The demand for road diesel in Canada

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Abstract

In this paper, we estimate the demand for road diesel in Canada using aggregate annual data for the period 1986-2008. We focus the analysis on short and long run price and the elasticities with respect to the level of economic activity as measured by GDP per capita. Two methodological approaches are used. We estimate a partial adjustment model and an error correction model based on cointegration techniques. We find that the price has little impact on the demand of diesel while, on the contrary, the elasticity with respect to the level of economic activity is close to 2.

Keywords
Road diesel; demand; elasticity; partial adjustment model; cointegration
The demand for road diesel fuel in Canada

I. Introduction

Literally hundreds of researches have studied the demand for gasoline (for reviews see Espey 1998; Graham and Glaister, 2004; Goodwin et al., 2004; Basso and Oum 2007). Much less effort has been made studying the demand for road diesel fuel (exceptions include Fouquet and Pearson, 1997 and Polemis, 2006). Yet, in many countries, the consumption of road diesel has been increasing much faster than gasoline fuelled in part by the rapid expansion of trucking. For example, in Canada, while gasoline consumption has been multiplied by 1.5 over the 1971-2008 period, road diesel consumption has grown by a factor of 7.4 during the same period. If gasoline remains the principal source of energy for road transportation activities at 54.4% in 2008, diesel is second at 32.5% up from 25% in 1990. The lack of research on road diesel demand could be due in part to the heterogeneity of users in many countries. For example in Europe, road diesel is used not only by trucks but also by a large share of automobiles.\(^1\) In Canada however, the share of light duty vehicles (automobiles and light trucks) in road diesel consumption was a meagre 1.14% in 2008. In fact, medium and heavy trucks consumed over 92% of road diesel while the balance is fuelling buses (6.7%). This makes the analysis of road diesel easier and more relevant as the main driving force behind road diesel demand is trucking activities. The main objective of this paper is therefore to measure how the price of diesel and the level of economic activities are affecting the demand for road diesel fuel in Canada.

There are a few papers that provide some indications on road diesel demand. First, Fouquet et al. (1997) use co-integration methods to estimate the dynamics of various UK sector energy demand including road diesel. The analysis is carried over the period 1960-1994. They report income elasticity for the demand of diesel ranging from 0.37 to 0.45 in the short run and 1.95 to 2.05 in the long run. Their analysis also suggests that diesel price would not influence demand both in the short and long run. Polemis (2006) analyses the determinants of road energy demand in Greece for the 1978-2003 period. A system of two equations, one for gasoline and one for diesel,

\(^{1}\) It is estimated that, in 2007, over 50% of new automobiles sold in Europe use diesel (see Comité des constructeurs français d’automobiles, 2008).
is estimated using cointegration and vector autogression analysis. The price elasticity is found to
be -0.07 in the short run and -0.44 in the long run while income elasticity is 0.42 in the short run
and 1.18 in the long run. Furthermore, Polemis finds that the price of gasoline has no significant
effect on diesel demand.²

In this paper, we estimate the demand for road diesel in Canada using aggregate annual data for
the period 1986-2008. We focus the analysis on short and long run price and income elasticities.
Two methodological approaches are used. We estimate a partial adjustment model and an error
correction model based on cointegration techniques. In section 2, we describe our
methodological approaches and our data. The results are presented in section 3 and we conclude
in section 4.

2. Data and Methodology

The main data sources are Statistics Canada and MJ Ervin & Associates. Diesel consumption is
provided by the Road Motor Vehicle Survey which collects information on net sales of diesel for
which road taxes were paid. Our data covers the 1986-2008 period.³ For the price of diesel, we
compute an average retail price using the information collected by MJ Ervin & Associates on
weekly price of diesel at retail stations in 10 different Canadian cities. This measure is clearly
imperfect for as it only covers part of Canada and it also ignores that major trucking companies
do not pay the full price displayed at retail stations. We expect however that this price measure
should be closely correlated with actual prices. All the other variables used in the analysis are
obtained from Statistics Canada (e.g. GDP, population, imports and exports). Figures 1 to 3
illustrate respectively the changes in per capita road diesel sales, the average price of diesel and
the level of GDP per capita over the 1986-2008 period in Canada.

² We can also mention a study by Boshoff that uses quarterly data for the period 1998-2009 in South Africa. The
long run price elasticity is estimated at -0.13 while income elasticity is 1.51.
³ Unfortunately over this period, some provinces have eliminated road fuel taxation at some point in time leading to
artificial shifts in net sales. Specifically, Alberta has abolished road fuel taxation from 1978 to 1987 and
Saskatchewan from 1982 to 1987. In order to correct for these problems, we use domestic sales of diesel as provided
by Statistics Canada data on monthly supply and disposition of refined petroleum products. This series is complete
and do not depend upon taxation rules. Domestic sales is however not directly comparable to net sales of road diesel
as it includes all uses of diesel (e.g. off-road, rail, industrial usage). For each of the three provinces with missing
data, we therefore regress net sales of road diesel on domestic sales and use the predictions to complete our series on
net sale of road diesel.
First, we estimate a dynamic reduced form demand model. Specifically, we use a partial adjustment model which allows distinguishing easily short and long run effects. Our basic specification has the following form:

\[ \text{Log(\text{Dr})} = \alpha_0 + \alpha_1 \text{Log(G)} + \alpha_2 \text{Log(\text{GDP})} + \alpha_3 \text{Log(\text{Dr}_{-1})} + \varepsilon \]
With $D_{cap_t}$ the level of road diesel consumption per capita during year $t$ (in liters), $P_t$ the real price of diesel ($ of 2002), $GDP_{cap_t}$ the per capita level of GDP ($ of 2002), $D_{cap_{t-1}}$ the level of road diesel consumption per capita during year $t-1$ and $\varepsilon_t$ an error term. The short run price elasticity is measured by $\alpha_1$ while the long run price effect is obtained by dividing $\alpha_1$ by $\frac{1}{1-\alpha_2}$. The variable $GDP_{cap_t}$ should be interpreted in our context more as an indicator of the level of economic activities which determines the demand for trucking than a traditional consumer income effect. For ease of exposition, we do however refer to $\alpha_2$ as the short run income elasticity and $\frac{\alpha_2}{1-\alpha_2}$ as the long run income elasticity.$^4$

This reduced form dynamic model has the advantage of being simple and has been extensively used in the literature on gasoline demand (see Basso and Oum 2007). However, it is often plagued by serial correlation and heteroskedasticity. Moreover, it may be subject to spurious correlation if the time series are not stationary. The second approach is therefore based on co-integration techniques and the estimation of an error correction model which should, in principal, avoid these shortcomings.

In this second approach, we first need to test for the stationarity of the time series and determine their order of integration. A time series process is stationary if the mean and variance are constant over time. Moreover, the covariance between two points in time should only depend upon the time distance between these two points (see Greene, 2003). A series is said to be integrated of order $I(d)$ if it is not stationary but its $d$ differences is. Augmented Dickey-Fuller (ADF) tests can be used to access the order of integration. If the time series are $I(d)$ then it is possible that there are cointegrated meaning that a long run relationship still exists between these series even if there are not stationary (i.e. they have a common attractor). In our setting, the long run relationship has the following form:

$$\text{Log(Dcap)} = \beta_0 + \beta_1 \text{Log}(P) + \beta_2 \text{Log}(GDP_{cap}) + \varepsilon_t$$

$^4$ Note that we only report in this paper the results of our most preferred specification but the role of alternative determinants was explored. For example, we tested a variable measuring the share of import and export in total GDP. We also tried the share of trade with the US and Mexico in total GDP. The impact of the price of gasoline was also examined as well as the level of unemployment and a trend variable.
If the error term is stationary, we can reject the hypothesis of the absence of co-integration of the series. In this case, the coefficients $\beta_1$ and $\beta_2$ measure the long run price and income elasticities. To find short run effects, an error correction model (ECM) is estimated. It has the following specification:

$$\Delta \log(D_{cap}) = \gamma_1 + \gamma_2 \Delta \log(P) + \gamma_3 \Delta \log(\text{GDP}_\text{cap}) + \gamma_4 \Delta \log(D_{cap,-1}) + \gamma_5 \Delta \log(\text{GDP}_\text{cap,-1}) + \gamma_6 \epsilon_{t-1} + \theta_t$$

With $\gamma_1$ and $\gamma_2$ measuring the short run price and income elasticities and $\gamma_6$ the speed of the adjustment process toward the long run equilibrium.\(^5\)

### 3. Empirical results

Table 1 presents the results from the partial adjustment model. Based on these results, the demand for road diesel in Canada would be price inelastic both in the short and long run (-0.18 and -0.47 respectively) while it would be income inelastic in the short run but elastic in the long run (0.78 and 2). However, the analysis of the residuals reveals the present of autocorrelation.

**Table 1. Results for the partial equilibrium model**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \log(P)$</td>
<td>-0.18***</td>
<td>0.06</td>
</tr>
<tr>
<td>$\Delta \log(\text{GDP}_\text{cap})$</td>
<td>0.78**</td>
<td>0.35</td>
</tr>
<tr>
<td>$\Delta \log(D_{cap,-1})$</td>
<td>0.61***</td>
<td>0.008</td>
</tr>
<tr>
<td>Constant</td>
<td>-5.13*</td>
<td>2.50</td>
</tr>
<tr>
<td>Durbin-Watson</td>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td>R-square</td>
<td>0.97</td>
<td></td>
</tr>
<tr>
<td>Long run price elasticity(^b)</td>
<td>-0.47</td>
<td></td>
</tr>
<tr>
<td>Long run income elasticity(^b)</td>
<td>2***</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) significant at the 10% level; \(^b\): significant at the 5% level, \(^**\): significant at the 1% level

\(^a\): Hubber/White standard error robust to heteroskedasticity and serial correlation of the error terms.

\(^b\): significance evaluated by using a non-linear Wald-type test

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\(^5\) The lags are necessary to eliminate serial correlation in the error terms.
We next turn to the results from the cointegration analysis. Table 2 reports the results concerning the order of integration of the different time series. We find that our three series are $I(1)$ meaning that we can examine the possibility for cointegration. The results of the long run model are presented in Table 3. We reject the hypothesis of non-stationarity of the residuals at the 5% level suggesting that the series are indeed cointegrated. The long run price elasticity is -0.21 while the long run income elasticity is 1.86. We therefore find somewhat smaller elasticities with this approach than with the dynamic model as it is often the case (see Basso and Oum, 2007). We then proceed by estimating the error correction model (see Table 4). We find that the short run price elasticity is very small and not statistically significant. In contrast, the short run income elasticity is quite important. The adjustment rate is evaluated at 36% meaning that less than three years are necessary for reaching the long run equilibrium value.

Thus, based on this approach, the price of diesel would have no real impact on the short run while the impact on the long run would be quite small. The main determinant of the demand would be the level of economic activity as measured by GDP per capita with a short and long run elasticity close to 2. While the results are somewhat different than with the dynamic model, both approaches results point to the same general conclusion: price has little impact while the level of economic activity is key. This conclusion is therefore very similar to what the few other existing studies have already concluded.

Table 2. Results for the Augmented Dickey-Fuller Stationarity Tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>Functional form</th>
<th>Lags</th>
<th>d-DF stat.</th>
<th>I(d)</th>
<th>Test critical values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constant Trend</td>
<td></td>
<td></td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>$\Delta \log(D)_{\text{mp}}$</td>
<td>=0 =0 0 0</td>
<td>-2.54 0</td>
<td>-2.67 -1.95 -1.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta \log(D)$</td>
<td>=0 =0 0 1</td>
<td>-5.30 0</td>
<td>-4.49 -3.65 -3.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta \log(G)_{\text{mp}}$</td>
<td>=0 =0 0 0</td>
<td>-1.99 0</td>
<td>-2.67 -1.95 -1.60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Results of the cointegration model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\log(p)$</td>
<td>-0.21***</td>
<td>0.07</td>
</tr>
<tr>
<td>$\log(\text{GDP per capita})$</td>
<td>1.86***</td>
<td>0.10</td>
</tr>
<tr>
<td>Constant</td>
<td>-12.51***</td>
<td>0.85</td>
</tr>
<tr>
<td>R-square</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>ADF test statistic$^a$</td>
<td>-2.38**</td>
<td></td>
</tr>
</tbody>
</table>

$^a$: Test critical values: -2.67 at 1% level and -1.95 at 5% level

Table 4. Results of the error correction model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \log(p)$</td>
<td>-0.05</td>
<td>0.07</td>
</tr>
<tr>
<td>$\Delta \log(\text{GDP per capita})$</td>
<td>1.78***</td>
<td>0.33</td>
</tr>
<tr>
<td>$\Delta \log(D\text{cap}_{t-1})$</td>
<td>-1.04**</td>
<td>0.42</td>
</tr>
<tr>
<td>$\Delta \log(D\text{cap}_{t-1})$</td>
<td>0.46**</td>
<td>0.21</td>
</tr>
<tr>
<td>$\epsilon_{t-1}$</td>
<td>-0.36**</td>
<td>0.15</td>
</tr>
<tr>
<td>Constant</td>
<td>0.004</td>
<td>0.008</td>
</tr>
<tr>
<td>R-square</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>Durbin-Watson</td>
<td>2.09</td>
<td></td>
</tr>
</tbody>
</table>

4. Conclusion

In this research, we estimate the price and level of activity elasticity for the demand of road diesel using two approaches, one based on a partial adjustment model and one on cointegration technics. We find that the specific values of the elasticities are somewhat different between the two approaches. This could be explained by the fact that the dynamic model suffers from serial correlation which probably signal a specification problem. The limited size of our time series may also explain these differences. Still the results of these two approaches points to the same overall conclusion that the demand for road diesel depends very little on the price but is very much influenced by the level of economic activity as measured by GDP per capita. Furthermore,
this conclusion is very much in line with the few existing studies. In future research, it would be interesting to try to estimate a more structural model explaining the main determinants of the demand for road diesel such the number of trucks, the distance driven or the fuel efficiency to the truck fleet.

References


