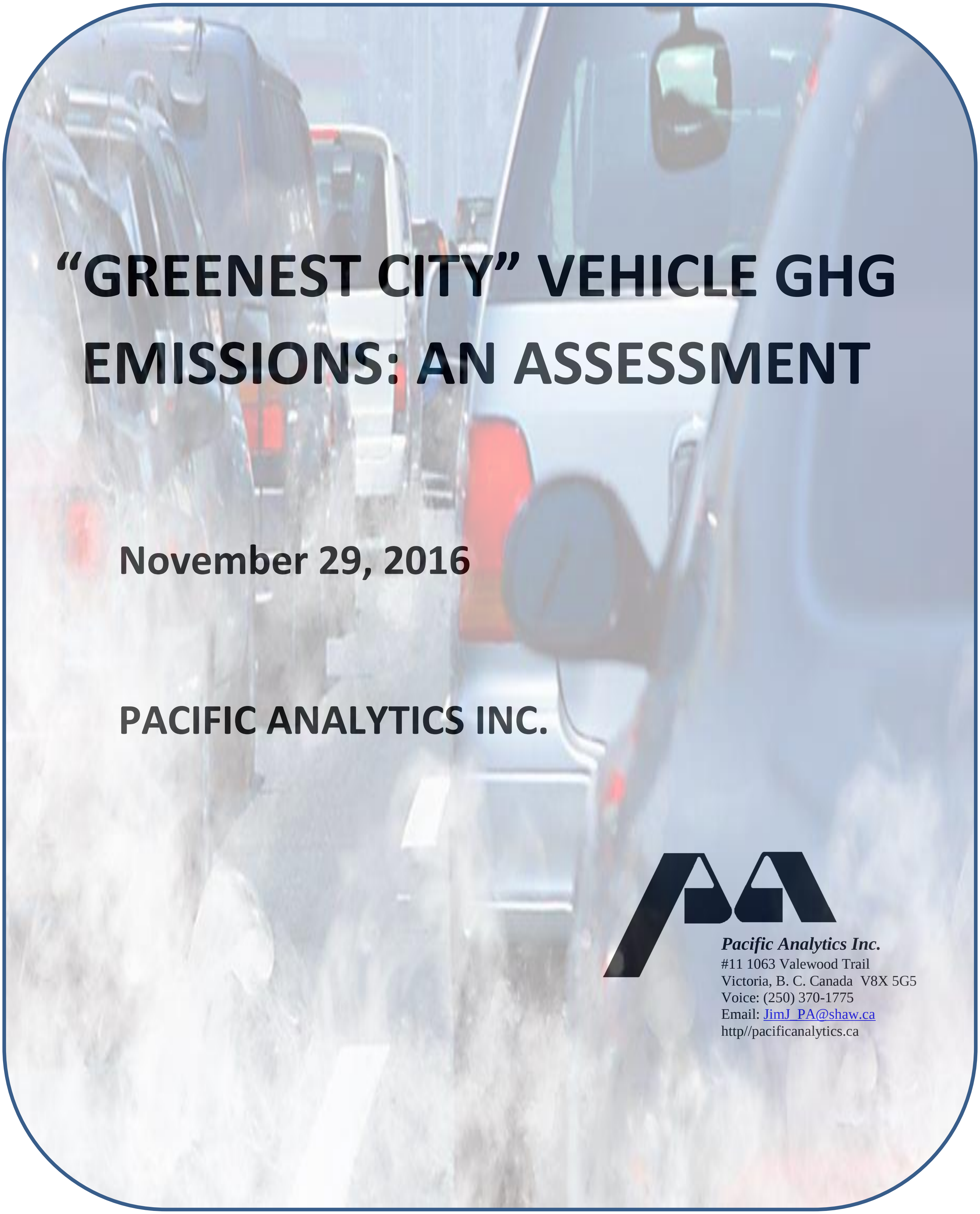

"GREENEST CITY" VEHICLE GHG EMISSIONS: AN ASSESSMENT

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ABSTRACT

In 2009, the City of Vancouver initiated its "*Greenest City*" action plan with the laudable aim of reducing total municipal greenhouse gas (GHG) emissions by 33% by 2020 from a 2007 baseline. One of the targets set was to reduce average vehicle kilometres travelled (VKT) per capita by 20% over that same period.

In July, 2016, the city released an "Action Plan Update" outlining how well the city was meeting its objectives. Based on AirCare odometer data which excludes all vehicles younger than seven years, the Update found that average VKT per capita by 2015 had fallen by 27% since 2007 (more than surpassing its objective) with an almost 18% decline since 2011. In terms of actual fuel consumption (effectively, GHG emissions), there was a 24% decline since 2007, and over a 15% decline since 2011.

Contrast that 15% decline in fuel consumption with Ministry of Finance fuel sales data for the South Coast region (slightly larger than Metro Vancouver) which shows an <u>increase</u> of close to 5% between 2011 and 2015. Either motorists in Vancouver had a remarkable driving epiphany compared to those in Metro Vancouver between 2011 and 2015, or the AirCare data and the methodology used do not capture correctly what has been happening since 2011. In this study, we identify a number of problems with the data and the methodology used in the Update and, using equivalent AirCare data for Metro Vancouver, we find that the Update results for the 2011 to 2015 are unlikely to be valid.

Using our VKT/GHG Forecasting Model which was developed for the Ministry of Environment (CEEI) and TransLink and which integrates a detailed statistical analysis of VKT by vehicle type, we found that average VKT in Vancouver, far from falling, actually rose by almost 5% between 2011 and 2015. We detail the advantages of using this approach, and how it not only provides more reliable estimates of historical VKT, but also affords insights into what factors have caused these changes to average VKT, and how changes to factors in the future (e.g., changes to the carbon tax, greater penetration of electric vehicles, changes in land use and zoning regulations, increase in transit availability) will likely affect driving behaviour and GHG emissions.

“Greenest City” Vehicle GHG Emissions: An Assessment

INTRODUCTION

In 2009 the City of Vancouver initiated its first “Greenest City” action plan, outlining 15 targets to reduce community based greenhouse gas (GHG) emissions by 33% between 2007 and 2020 with the aim of becoming “the world’s greenest city by 2020”. Along with measures to increase green jobs in the city, increase neighbourhood food assets by 50%, beat international air quality standards, plant 150,000 trees, reduce average home energy use by 33%, reduce solid waste going to landfills by 50%, and reduce per capita water consumption by 33%, all by the year 2020, Vancouver also established laudable goals to improve overall mobility in the city, including having the majority of trips made by foot, bicycle or public transit and reducing the average distance driven per resident by 20%. Recently, these goals have become even more important in the quest to meet Canada’s GHG reduction goals outlined in the Paris Agreement.

Clearly, accurate data are essential for monitoring whether Vancouver is achieving the goals set out in that action plan. It is also essential that the data enable Vancouver to determine what factors are influencing positively or negatively the trends in GHG emissions. But generating reliable estimates is challenging: some approaches are relatively easy to implement but are fraught with uncertainties and poor analytical understanding; others are more sophisticated and provide both better estimates and greater insight into what is leading to changes. So one must ask whether using a more simplistic approach provides sufficient reliability or are the estimates it produces simply too inconsistent with known behaviour to be acceptable.

Which brings us to the report released by the City of Vancouver in July, 2016, entitled “*Greenest City: 2020 Action Plan 2015-2016 Implementation Update*”[1] which outlined Vancouver’s greenhouse gas (GHG) reduction successes since 2007. As part of that achievement, it found that passenger vehicle kilometres travelled (VKT) per capita dropped from an estimated 5,950 kms in 2007 to 4,319 in 2015, a decline of 27%. Total passenger kilometres travelled fell from an estimated 3.69 billion kilometres in 2007 to 2.80 billion kilometres in 2015[2], a reduction of 24%[3]. It is our contention that these findings are a result of poor data and an unsatisfactory, somewhat simplistic methodology; this paper outlines some of the problems with the data and methodology and offers a tested alternative that provides not only more accurate and credible estimates of VKT but also insights into what factors actually influence these changes in VKT.

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1 http://vancouver.ca/files/cov/greenest-city-action-plan-implementation-update-2015-2016.pdf

2 2015-2106 Update (cited in footnote 1 above) and the Transportation Survey Panel report of 2014 - http://vancouver.ca/files/cov/transportation-panel-survey-2014-final-report.pdf

3 The percentage difference between VKT per capita (-27%) and total kilometres (-24%) is due to changes in overall population and vehicle ownership per capita.

FUEL CONSUMPTION

GHG emissions do not come directly from kilometres travelled - they come from the fuel consumed to travel those kilometres. To convert from total kilometres travelled to fuel consumption, one must divide by the average fuel consumption rate (litres/100 kms) for passenger vehicles in Vancouver. Average fuel consumption rates in Vancouver fell from an estimated 11.66 litres/100 kms in 2007 to 11.13 litres/100 kms in 2015.[4] Accordingly, if one believes the "*Greenest City*" estimates, there was a decline in overall passenger vehicle fuel consumption from 430 million litres in 2007 to 317 million litres in 2015, a decline of 26%.

There is no comprehensive database of kilometres driven by each vehicle in Vancouver as there is for fuel consumption rates. As such, one cannot ground-truth the estimate of a 27% decline in per capita VKT. But is there a way of ground-truthing the 26% decline in passenger vehicle consumption of fuel in the city? And it is to that question that we now turn.

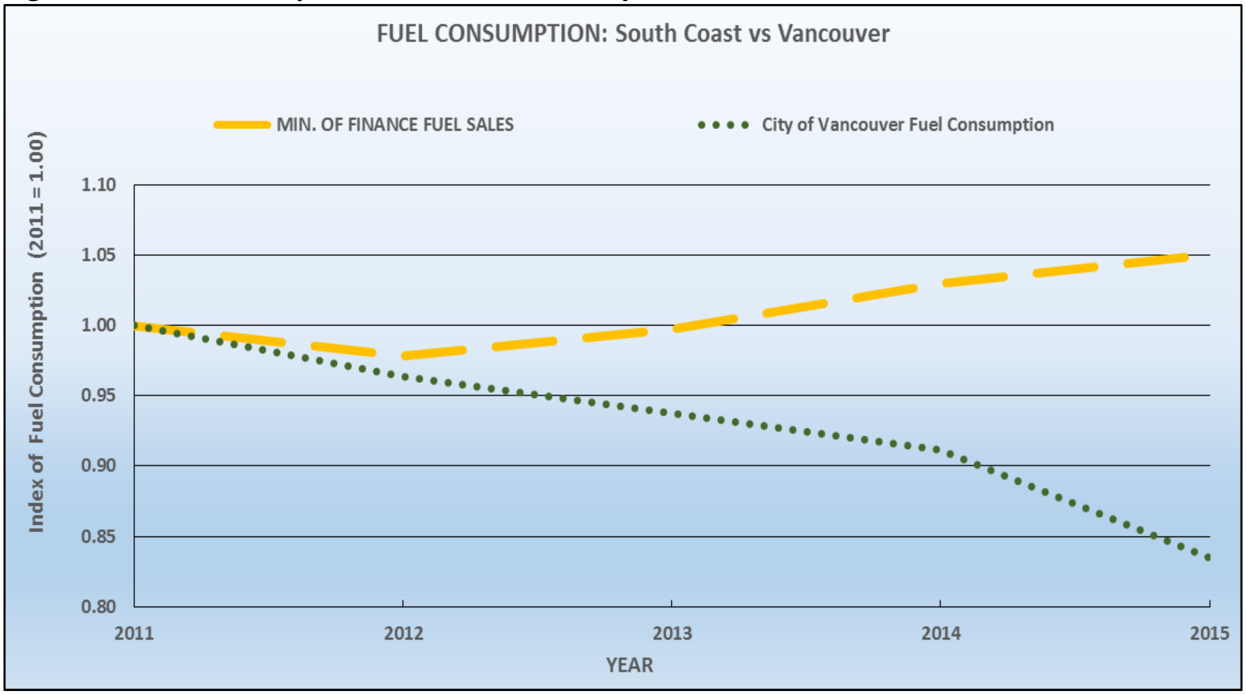
Figure 1 on the following page contrasts fuel sales for the 2011 to 2015 period in the South Coast region as calculated by the Ministry of Finance with estimated fuel consumption in Vancouver as estimated by the city in its "*Greenest City*" report.[5] Ministry of Finance fuel sales encompass a region ("South Coast") slightly larger than Metro Vancouver and represent fuel sales to wholesalers and therefore on a month-to-month basis are not exactly equivalent to fuel consumption since there is some lag time between wholesaler purchases and retailer sales. Nevertheless, when looking at the trends in the percent change in consumption on an annual basis, these differences all but disappear.[6]

4 The estimates of fuel consumption rates (litres/100 kms) are based on data from our VKT/GHG Forecasting Model. This model was first developed in conjunction with the Ministry of Transportation to estimate fuel taxes, later with the Ministry of Environment to estimate municipal-level GHG emissions, and in 2013-2014 it was expanded and enhanced in collaboration with TransLink to incorporate a variety of transit variables in order to better estimate driving behaviours at the municipal level. Each registered passenger vehicle in BC in each quarter (since 2001) is assigned a fuel consumption rate based on Natural Resources Canada (NRCan) and US Environmental Protection Agency (USEPA) average fuel efficiency estimates. The subset of vehicles registered in Vancouver was averaged to estimate overall average fuel consumption rates. Note that these rates may not have declined as fast as some may expect since the proportion of Pickups and SUVs in the overall stock has risen considerably over the last decade, damping efficiency gains. For a more comprehensive discussion of changes in average consumption rates and vehicle proportions over time, see http://pacificanalytics.ca/autostat and the article "Vehicle GHG Emissions in Metro Vancouver and Vancouver: 2005-2015"

5 For the 2011 data release, the Ministry of Finance undertook a major methodological update to its estimation procedure to better capture sales within the South Coast. Accordingly, the pre-2011 data are not comparable to later data and, unlike data since 2010, do not fairly represent sales in the South Coast region.

6 We plotted several variations of the Ministry of Finance data: three month moving averages to smooth the data; February to February and March to March totals to account for the difference in wholesale vs retail sales, but the overall trend lines remain the same as shown in Figure 1.

Figure 1: Fuel Consumption: South Coast vs City of Vancouver



Source: Ministry of Finance; City of Vancouver: *Greenest City Action Plan*

These trends in South Coast sales since 2011 are strongly indicative of fuel consumption in the region; as can be seen, fuel sales began rising from 2012 onward. Contrast that to fuel sales estimated in the *Greenest City* report which suggests a decline every year since 2011 and by 2015 the estimate is over 22% lower than what actually happened in the South Coast as a whole.[7] One must ask whether such a significant difference in driving behaviour in Vancouver versus the South Coast as a whole is likely and, if true, what would have caused this major variance.

VKT/GHG FORECASTING MODEL

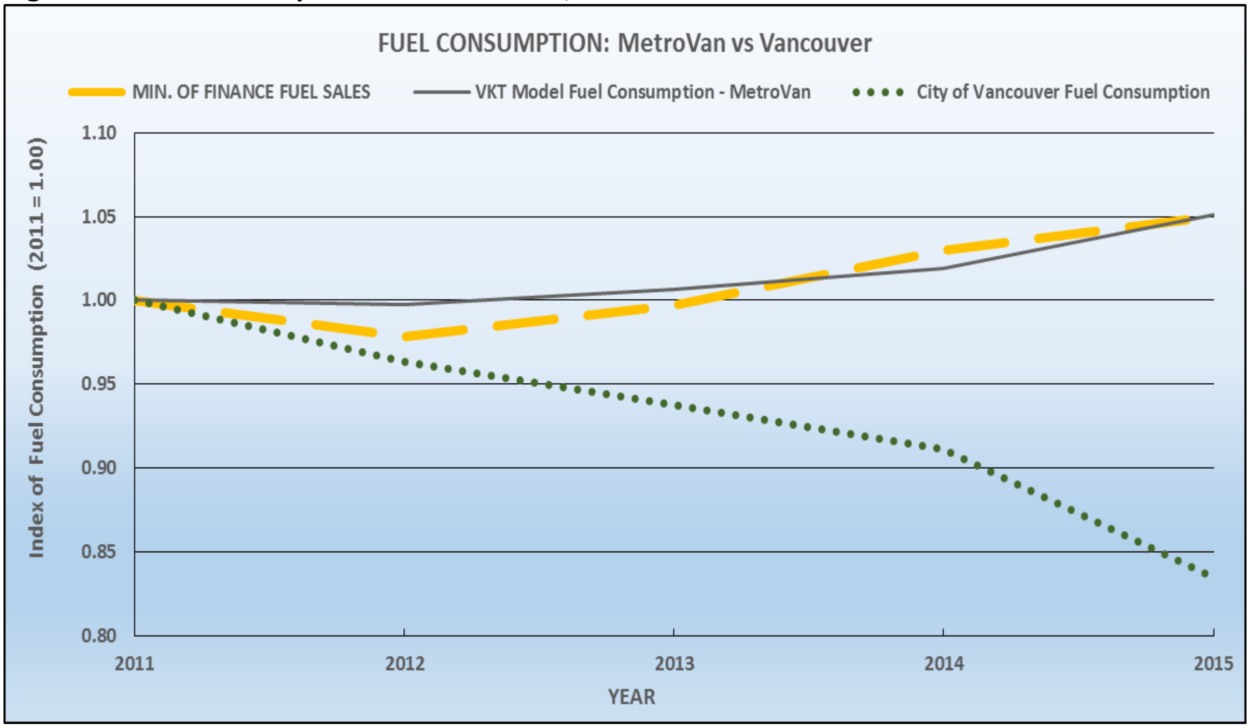
The VKT/GHG Forecasting Model[8] was developed over the last decade, first for the Ministry of Transportation, then for the Ministry of Environment, and later for TransLink in order to estimate vehicle GHG emissions for each municipality. It was used to generate the Community Energy and Emissions Initiative (CEEI) municipal GHG estimates for 2007 and 2010 released by the Ministry of Environment in 2014. In a nutshell, the Model calculates municipal fuel consumption based

[7] The growth in the number of passenger vehicles between 2011 and 2015 was slightly higher in Metro Vancouver (~6.5%) than in the City of Vancouver (~3.7%) and thus one would expect total fuel consumption in Vancouver, all other things equal, to be around 3.0% lower (the improvement in fuel consumption rates was actually slightly better in Metro Vancouver). Since the *Greenest City Update* indicates that the fuel consumption difference was 22% lower, this only could have occurred if average VKT per vehicle fell by 20% per vehicle compared to Metro Vancouver over the 2011 – 2015 period.

[8] A comprehensive description of the Model including all variables used in the Model can be found at the website http://pacificanalytics.ca/autostat

on the detailed stock of vehicles multiplied by the average fuel consumption rates (litres/100 kms) by vehicle class multiplied by the average vehicle kilometres travelled (VKT) by vehicle class where stock and average consumption rates are actuals and the estimates of VKT are econometrically determined.[9] The results of the Model are displayed in **Figure 2** below.

Figure 2: Fuel Consumption in South Coast, Metro Vancouver and Vancouver



Source: Ministry of Finance; VKT/GHG Forecasting Model; City of Vancouver: *Greenest City Action Plan*

What is obvious is that the Model results for Metro Vancouver closely track the trend in fuel sales issued by the Ministry of Finance for the South Coast region. And indeed, the drop in Ministry fuel sales in 2012 in contrast to relatively flat fuel consumption estimated by the Model for the

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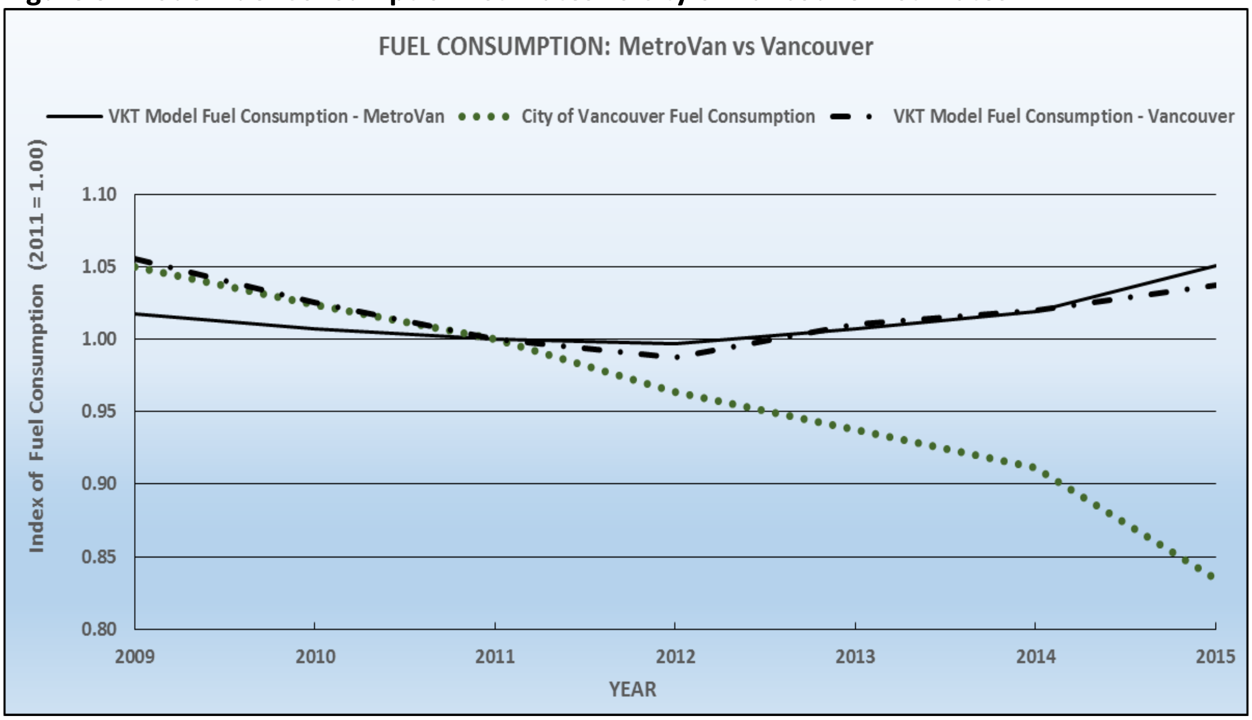
[9] A quick summary of the Model is as follows: The Model comprises 16 different vehicle classes (small cars, large cars, SUVs, pickups, minivans, medium-duty pickups, medium-duty vans, RVs, motorcycles, heavy city trucks, heavy highway trucks, small buses, large buses, small transit buses, large transit buses, and taxis), each split by 2 licence types (driving for pleasure only and to or for work purposes) and 5 fuel types (gasoline, diesel, hybrid, other, and electric) and split out for each model year. The vehicle stock are actuals derived from ICBC for each quarter from 2001. The fuel consumption rates are taken from the Natural Resources Canada (NRCan) database of fuel consumption rates by vehicle type and model year augmented by similar data from the US Environmental Protection Agency (USEPA).

The VKT estimates (by each vehicle type – e.g., small gasoline vehicles driven for pleasure) are econometrically derived using the explanatory variables: fuel prices; incomes; vehicle age; age of driver; sex of driver; average distance from Central Business District (downtown Vancouver); average distance from Regional Town Centre; density, access to transit; access to roads; transit fare cost; bus hours, Expo Line hours, Millennium Line hours; Canada Line hours; Seabus hours; West Vancouver Bus hours; West Coast Express Rail hours; West Coast Express Bus hours. An example of one of the regressions can be found in Appendix A.

same year can be explained in large part by the substantive increase of Metro Vancouver vehicles crossing the US border in that year and purchasing fuel, a fact which would lower fuel sales in the Metro Vancouver but not fuel consumption.

The Model estimates for Metro Vancouver are consistent both in absolute terms and in trends with known values provided by the Ministry of Finance. Indeed, in absolute terms the Ministry and Model values for gasoline sales are within 1%.[10] So how does the Model, populated by Vancouver-specific stock and fuel consumption rate data and using regression equations based on Vancouver-specific vehicles and variables, track fuel consumption? **Figure 3** displays the trends in fuel consumption based on these data and contrasts that against the Metro Vancouver results and the *Greenest City* estimates.

Figure 3: Model Fuel Consumption Estimates vs City of Vancouver Estimates



Source: VKT/GHG Forecasting Model; City of Vancouver: *Greenest City Action Plan*

The Model data for Vancouver directly tracks the *Greenest City* estimates for the 2009 to 2011 period and then begins to diverge, drastically after 2012. We must ask the question: what in the two methodologies/data sources/assumptions might explain the difference and most importantly which is more analytically sound?

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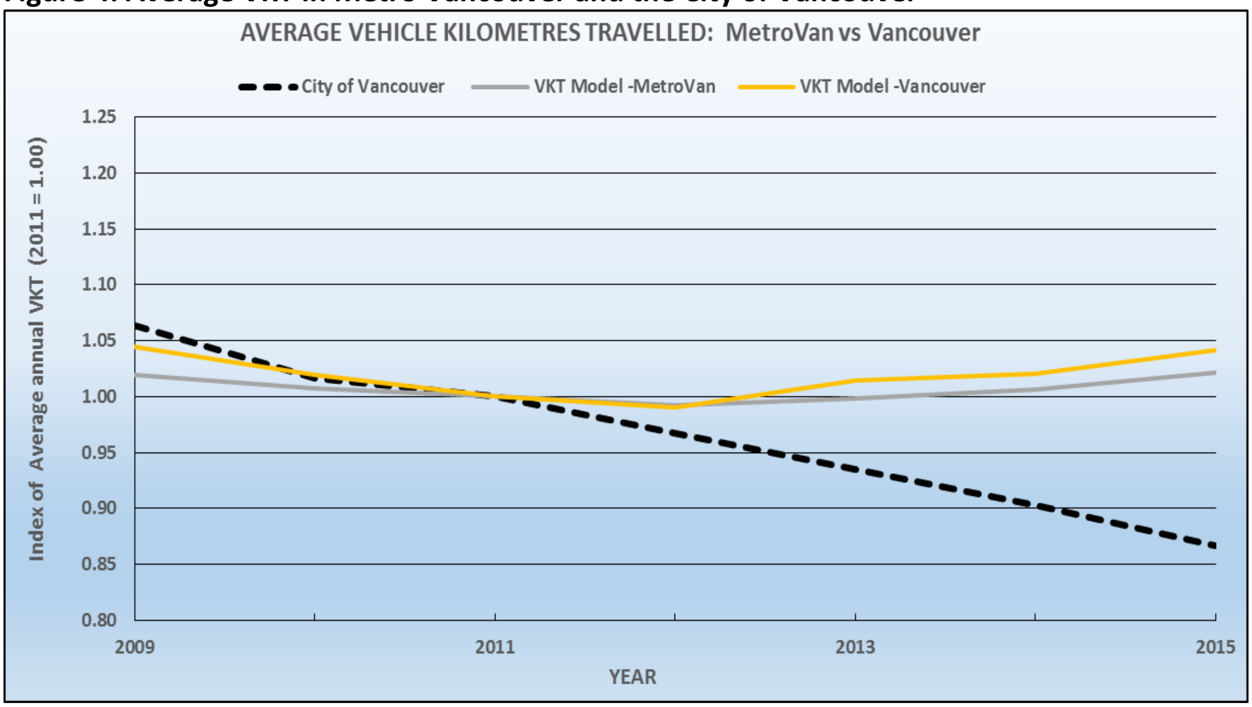
[10] It is unlikely the two values would match exactly. First, Ministry values are sales and not consumption and include areas not included in Metro Vancouver. At the same time, MetroVan residents purchase some of their gasoline and diesel in other regions of the province or in the US and some non-MetroVan residents travel to the region and purchase gasoline and diesel.

THE DATA AND METHODOLOGY FOR VKT ESTIMATES

The essential difference between the fuel consumption estimates produced by the VKT/GHG Forecasting Model and the *Greenest City* estimates are the trends in average VKT over time. **Figure 4** below displays the average VKT (per passenger vehicle) as estimated by the VKT/GHG Forecasting Model (for Vancouver and for all of Metro Vancouver) and for Vancouver as estimated in the *Greenest City* report (per capita values were converted to a per registered vehicle value for this graph). As highlighted, average VKT over the 2009 to 2011 period tracks more-or-less the same trend for all three estimates, but starting in 2012 and continuing through to 2015, the *Greenest City* estimate display a substantively different profile. Indeed, where the estimates generated in the VKT/GHG Forecasting Model show a slight increase over that time for both MetroVan and Vancouver, the *Greenest City* values display a large and consistent decline.

Figure 4: Average VKT in Metro Vancouver and the City of Vancouver



Source: VKT/GHG Forecasting Model; City of Vancouver: Greenest City report

The VKT estimates generated by the Model are influenced by a number of factors (see footnote 9 for a list of variables). Most important is the trend in fuel prices over this period. Gasoline went from a pump price of $1.12 per litre in 2011 to $0.96 in 2015. This drop in price would have caused average VKT to increase by roughly 1.9%[11] all other things equal. But things were not equal over that time period:

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[11] See http://pacificanalytics.ca/autostat for a copy of a report "The Impacts of the Carbon Tax on Vehicle Fuel Usage in Metro Vancouver" for a discussion of fuel price elasticities and how other factors such as incomes, transit fares, bus hours, and the like affect average driving behaviour for each vehicle class.

- average real incomes increased (by ~2.3%) leading to higher average VKT;
- real dollar transit fares increased by over 11% (higher fares reduces the incentive to take transit and lead, all things equal, to higher average VKT);
- Expo/Millennium Line hours declined slightly over the 2011-2015 period (in contrast, the Canada Line did increase its hours, a fact recognised in the econometric equations); and
- the proportion of small cars (which generally are driven less) shrank over that period and the proportion of SUVs and Minivans (which generally are driven more than small cars) grew fairly strongly.

Accordingly, concrete factors influencing driving behaviour mostly tended to encourage greater driving over the 2011 – 2015 period both for vehicles in the City of Vancouver and for vehicles registered in the larger area of Metro Vancouver.[12]

In the *Greenest City* document VKT estimates are based on data from the AirCare database. Two sets of AirCare data were provided to the City of Vancouver. The first set of data were for the years prior to 2011 where annual[13] VKT estimates by each vehicle going through AirCare were used to calculate average VKT by age of vehicle. While these data have their own issues, our focus in this paper is on the 2012 – 2015 period, and therefore a full assessment of those earlier estimates is not provided in this paper.

In the second set of data from 2011 to 2014 only odometer readings were provided. In this case, "annual" estimates were calculated based on two year averages: the difference between 2013 and 2011 odometer readings divided by two (for 2012) and the difference between 2014 and 2012 odometer readings divided by two (for 2013).[14] The estimates for 2014 were "extrapolated" (that is, the trend line was continued).

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[12] Some may argue that there is a higher incidence of car sharing, biking lanes and walkability in Vancouver. While these factors likely did lead to a reduction in driving, much of the increase in these commuting trips were offset by a decrease in transit use, that is, people moved from transit to biking or walking and therefore did not impact driving as much as supposed. http://vancouversun.com/news/local-news/vancouver-leads-the-pack-for-bike-commutes.

[13] "Annual" is a misnomer. The odometer reading (to the nearest 1,000 kms) is recorded for each vehicle going through AirCare and this value is compared to the odometer reading from that vehicle's previous AirCare record and converted to a yearly value. Since the majority of vehicles (and no vehicles younger than 7 years) go through AirCare only every two years, the "annual" VKT estimate really is an average for the preceding two years. In addition, in any given year, much of the VKT will have taken place in the previous year – a vehicle going through in January would be counted in that year, but almost all the driving took place in the previous year. In addition, many older vehicles are driven part time – vehicles older than 20 years are on average registered only 86% of the time. If not corrected for, this will affect the average VKT estimate for many vehicles in the AirCare database. Based on all these factors, the "annual" values are a very poor reflection of actual driving in any one year.

[14] The issues with the pre-2011 data apply to these later data as well. It should be noted that the VKT/GHG Model also uses AirCare data (enhanced by other odometer readings), but the data were adjusted to account for time-of-year driving and part-time driving, and of course, the estimates are identified by type and class of vehicle.

From these data, an estimate of annual VKT for each vehicle age was calculated for vehicles older than seven years and a (more-or-less straight-line) trend line plotted in order to get average VKT estimates for newer vehicles[15]. Average VKT in 2013 and 2014 were estimated based on the average age of the annual ICBC vehicle stock or 9.2 years and 9.3 years respectively (based on quarterly data from our VKT/GHG Forecasting Model, these average ages were 9.13 and 9.21 respectively). Applying these estimates to the plotted trend line, the *Greenest City* report calculated a decline in average VKT (per vehicle) from 11,872 kms in 2013 to 11,455 in 2014, or a decline of 3.5%.

ISSUES WITH THE DATA AND METHODOLOGY

As alluded to in footnote 13, it should be apparent that there are serious problems with the data used in this methodology:

1. First, an average over two years is not a good indicator of annual values;
2. Second, much of the recorded driving in any AirCare record takes place in the previous year;
3. Third, no adjustment for part-time driving was undertaken;
4. Fourth, no vehicles with a model year later than 2007 are included in the data. Since these vehicles represented 42%of all vehicles on the road in 2014, this is a serious limitation of the data; and
5. Fifth, the AirCare odometer readings are accurate only to the nearest 1,000 kilometres and as such the annualised "difference" value could be out by as much as 1,000 kilometres, far more than the estimated difference of 417 kilometres used in the *Greenest City* report to calculate the 3.5% decline.

Even if the data were acceptable, there also are issues with the methodology itself:

1. Most important is that the change in VKT is directly linked to the change in the average age of vehicles. If average age increases (as it did in 2014) then the estimate of average VKT declines regardless as to what has happened to factors we know influence driving behaviour: fuel prices, incomes, transit fare costs, etc. Using an extreme case, if there were a transit strike and people were forced into their vehicles, this methodology would still estimate a decline in VKT;
2. Second, a straight-line trend does not reflect the reality of driving behaviour by age of vehicle;

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[15] A straight-line trend line suggests that each additional year of vehicle age reduces the number of kilometres driven the same amount. A review of the data dispels this view. New vehicles experience quite small reductions in average VKT for the first few years, but the average VKT then begins falling (small gasoline cars, for example, reduce their annual driving by approximately 3,000 kilometres between age 4 to age 9) only to start levelling out after age 10 (between age 10 and age 20 small gasoline cars reduce their annual VKT by about 1,000 kilometres).

3. Third, the methodology does not account for the difference in the proportion of vehicle classes in the AirCare dataset versus the proportion in the actual stock. As stated earlier, the AirCare data do not include any vehicles younger than seven years and therefore do not reflect the lower proportion of small cars and higher proportion of SUVs and Minivans that is found in the actual stock;
4. AirCare ended in December, 2014 and as such there are no data for the period after 2014. Extrapolating the recent trend to later years clearly is not correct. The 2015 Update does not provide an update to the methodology, but based on discussions with City staff, it appears that the 2015 estimates (a decline of 7.7% over 2014) were based on a sample of self-reported drivers. Whether this sample takes into account differences in vehicle classes, licensing and fuel types, vehicle ages, part-time driving, age and sex of drivers, road and transit access, etc. is not clear. What is clear is that, if the sample does not stratify for all these factors, even if self-reporting is valid (experience tells us not), the results are likely not indicative of changes in driving.

Let us summarise the situation. We know from the Ministry of Finance that fuel sales in Metro Vancouver – and thus average VKT in Metro Vancouver – increased over the 2012 to 2015 period. We also know that the AirCare data used in the *Greenest City* report is what is generating the estimates of a significant decline in VKT for Vancouver. If it is true that average VKT in the City of Vancouver declined significantly over this period, it must also be true that the trends in AirCare data for Metro Vancouver must be significantly different from the same trends in data for Vancouver. Indeed, as we saw in **Figure 4**, it must be true that the AirCare difference between Metro Vancouver VKT trends and City of Vancouver VKT trends must be in the order of 15%.

And there's the rub – there is no major difference. Indeed, for a number of vehicle classes (large cars driven to/from work and all SUVs), the trend in average VKT in the AirCare data over the 2011 to 2014 period was higher in Vancouver than in Metro Vancouver as a whole. **Figure 5** on the following page displays the weighted changes in average VKT for Metro Vancouver and the City of Vancouver contained in AirCare data.[16] What is abundantly clear is that there is virtually no difference between the AirCare data for Metro Vancouver and for the City of Vancouver. In crystal clear language: the data used in the *Greenest City* report do not support the finding that the change in average VKT in the City of Vancouver since 2012 is more than 15% lower than in Metro Vancouver.

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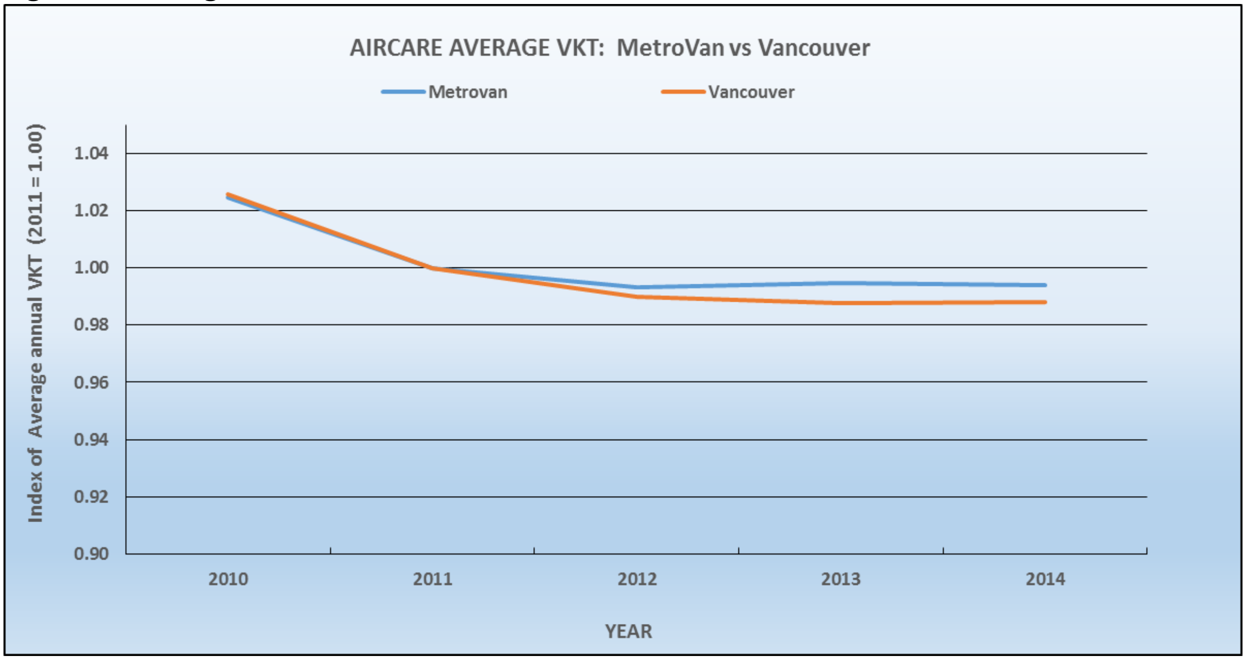
[16] It is important to reiterate that the AirCare data only include vehicles older than seven years. As such **Figure 5** does not reflect the trends in overall VKT, only in those data contained in the AirCare dataset. Despite this, the premise is still valid: for the trend in average VKT in Vancouver to be 15% lower than in Metro Vancouver, it must be true that the trend in AirCare data for the two regions must also differ by roughly that amount.

Figure 5: Average VKT derived from AirCare Data



Source: AirCare data

An earlier version of this study was shared with staff at the City of Vancouver for their comments. In discussions with those not involved with the *Greenest City* initiative, an interesting fact came up: data from the Kent Group detailing fuel sales by service station within the Vancouver boundaries indicates that fuel sales over the 2011 to 2015 period increased by roughly 5% or more-or-less the same as what the VKT/GHG Model is suggesting.[17] The conclusion is surprising but clear: not even the City of Vancouver agrees with the *Greenest City* findings.

From the analysis it is evident that the data and methodology employed by the City of Vancouver for estimating average VKT is not reliable for the 2011 to 2015 period, and further, that it does not support the finding that Vancouver is achieving its stated vehicle GHG emissions target.

The methodology used also has another issue: while perhaps not as important as being able to estimate changes in average VKT accurately, a key deficiency is that the approach adopted by the City of Vancouver does not enable one to estimate what is actually causing those changes in VKT. From a strategy and/or planning perspective, it is critical to know whether VKT is (say) declining due to factors totally outside the influence of the city/region – such as the price of fuel or changes in average incomes – or due to factors such as better and/or lower cost transit, better land use and zoning initiatives, or changes to transit and road access.

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17 www.kentgroupltd.com. Kent fuel sales in Vancouver do not, of course, reflect perfectly fuel use by Vancouver vehicles. However, when looking at the percent change over time, it is highly likely that the changes in Kent fuel sales are closely aligned with actual Vancouver vehicle fuel consumption.

CONCLUSION

The City of Vancouver has embarked on an ambitious and commendable initiative to reduce its environmental footprint with the aim of becoming the greenest city in the world by the year 2020. They have set stringent targets with published assessments of their accomplishments and, where possible, are providing quantitative measurements of those achievements. That said, confidence in the data and the methodology used to derive those measurements is critical to public buy-in; indeed, a major challenge in trying to become the “greenest city” depends on managers and residents having access to accurate and credible data on actual environmental performance.

Neither the data nor the methodology used to estimate vehicle GHG emissions in Vancouver meet that standard. We are not the only group to question Vancouver’s achievements regarding vehicles; indeed, many analysts are aware that the very large reductions in kilometres driven reported by the City simply cannot be triangulated with either anecdotal evidence of driving activity or other data sources. We are, however, among the first to lay out the data and methodological problems with the City’s approach and to provide an alternative: the same technique used by the Ministry of Environment (CEEI) and by TransLink to generate municipal estimates.

If the City is to make progress on and maintain its credibility in its GHG reduction targets and initiatives, we believe a new measurement approach for vehicles is required. This is especially true now that the AirCare data has disappeared. Indeed, the City has the opportunity to shift to a more sophisticated, reliable and tested estimation technique that not only will meet the challenges of producing credible and timely estimates of vehicle GHG emissions, but also has two additional advantages: the capacity to inform the City as to what factors are leading to changes in driving behaviour and by how much; and the ability to generate future scenarios of GHG emissions and to test the implications of changes in important factors. For example, what will be the consequences of increasing the carbon tax; how are electric vehicles going to change the emission profile in coming years; how will different zoning regulations change emissions; how will an increase in future transit availability affect driving behaviour? Of course, the City also will need to acknowledge that trends in its vehicle emissions are not currently compatible with *Greenest City* ambitions.

A copy of this report can be downloaded from: http://pacificanalytics.ca/autostat

APPENDIX A: Example of a Regression Equation for Estimating VKT

REGRESSION EQUATION FOR SUVs PG (Pleasure, Gasolne)

Dependent Variable: LOG(KMS)				
Method: Panel Least Squares				
Date: 06/11/16 Time: 10:44				
Sample: 2002Q1 2014Q3 IF CSD = 22				
Periods included: 51				
Cross-sections included: 24617				
Total panel (unbalanced) observations: 237351				
White diagonal standard errors & covariance (d.f. corrected)				
	Coefficien	Std. Error	t-Statistic	Prob.
C	7.295436	0.334754	21.79341	0
Q1	-0.02281	0.001697	-13.4366	0
Q2	-0.01013	0.001588	-6.37773	0
Q3	0.007891	0.00144	5.481666	0
LOG(R_GAS_A)	-0.13958	0.011424	-12.2178	0
LOG(ALL_INC_0)	0.098568	0.032415	3.040798	0.0024
LOG(VEH_AGE)	-0.08048	0.010332	-7.78915	0
AGE16	0.009454	0.014873	0.635623	0.525
AGE65	-0.03848	0.005224	-7.36556	0
SEX	0.062148	0.004987	12.46094	0
CBD	0.004925	0.001193	4.12686	0
RTC	0.003868	0.001757	2.201102	0.0277
DENSITY	-0.00027	0.0000717	-3.79412	0.0001
FARES	0.000203	0.000337	0.601858	0.5473
BUS_HOURS	-3.4E-07	0.000000023	-14.793	0
EXPO_MILL+CANADA	-5.6E-07	3.33E-08	-16.7738	0
SEABUS	-2.5E-06	0.00000287	-0.88263	0.3774
0	0	0	0	0
0	Effects Spe	0	0	0
0	0	0	0	0
Cross-section fixed (dummy va	0	0	0	0
0	0	0	0	0
R-squared	0.810311	Mean dependent var	0	7.735204
Adjusted R-squared	0.788346	S.D. dependent var	0	0.507717
S.E. of regression	0.233579	Akaike info criterion	0	0.027404
Sum squared resid	11605.76	Schwarz criterion	0	1.104391
Log likelihood	21380.78	Hannan-Quinn criter.	0	0.342046
F-statistic	36.89056	Unadj. Durbin-Watso	0	0.26068