is of the investment-utilisation type. The basic identity for aggregate gasoline demand in the model, $AG$, is given by

$$AG = MS \cdot S \cdot E$$

* Assistant Professor, College of Commerce and Economics, Kuwait University.
where:

\[ MS = \text{miles driven per car (vehicle miles)}; \]
\[ S = \text{total cars in the fleet}; \]
\[ E = \text{average fuel economy of the fleet (miles/gallon)}. \]

This model has its theoretical basis in the household production literature, that is, Becker (1965), Lancaster (1966), and Pollack and Wachter (1975).

**The gasoline per car equation**

Following the convention of earlier models, the household demand for gasoline is modelled as the outcome of a utility-maximisation, conditional on vehicle choice. The solution of such a model yields:

\[ GS = g(Pg/e, YH, UN) \cdot E \]  
(1)

which gives the gasoline consumed per car (GS), where:

\[ GS = MS \cdot E \]  
(vehicle miles × miles per gallon);

\[ Pg/e = \text{price of gasoline per mile, which is the outcome of the price of gasoline per gallon divided by the fuel efficiency given in terms of miles per gallon}; \]

\[ YH = \text{household disposable income}; \]
\[ UN = \text{unemployment rate}. \]

Furthermore, previous studies have utilised a number of demographic variables. The following demographic variables are included in the model: the percentage of population of driving age (16-65) (POP), and the number of cars per household (AH).

Then, the log-linear relationship for equation (1) can be written as:

\[ \ln GS = A + B1 \ln Pg/e + B2 \ln YH + B3 \ln UN + B4 \ln AH + B5 \ln E \]  
(2)

**The stock of cars per household equation**

In the literature, the lagged values of the stock of cars, along with the cost of gasoline per mile and the average price of new cars, have been used as explanatory variables for the stock holding decision. Also, an income per household variable, YH, and the percentage of population of driving age, POP, are all utilised.

The basic equation for estimating the car holdings per household is given as:

\[ (S/H) = g[Pn, Pg, (S/H)_{t-1}, YH, POP] \]  
(3)

where:

\[ S/H = \text{stock of cars per household or (s)}; \]
\[ Pn = \text{price of new cars}; \]
\[ Pg = \text{price of gasoline per gallon}. \]

The log-linear functional form will be:

\[ \ln s = C + D1 \ln Pn + D2 \ln Pg + D3 \ln YH + D4 \ln s_{t-1} + D5 \ln POP \]  
(4)

**The new car sales per household equation**

In this sub-section, the household’s decision to buy a new car is modelled. The basic relationship is given by:
Transport Gasoline Demand in Canada

\[ (NR/H) = f(P_n, P_{g/e}, YH, UN) \]  

where \( NR/H \) = new car sales per household or (nr).

However, since strikes in the car industry may delay the purchase of a new vehicle, a variable which represents the man-days lost in the car industry due to strikes, \( ST \), is included. Assuming a log-linear functional form, equation (5) gives the following relation:

\[ \ln nr = E + F_1 \ln P_{g/e} + F_2 \ln P_n + F_3 \ln YH + F_4 \ln UN + F_5 \ln ST \]  

(6)

The new car fuel-efficiency equation

The fuel economy of new cars is defined by the sales-weighted average as follows:

\[ EN = \sum_j EN_j \cdot N_j / NR \]  

(7)

where:

- \( EN_j \) = technical fuel economy for the \( j \)-th size class of cars;\(^1\)
- \( N_j / NR \) = ratio of cars \( j \) sold to total new sales in Canada.

The relationship in the equation above identifies the two determinants of a change in fuel economy: first, the change in the technology of the vehicles; and, second, the change in the distribution of new car sales by size. The first change is determined by the manufacturers and is the subject of the current sub-section. The second is the result of household preference and is discussed in the next sub-section.

A comparison of the fuel economy of different classes of cars by their size (interior volume) rather than their weight has been suggested by both the US Environment Protection Agency (EPA) (1984) and the Society of Automotive Engineers (1985). Both argued that the consumers are probably more interested in the size and utility of a vehicle rather than its weight. The EPA developed a new vehicle size classification based on the interior volume of the automobile which can be used to compare the fuel economy of various vehicles. Table 1 gives a description of these classes.

The recent use of new ultra-light materials in the manufacturing of cars has made it possible to build a vehicle with more, or at least the same, interior space but with less weight and thus a more fuel-efficient engine. These classes capture such technological advances rather well.

Because of the relatively small Canadian market, car manufacturers are assumed to be primarily concerned with economic conditions in the United States, especially with regard to gasoline prices.

Car manufacturers are assumed to make decisions on the design of four interior volume classes of new cars several years prior to the commercialisation of the model.

The fuel economy chosen for the future model is that level which maximises the present value of revenue minus costs. The manufacturers believe that consumers' demand

---

\(^1\) The technical fuel economy of cars is the fuel economy under test driving conditions. A reliable source for this information is provided by the Environment Protection Agency's publications for all models of new cars.
Table 1

The Interior Volume Classes of New Cars

<table>
<thead>
<tr>
<th>Type*</th>
<th>$FT^3$</th>
<th>$M^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sub-Compact</td>
<td>&lt;85 - 100</td>
<td>&lt;2.41 - 2.84</td>
</tr>
<tr>
<td>2. Compact</td>
<td>100 - 110</td>
<td>2.83 - 3.11</td>
</tr>
<tr>
<td>3. Mid-Size</td>
<td>110 - 120</td>
<td>3.11 - 3.40</td>
</tr>
<tr>
<td>4. Large</td>
<td>&gt;120</td>
<td>&gt;3.40</td>
</tr>
</tbody>
</table>

* Units are in Cubic Feet & Cubic Metres.

Table 2

Fuel Economy Standards In The United States

<table>
<thead>
<tr>
<th>Year</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>18 mpg</td>
</tr>
<tr>
<td>1979</td>
<td>19 mpg</td>
</tr>
<tr>
<td>1980</td>
<td>20 mpg</td>
</tr>
<tr>
<td>1981</td>
<td>22 mpg</td>
</tr>
<tr>
<td>1982</td>
<td>24 mpg</td>
</tr>
<tr>
<td>1983</td>
<td>26 mpg</td>
</tr>
<tr>
<td>1984</td>
<td>27 mpg</td>
</tr>
<tr>
<td>1985 and after</td>
<td>27.5 mpg</td>
</tr>
</tbody>
</table>

for fuel efficiency in year $t$ depends upon the price of gasoline that year subject to a particular size car. Therefore, different lag structures were used for the gasoline price in the US. A polynomial distributed lag was found to be the most successful.

Furthermore, in order to capture the costs of designing a more fuel-efficient car in the interior volume class $j$, dummy variables for the size classes $Z_j j = 1,\ldots,4$ are imposed. In 1975 fuel efficiency standards were passed in the US which set sales-weighted fuel economy levels for 1978-1990. These are shown in Table 2. Failure to meet these standards meant a financial penalty.\(^2\) To capture the response by producers to these standards, several dummy variables were tested.

The new car fuel efficiency equation in the log-linear functional form is given as:

$$
\text{Ln}EN_j = K1Z_j + K2DST + K3L\text{Ln}P_{g_{r-1}} + K4\text{Ln}P_{g_{r-2}} + K5\text{Ln}P_{g_{r-3}} + K6\text{Ln}P_{g_{r-4}} \quad (8)
$$

\(^2\) The penalty for not achieving the standard is $5.00 per vehicle for each tenth of a mile per gallon below the mandated level. However, because of the failure of the 1985-1987 model year cars to achieve these standards, the EPA has modified the standards for 1987, 1988, 1989 and 1990 to 26, 26, 26.5 and 27.5 mpg respectively.
Transport Gasoline Demand in Canada

M. N. Eltony

where:

\[ Z_j \] = dummy variable for each jth interior volume class;

\[ DST \] = dummy variable for fuel efficiency standards 1975-1985;

\[ P_{g,t-1} \] = US gasoline prices lagged 1, 2, 3 and 4 time periods.

At this point two important identities should be introduced. The fuel economy of the fleet, \( E \), is defined as the harmonic mean of the new car fuel economy, \( EN \), and the fuel economy of the last year's stock, \( UC \).

\[ E = EN \cdot NR/S + E_{t-1} \cdot UC/S \]  (9)

The proportions of new cars, \( NR/S \), and used cars, \( UC/S \), can be determined from the following relationship:

\[ S = NR + UC \]  (10)

which simply states that the addition of used cars, \( UC \), and new cars, \( NR \), is equal to the current stock of cars in the fleet. In equation (4) the stock of cars in the fleet was specified, while in equation (6) the volume of new car sales was specified. Therefore, the proportions of new car sales and used cars, over the fleet, can be determined by the following equations:

\[ NR/S = NR/(NR + UC) \] and

\[ UC/S = UC/(NR + UC) = 1 - (NR/S) \]  (11)

**The sales ratio of new cars**

Following the previous discussion, there are four classes of new cars to choose from: Sub-Compact, Compact, Mid-size, and Large.

Because there are four alternatives available, of which one is chosen by the consumer, the decision can best be modelled in the framework of the multinomial quantitative choice model (McFadden, 1973). In this kind of model, the household is assumed to choose among several alternatives and the decision depends upon characteristics of the household and of the alternatives. The objective of the model is to provide a prediction of the probability that a household with particular characteristics will choose one type of car over another.

Let the ratio of the probability of choosing alternative \( z \) to the probability of choosing alternative \( x \) by household \( i \) be \( P_{z,i}/P_{x,i} \). Let \( K_i \) denote a bundle of characteristics of the household and \( L_z \) represent characteristics of the alternative car types.

Then, the model of new car choice can be described by the following equation:

\[ P_{z,i}/P_{x,i} = e^{Az + B_t K_i + C L_z} / e^{Ax + B_t K_i + C L_x} \]  (12)

Taking the logarithms of both sides of the above equation yields

\[ \ln (P_{z,i}/P_{x,i}) = (Az - Ax) + (B_z - B_x) K_i + C (L_z - L_x) \] for \( z = 2, 3, 4 \)  (13)

Data on the basis of household choice of the type of new car are not readily available; however, the probabilities can be substituted by the relative frequencies of the households with the bundle of attributes \( K_i \), choosing alternative \( z \). Then substituting the relative frequencies for the probabilities and suppressing the household subscript yields the following equation:

197
\[
\ln \left( \frac{Nz}{Nx} \right) = (Az - Ax) + (Bz - Bx) K + C (Lz - Lx) \quad \text{for } z = 2, 3, 4
\] (14)

In order to be able to estimate the equations in a manner similar to logit estimation (Amemiya, 1981), the coefficient on the characteristics of the vehicle variables, \( L \), are constrained to be equal across the equations.\(^3\)

In the estimation of the equations the household disposable income, the regional unemployment rate, the number of man-days lost as a result of strikes in the automotive industry and the percentage of driving age population are the characteristics of the household, \( K \).

The difference in the car prices, \((Pnz - Pnx)\), and in the gasoline cost per mile, \(Pg (1/enz - 1/enx)\), are the vehicle type characteristics, where \(enz\) and \(enx\) are the fuel efficiency of vehicle type \( z \) and type \( x \) respectively.

Equation (14) can be re-stated as follows:

\[
\ln \left( \frac{Nz}{Nx} \right) = A + B YH + C UN + D ST + E POP +
\]
\[\quad \quad \quad \quad F (Pnz - Pnx) + GPg(1/enz - 1/enx) \quad \text{for } z = 2, 3, 4
\] (15)

where :
\[
A = (Az - Ax) \\
B = (Bz - Bx) \\
C = (Cz - Cx) \\
D = (Dz - Dx) \\
E = (Ex - Ex)
\]

3. The Data

Pooled time-series and cross-section data on the Canadian provinces from 1969-1988 were used. All prices and income are expressed in relation to the consumer price index (1981 = 100). Reports published by Statistics Canada provided the data on car stocks, regional unemployment rates, net gasoline sales,\(^4\) the price of gasoline at the pump in several major Canadian cities, new car registration, residential population in urban areas, driving age population, prime interest rate, number of households by province and the consumer price index in major cities. The household income was obtained from Statistics Canada's Household Expenditure Survey. The number of cars per household was obtained

\(^3\)To explain this point further, consider the following set of equations:

(i) \( \ln (N2/N1) = (A2 - A1) + (B2 - B1) K + C21 (L2 - L1) \)

(ii) \( \ln (N3/N1) = (A3 - A1) + (B3 - B1) K + C31 (L3 - L1) \)

(iii) \( \ln (N4/N1) = (A4 - A1) + (B4 - B1) K = C41 (L4 - L1) \)

From (i) and (ii), \( \ln (N2/N3) \) can be found. That is

(iv) \( \ln (N2/N3) = (A2 - A1) + (B2 - B1) K + C21 (L2 - L1) - (A3 - A1) - (B3 - B1) K - C31 (L3 - L1) \)

If \( C31 = C21 = C \) then

(v) \( \ln (N2/N3) = (A2 - A3) + (B2 - B3) K + C (L2 - L3) \)

The same argument holds for \( \ln (N2/N4) \) from (i) and (iii) and all other possible combinations. See Gallini (1983), p. 305, on this point.

\(^4\)For example, the taxable gasoline which is primarily sold to the drivers of cars, buses and trucks at the gas pump.
Transport Gasoline Demand in Canada

from the Household Facilities and Equipment Survey. The average fuel-efficiency data were obtained from Statistics Canada’s Household Fuel Consumption Survey. The earlier fuel efficiency series data were gathered from the Canadian Automobile Survey, the Economic and Technical Review Report, published by Environment Canada.

The price of new cars from four categories, classified by the interior volume of the vehicle, are weighted averages of the prices of the four largest sellers in Canada for that year. The source of these prices was the Canadian Golden Book of Used Car Prices 1968-1989.

Sales figures for all models of cars in Canada were made available to this study by R. L. Polk & Co. (Toronto). The sales data were used to construct the sales ratios for fuel categories of cars classified by their interior volume. The fuel economies for these four classes are published annually in the Gas Mileage Guide (EPA, US Department of Energy). The fuel economies data and the sales ratios for the different classes were used to create the sales-weighted average fuel economy for new cars (EN) as defined in Equation (7).

Several issues of the United States Statistical Abstract 1968-1988 were used as the source for the information on gasoline prices and the consumer price index in the US.

4. The Estimation Results

A variance components model (Pindyck and Rubinfeld, 1976), which allows separate provincial intercepts, is assumed using pooled time-series and cross-sectional provincial data. The estimation procedure employed for most of the equations in the model is Ordinary Least Square (OLS) with auto-correlation correction when necessary.

Estimation of gasoline per car

Equation (1) in Table 3 gives the results for this estimation. The signs of the estimated coefficient on income, unemployment rate, price of gasoline per mile, fuel efficiency of the fleet and the number of vehicles per household are consistent with economic theory. The price of gasoline per mile, the fuel economy of the fleet, the household disposable income, the unemployment rate and the number of vehicles per household are all significantly different from zero at the 99 per cent level. The provincial intercept terms are also significant: they account for the differences among provinces which cannot be quantified, that is, the availability of public transport systems, degree of urbanisation and so on. The short-run gasoline price elasticities per car, holding the fuel economy constant, is approximately –0.21. The results give a short-run income elasticity of approximately 0.15.

Estimation of stock of cars per household

The result for this estimation is reported in Table 3 as Equation (2). The price of gasoline per gallon was found empirically to be more successful than the price per mile for the stock of cars equation. However, when the price of gasoline per gallon, lagged one time period,
was included better results were obtained.

The coefficient for the cost of gasoline per gallon has a negative sign as a reflection of the fact that gasoline and cars are complementary goods. Researchers have reported that the price of gasoline and the price of new cars tend to be correlated. This is because other characteristics of the car which are related to fuel efficiency, such as power and size, are not accounted for.

Because of this problem of collinearity between the price of gasoline and the price of new cars, none of the tested specifications produced a statistically significant coefficient for the price of new cars; nevertheless it has a negative sign.

One possible reason why the new car price did not behave well in the stock equation is that the new car price is not the flow cost of the services, which depends on the financing of the car, and is approximately the real interest rate times the price of the car, plus maintenance costs. But if the real interest rate is relatively constant and maintenance costs are a constant proportion of the car price over the estimation period, then the price of new cars represents a good proxy for the desired variable.

The prime interest rate in Canada was included in an alternative specification. Its estimated coefficient has the right sign and it was found to be significant but the price of new cars remained insignificant.

Moreover, the gasoline price elasticities of the stock of cars per household were found to be small, approximately 0.12. It should be noted that this is a short-run elasticity since in the long run, the household could switch to smaller, more fuel-efficient cars.

**Estimation of new car sales**
The results of the new car sales estimation are given in Table 3 as Equation (3). The coefficient of the new car prices variable has a negative sign and is highly significant, as is the coefficient of the gasoline cost per mile. There is no indication of a collinearity problem between the two prices. Income per household has a positive sign, confirming that cars are normal goods. The coefficient for the unemployment rate \( (UN) \) has a negative sign so that at lower levels of unemployment, new car sales are expected to increase.

The unemployment rate variable \( (UN) \) has been included as an indicator of cyclical economic conditions. It provides information about the phase of the business cycle and the expected income which would not be provided by the inclusion of only the disposable income variable.

The variable for strikes in the car industry \( (ST) \) represents a supply constraint on the availability of new cars, and the coefficient for this variable has a negative sign. Some researchers have argued that the coefficient of this variable should be zero since any problems with the availability of domestic cars could be made up by an increase in imports. This is certainly plausible. However, if imported cars are not a perfect substitute for domestic ones, then an effect is still expected.

**Estimation of fuel efficiency of new cars**
The results for this equation are given in Table 4. A polynomial distributed lag of degree 1 is imposed on the gasoline price with zero restriction on the coefficient of the current
Transport Gasoline Demand in Canada

M. N. Eltony

Table 3

Results of Estimations for Canadian Provinces
(t-statistics in parentheses)

<table>
<thead>
<tr>
<th>Equations</th>
<th>(1) Ln GS</th>
<th>(2)Ln s</th>
<th>(3)Ln nr</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFLD</td>
<td>7.2006 (10.61)</td>
<td>0.2073 (0.2381)</td>
<td>7.8894 (4.329)</td>
</tr>
<tr>
<td>PEI</td>
<td>7.2234 (10.86)</td>
<td>0.3284 (0.3754)</td>
<td>7.7907 (4.284)</td>
</tr>
<tr>
<td>NS</td>
<td>7.1705 (10.75)</td>
<td>0.2638 (0.3019)</td>
<td>7.8021 (4.286)</td>
</tr>
<tr>
<td>NB</td>
<td>7.2336 (10.90)</td>
<td>0.2814 (0.3216)</td>
<td>7.8878 (4.335)</td>
</tr>
<tr>
<td>QUE</td>
<td>7.0088 (10.44)</td>
<td>0.2256 (0.2570)</td>
<td>7.8721 (4.305)</td>
</tr>
<tr>
<td>ONT</td>
<td>7.0179 (10.26)</td>
<td>0.2508 (0.2844)</td>
<td>7.6989 (4.162)</td>
</tr>
<tr>
<td>MAN</td>
<td>6.9269 (10.26)</td>
<td>0.2828 (0.3215)</td>
<td>7.4788 (4.065)</td>
</tr>
<tr>
<td>SASK</td>
<td>7.0283 (10.44)</td>
<td>0.2475 (0.2812)</td>
<td>7.3571 (3.993)</td>
</tr>
<tr>
<td>ALTA</td>
<td>7.1069 (10.44)</td>
<td>0.3143 (0.3547)</td>
<td>7.5888 (4.086)</td>
</tr>
<tr>
<td>BC</td>
<td>6.9064 (10.23)</td>
<td>0.2920 (0.3310)</td>
<td>7.4933 (4.068)</td>
</tr>
</tbody>
</table>

| Ln YH     | 0.1466 (2.045) | 0.1402 (2.1061) | 0.3453 (2.9921) |
| Ln Psp/e  | -0.2095 (-3.971) | -0.2726 (-3.002) |          |
| Ln E      | -0.7420 (-11.319) |          |          |
| Ln UN     | -0.0495 (-2.298) |          | -0.2956 (-6.975) |
| Ln AH     | -0.4714 (-7.599) |          |          |
| Ln Psp-1  | -0.1206 (-3.029) | -0.7179 (-4.985) |          |
| Ln Pt     | -0.0297 (-1.402) |          |          |
| Ln s-1    | 0.4955 (7.789) |          |          |
| Ln POP    | 0.3006 (1.825) |          |          |
| Ln ST     | -0.00395 (-2.451) |          |          |

\[ R^2 \] 0.9074 0.8125 0.7655

SER 0.0500 0.0555 0.1054

DW 2.0927 2.0670 2.0342

F 130.36 62.59 41.19

The notation for the provinces is: NFLD = Newfoundland; PEI = Prince Edward Island; NS = Nova Scotia; NB = New Brunswick; QUE = Quebec; ONT = Ontario; MAN = Manitoba; SASK = Saskatchewan; ALTA = Alberta; BC = British Columbia.
Table 4

The New Cars Technical Fuel Efficiency Equation
(t-statistics in parentheses)

<table>
<thead>
<tr>
<th></th>
<th>Z1</th>
<th>Z2</th>
<th>Z3</th>
<th>Z4</th>
</tr>
</thead>
<tbody>
<tr>
<td>LnEN</td>
<td>4.0061</td>
<td>3.9380</td>
<td>3.7232</td>
<td>3.5491</td>
</tr>
<tr>
<td></td>
<td>(29.763)</td>
<td>(29.583)</td>
<td>(27.969)</td>
<td>(26.662)</td>
</tr>
<tr>
<td>DST</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pt-1</td>
<td>Pt-2</td>
<td>Pt-3</td>
<td>Pt-4</td>
</tr>
<tr>
<td>LnEN</td>
<td>0.082372</td>
<td>0.20138</td>
<td>0.19829</td>
<td>0.19519</td>
</tr>
<tr>
<td></td>
<td>(2.0329)</td>
<td>(3.0178)</td>
<td>(5.3147)</td>
<td>(7.9252)</td>
</tr>
</tbody>
</table>

\[ R^2 = 0.9991 \quad SER = 0.0091 \quad F = 9621.9 \]

period price. On the basis of both \( R^2 \) and Minimum Standard Error criteria, the optimum lag length is 4. This indicates that design changes are made 1 to 4 years prior to the year of marketing the final product. There is evidence from the industry to support this finding. According to the *International Business Week Magazine*, several car manufacturers spend about 3 to 4 years in designing a new model before the commercialisation year.

The coefficients of the gasoline price per gallon are of almost the same size, indicating that the design of the new model can be altered up to the last year before the marketing. Further, the gasoline price elasticity of new car fuel efficiency is about 0.8 over the four year design period.

In Table 4, the results for the dummy variables for size classes \( Z_1, \ldots, Z_4 \) illustrate that the larger the interior volume of the car, the lower the fuel economy of the new car. Also, the dummy variable for the fuel economy standards indicates a positive effect on the fuel efficiency of new cars of all classes.

Estimation of sales ratio of new cars

Three equations with cross restrictions on the estimates of the new car price variable \( (P_{nz} - P_{nx}) \) and gasoline cost per mile variable \( P_g (1/enz - 1/enx) \) are estimated simultaneously. The three equations were estimated for the sales in categories 2, 3 and 4 relative to the sales in category 1.

The estimation results for the new car sales ratios are given in Table 5. The results show that the larger the difference between the price of new cars in the larger categories and in

---

### Table 5

**Sales Ratios for the New Cars**

<table>
<thead>
<tr>
<th>Categories</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Pg(1/enz−1/enx) )</td>
<td>-11.738((−8.105))</td>
<td>-11.738((-5.272))</td>
<td>-11.738((-5.996))</td>
</tr>
<tr>
<td>( Pnz − Pnx )</td>
<td>-0.1073 (10^{-3})((-4.684))</td>
<td>-0.1073 (10^{-3})((-3.047))</td>
<td>-0.1073 (10^{-3})((-3.465))</td>
</tr>
<tr>
<td>( YH )</td>
<td>0.56133 (10^{-4})((5.728))</td>
<td>0.6720 (10^{-4})((4.496))</td>
<td>0.19903 (10^{-4})((1.876))</td>
</tr>
<tr>
<td>( UN )</td>
<td>0.0428((3.582))</td>
<td>0.0668((3.629))</td>
<td>-0.0443((-2.676))</td>
</tr>
<tr>
<td>( ST )</td>
<td>-0.14345 (10^{-6})((-3.109))</td>
<td>-0.99303 (10^{-7})((-2.409))</td>
<td>-0.41328 (10^{-7})((-1.656))</td>
</tr>
<tr>
<td>( POP )</td>
<td>-0.08312((-6.671))</td>
<td>-0.20643((-10.613))</td>
<td>-0.1797((-10.634))</td>
</tr>
<tr>
<td>NFLD</td>
<td>3.6621((6.333))</td>
<td>11.482((11.98))</td>
<td>12.327((14.101))</td>
</tr>
<tr>
<td>ONT</td>
<td>4.4766((6.189))</td>
<td>13.423((11.452))</td>
<td>13.703((12.935))</td>
</tr>
<tr>
<td>MAN</td>
<td>4.4798((6.128))</td>
<td>13.568((11.493))</td>
<td>13.775((12.98))</td>
</tr>
<tr>
<td>SASK</td>
<td>4.4935((6.175))</td>
<td>13.426((11.444))</td>
<td>13.899((13.184))</td>
</tr>
<tr>
<td>ALTA</td>
<td>4.1269((5.926))</td>
<td>12.710((11.256))</td>
<td>13.316((12.993))</td>
</tr>
<tr>
<td>BC</td>
<td>4.2509((6.033))</td>
<td>12.585((10.973))</td>
<td>12.926((12.442))</td>
</tr>
</tbody>
</table>
category 1 (the smallest size), the smaller is the ratio of larger to small car sales. Similarly, as the gasoline cost increases, the sales of smaller cars become more frequent relative to sales of larger ones. The coefficients on both variables of car prices and gasoline cost are significantly different from zero at the 99 per cent level.

The results also suggest that as household disposable income rises, the number of cars sold in categories 2, 3, and 4 relative to sales in category 1 rises, which is evidenced by the positive sign for the household income variable in all three equations. A rise in the unemployment rate induces households to move down the size spectrum, decreasing the ratio of car sales in each category relative to the smallest cars.

Furthermore, man-days spent on strike in the Canadian car industry appear to have a negative effect on the sales in categories 2, 3, and 4 relative to category 1.

This result is intuitively appealing since a large proportion of the cars in the smallest category are imported, and thus would not be subject to domestic strikes.

A rise in the driving age population, POP, also has a negative effect on the sales in category 2, 3, and 4 relative to sales in category 1.

Finally, all the household characteristics variables are statistically significant at the 95 per cent level.

Price elasticity estimates
The objective of developing the model was to determine the household response to gasoline price changes. A widely used economic indicator of consumer response is the price elasticity of demand for gasoline. By simulating the model over the desired time horizon, 1989-2000, the price elasticities were determined. A base case was specified in which real household income, the unemployment rate, the real price of new cars, the interest rate, and the real price of gasoline per gallon in Canada and the United States are assumed to equal the 1988 values and remain constant for the rest of the time horizon.

In an alternative solution of the model only the real prices of gasoline in Canada and the US are assumed to increase by 10 per cent. The two dynamically controlled solutions of the model were obtained and the percentage change in gasoline consumption computed from the two solutions. Dividing the result for each year by 0.1 yields the dynamic price elasticity.

The price elasticity as described above includes all direct and indirect effects on gasoline consumption resulting from a 10 per cent change in the price of gasoline per gallon. The increase in the price of gasoline has a direct effect on the number of miles driven per car, the average fuel economy of the fleet, new car sales, and on the stock of cars. All these effects are captured in the price elasticity estimates. Table 6 gives the short-run (one year) price elasticity and the longer-run price elasticity estimates for two to ten years. Because the intercept term is the only parameter that is allowed to vary across provinces, there is little variation in the price elasticities across provinces; therefore only results for Canada as a whole are reported in Table 6. The short-run (one year) elasticities appear larger than expected.

We have noted from Table 3's equation (1) that the direct response to an increase in the price of gasoline, holding the stock of cars and the fuel economy of the fleet constant,
Table 6

Dynamic Price Elasticities of Gasoline Demand in Canada

<table>
<thead>
<tr>
<th>Year</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.3120</td>
</tr>
<tr>
<td>2</td>
<td>0.4673</td>
</tr>
<tr>
<td>3</td>
<td>0.5370</td>
</tr>
<tr>
<td>4</td>
<td>0.5981</td>
</tr>
<tr>
<td>5</td>
<td>0.6984</td>
</tr>
<tr>
<td>6</td>
<td>0.8132</td>
</tr>
<tr>
<td>7</td>
<td>0.8935</td>
</tr>
<tr>
<td>8</td>
<td>0.9478</td>
</tr>
<tr>
<td>9</td>
<td>0.9839</td>
</tr>
<tr>
<td>10</td>
<td>1.0073</td>
</tr>
<tr>
<td>11</td>
<td>1.0192</td>
</tr>
<tr>
<td>12</td>
<td>1.0239</td>
</tr>
</tbody>
</table>

was -0.21. When changes in the fuel economy of the vehicles on the road and fleet size through new car sales and the scrapping of used cars are included, −0.1 is added to the price elasticity. This is higher than Gallini’s result of −0.06 and indicates that at least 25 per cent of the decrease in gasoline consumption in the first year results from changes in the average fuel economy of the fleet, adjustment to car stocks, and new car sales.

The adjustment to the price increase appears to be rapid, which is indicated by the rise in the price elasticity within the first four years after a price change. Ten years after the 10 per cent increase in the gasoline price, the reduction in consumption settles to approximately 10 per cent of the consumption level without a price increase.

5. Conclusions

The model presented in this study is one of the few econometric studies that has attempted to model gasoline demand for Canada. The attempt was made to improve upon the existing models through careful description of the underlying decision-making process that faces the household, making the household rather than the individual the focus of the model and significantly extending the time-series beyond the scope of existing studies.

In the model, the household which already owns a car can react immediately to a price increase by driving fewer miles. The household which is planning to buy a new car can either postpone their vehicle purchases or choose a more fuel-efficient new car. Finally, the household which owns an aged car can scrap it in response to a higher gasoline price.
In the long run, the size and composition of the fleet according to the interior volume 
of the vehicles can continue to change and necessary miles may fall as households move 
closer to work. Also, in the long run, car manufacturers can modify the technology of the 
new cars according to their expectations regarding the future levels of gasoline prices and 
consumers’ demand for more fuel-efficient cars.

Another contribution of the model to the literature in addition to the use of the 
household expenditure survey data is the detailed treatment of the fuel efficiency of the 
new cars, where they were categorised according to their interior volume rather than their 
natural weight.

The results of estimating the model provided revealing information about elasticity of 
gasoline demand in Canada. The short-run dynamic own-price elasticity of gasoline demand ranged between 0.311 to 0.313 in absolute value across the provinces. Almost 75 
per cent of the household response to price change in the first year was accounted for by 
driving fewer miles. While these results are in line with Gallini (1983), they exhibit one 
different feature: at least 10 per cent of the response in the first year results from an 
alteration in the composition of the fleet to more fuel-efficient vehicles. This response 
accounted for only 4 per cent in Gallini’s study. The remaining 15 per cent is attributed 
to the change in the size of the fleet. In the intermediate term (five years) price elasticities 
range from 0.689 to 0.709, and the long-term elasticities (ten years) range from 0.975 to 
1.059. Moreover, the dynamic elasticities imply that the adjustment seems to take place 
very rapidly during the first four years. The results point to the importance of improving 
fuel efficiency as an effective means of reducing household gasoline consumption. They 
also show that the detailed treatment of the fuel efficiency of the fleet was justified. As an 
explanatory variable, the fuel efficiency variable was found to possess the right sign and 
to be highly significant in all equations. The results indicate that in many cases the 
households were able to keep their favourite car size because the manufacturers instituted 
significant improvements in fuel efficiency in new cars of all classes.

References

pp. 1483-530.


Transport Gasoline Demand in Canada

M. N. Eltony


*Date of receipt of final typescript: July 1992*