Total Societal costs for different commuting options in the city of Calgary; Comparing Transit, Automobile and Cyclist Costs.

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Abstract

Many groups support public transit and promote it by illustrating cost savings[1]. Costs usually include the full cost of owning a vehicle but for public transit it includes only the rider's cost of a transit ticket. This does not seem to be an accurate reflection of the true costs as transit is supported with public funding and many other costs like safety, health and environmental impact are not considered. This study aims to calculate and compare the full societal cost of using personal vehicle, public transit or cycling to work in Calgary.

Introduction

This study introduces some of the societal costs involved in the three commuting options, using personal vehicle, public transit or cycling. Using each option is influenced by number of factors. Two main factors are the "Direct Cost" factor and "Indirect Cost" factor. The direct cost factor includes "Infrastructure cost" and "Personal cost". The indirect cost factor include "Safety", "Health" and "Environmental Impact" aspects of using each commuting option. It makes several assumptions to estimate costs but the study can be useful in making cost comparisons between different travel modes and evaluating cost impacts that are mostly hidden from the public's view. This analysis can be used by transportation planners and to explain the full costs of commuting options to the public.

The paper continues with presenting an introduction and best estimations for infrastructure as well as personal costs for each option. It, then, evaluates indirect cost and offers an estimation for them as tangible dollar values. By analyzing the direct and indirect costs for each commuting option, a conclusion is drawn. At the end, some recommendations for further investigations and or studying is listed.

Infrastructure Costs

The first step in calculating the total societal cost of different modes of travel is to determine the direct cost of commuting infrastructure. . Infrastructure cost can be further divided in two categories: the operating cost and the capital cost. Both these costs are involved in providing the infrastructure for public transit, roads and pathways.

Operating costs of transportation systems

The operating costs of the system include costs to maintain and operate the physical infrastructure. This includes costs to repair traffic control devices, pavement, rail tracks, bus fleet and other transportation infrastructure. This also includes costs to operate the system, like drivers' wages, fuel, snow and ice control, sweeping and other operational costs.

According to the City of Calgary's 2004 financial statements[2], Transit's operating budget was $190 Million and Roads' operating budget was $121 Million for 2004.
The total pathway and on street bikeways costs were estimated at $2.16 million per year. This cost is derived from the Roads operating costs to maintain pathways. Roads spend $400,000 per year on 150 km of pathways[3]. The total system available to cyclists is 810 Km (550 Km pathways and 260 Km on street bikeways[4]). The cost is, therefore, extrapolate for 810 km, based on the 150km known to the author (the data accuracy can possibly be improved).

According to the 2001 Civic Census Travel to Work Survey [5], 15.4% of Calgary's commuters used public transit to commute to work, 78% used automobiles and the rest used other modes like walking, cycling or motorcycles. Calgary Transit[6] provided 117.4 million trips in 2004.
Based on "Vehicle Kilometers Traveled Report" [7] Transportation Planning estimated 39 million kilometers are driven on roads per weekday in 2001.
According to the 2001 survey[5], 4800 bicycle trips are made to work per day. This number was extrapolated to 5138 per day at a 2% growth rate for the last 4 years. With this data, we can estimate that 1.2 million bicycle commuting trips are made per year (assumed 238 commuter days per year). Another study[8] shows that cyclists make 38% of the trips on pathways and on street bikeways. According to that study, the average commuter trip is 12 km one way.

The following table summarizes the above data (numbers are rounded in the report).

Table 1: Operating Cost per Transportation Mode

Data	Transit	Roads	Pathways
Infrastructure Operational Costs	$190 M / year	$121 M / year	$2.16 M / year
Trips or kilometers per year	117.4 million trips (revenue and non revenue generating)	11103 million km per year or 39 million km/day (Car sharing was not taken into account*)	1.2 million trips per year or 5138 trips per day
Direct operating cost per trip.	190 / 117 = **$1.62 per trip**	121 / 11103 = $0.011 per km Total trip = cost/km x 12 km per day = **$0.12 per trip**	2.16 / 1.2 (x 38% for cyclists only[9]) = **$0.67 per trip**
Roads Costs	**$0.12 per trip** (Note LRT usage was ignored*****)	No additional Assignment	No additional Assignment
Total (per trip)	**$1.75**	**$0.12**	**$0.67**

*Areas where numbers can be improved

Capital costs of systems

The following section estimates the total annual capital costs of the system. These costs include the costs to build the system and major rehabilitation costs. It also includes the developers' costs in new subdivisions and expenditures by The City and The Province on transportation assets.

As the annual capital expenditure greatly varies from year to year, the average cost was estimated based on the total asset value divided by the estimated life of the assets. Developers' costs as well as the City and Provincial costs are included by using this method.

In order to calculate the cost the following data was used:

- According to the City of Calgary's Infrastructure status report[10], Roads' asset base is $7.9 Billion and Transit's $1.8 Billion.
- The on street bikeways and pathways are estimated at $103 million. This cost is derived from the Roads' asset valuation of its pathways. Roads estimated that the pathways are worth $19 million[3]. The total system available to cyclists is 810 km (550 km pathways and 260 km on street bikeways[4]). The cost is therefore extrapolated for 810 km, based on the 150 km known to the author. *The data accuracy can possibly be improved*.
- The average life of the assets are estimate at 32 years for Transit, 38 years for Roads and 14 years for pathways[10].

The following table summarizes the above data (numbers are rounded in the report).

Table 2: Capital Cost per Transportation Mode

Data	Transit	Roads	Pathways
Total Infrastructure Value	$1.8 Billion	$7.9 Billion	$103 Million
Average Life	32 years	38 years	14 years
Total infrastructure costs per year	1.8 / 32 = $56.25 M / year	7.9 / 38 = $207.89 M / year	103 / 14 = $7.33 M / year
Trips per year (Repeated from Table 1)	117.4 million trips	11103 million km per year (Car sharing was not taken into account*)	1.2 million trips
Direct infrastructure cost per trip.	56.25 / 117.4 = **$0.48 per trip**	207.89 / 11103 = $0.019 per km Total trip = cost/km x 12 km per day = **$0.228 per trip**	7.33 / 1.2 (x 38% for cyclists only[9]) = **$2.26 per trip**
Roads Costs	**$0.23 per trip** (Note LRT usage was ignored*****)	No additional Assignment	No additional Assignment
Total (per trip)	**$0.70**	**$0.23**	**$2.26**

*Areas where numbers can be improved

Total Infrastructure cost for commuting

By adding the operating and capital cost and multiplying it by 2 (number of commuting trips per day), we can estimate the total cost per day for the different transportation modes: (note Table 3 is based on Tables 1 & 2 and again numbers are rounded in the report)

Table 3: Total Cost per Transportation Mode

Data	Transit	Auto	Cyclist
Operating Costs	$ 1.75	$ 0.12	$ 0.67
Infrastructure Cost	$ 0.70	$ 0.23	$ 2.26
Total Costs per trip	$ 2.45 / trip	$ 0.35 / trip	$ 2.93 / trip
Total Costs per Day	**$ 4.91 / day**	**$ 0.71 / day**	**$ 5.84 / day**

Additional Personal Costs

The following costs represent the additional individual costs for different transportation modes.

Transit

The Transit system is financially supported by fare paying riders and by property taxes. As the analysis above include all the costs incurred to provide the Transit system in Calgary, no additional personal cost were added in the analysis.

A small percentage of riders pay an additional fee for reserved parking at Transit stations. The percentage of riders that pay for parking is currently insignificant in comparison to the total riders and was not included in this analysis.

Table 4: Additional Transit Costs

Total Additional Transit Costs not included before	**$0 per day**

Auto Users

Automobile users can choose from a myriad of vehicle options. New cars are the most expensive to own and operate, whereas a used compact is less expensive. See "Victoria Transport Policy Institute" (www.vtpi.org) for some interesting statistics on vehicle ownership. For this study, one car that CAA[11] provides data on was chosen. This cost is probably on the lower end compared to some of the cars in Calgary.

CAA estimates the total cost of operating a Chevrolet Cavalier Z-24, if it is driven 18,000 Km per year, will cost the owner $0.52 per kilometer. The total cost of ownership include maintenance, fuel, insurance, licensing and capital cost.

In Alberta, 19¢ of every liter of gasoline is additional tax levied for transportation (Petro-Canada[12]). This is over and above the GST charge. As our analysis already includes all the transportation costs, this tax should be subtracted from the ownership costs. At 10 Km/L[13] the additional fuel tax work out to 1.9¢ per km. The total cost for the Cavalier then is $0.50 per km.

Parking is very expensive in downtown Calgary. The Calgary Downtown Association[14] estimates it at $13 on average for daily parkers (2003). As most auto users to downtown pay this fee, it was included in the analysis.

Table 5: Additional Auto Cost

COSTS	Personal Auto Costs
Total Ownership Costs	$0.50/km x 24 km/ round trip = $12.02 per round trip
Parking	$13.00
Total Personal Commuter Costs	**$25.02 per day**

Cyclists

Cyclist can choose from a myriad of bicycles and accessory options. The table below calculates some arbitrary costs for a cyclist. Individual cyclists can spend less or more according to their preferences.

Table 6: Commuter Cyclists Costs

Capital Cost For Riders	
Commuter Bicycle	$300.00
Clothing	$290.00
Helmet	$40.00
Lights	$20.00
Back Pack	$30.00
Water Bottle	$15.00
Bells	$5.00
Total Capital Costs	**$700.00**
Operating Costs per year	
Batteries for Lights	$100.00
Tires	$60.00
Other	$40.00
Total Operating Cost	**$200.00**

By dividing the above costs by 238 commuter days, the total cost of $1.43 per day can be calculated (capital cost depreciated over 5 years).

In addition, a cyclist that rides twice a day will consume an additional 500 calories per day[15]. The cost of eating bananas[16] to recover the additional 500 calories is about $1.00.

Table 7: Cyclist Personal Cost

COSTS	Personal Cyclist Costs
Total Ownership Costs	$1.43 per day (no parking fees)
Additional Food	$1.00 for 500 calories
Total Personal Commuter Costs	**$2.43 per day**

Total Infrastructure and Personal Cost (mostly direct costs)

We are now ready to add the infrastructure and personal cost for the three options. By summarizing tables 3 to 7, the total costs are as follows:

Table 8: Total Infrastructure and Personal Costs

Mode	**Infrastructure Costs per day**	**Personal per day**	**Total Costs per day**
Transit	$ 4.91	$ 4 Adult (fare included in the $6.78, and ignored in total cost)	$ 4.91
Auto	$ 0.71	$ 25.02	$ 25.73
Cyclist	$ 5.84	$ 2.43	$ 8.27

Note that this table does not include health, safety and environmental costs discussed later in this paper. These costs are substantial and dwarf the direct infrastructure costs shown above.

From Table 8 the following observations can be made:

- Transit provides the lowest total direct cost when comparing infrastructure and personal costs.
- Using a personal vehicle for commuting in Calgary is by far the most expensive option. Even if three people share the car, it is still more expensive than the other modes.
- Infrastructure costs (mostly roads) for automobiles are the least expensive. This is because economies of scale lower the overall cost for the individual user.
- The roads infrastructure costs, when compared to other costs highlighted in this paper, is relatively small per user. Property costs (roads land use) are however not included and could have a significant impact on the total cost.
- Cyclist costs are much higher than most people will intuitively believe. This is partly due to the current low number of cyclists. If the number of cyclists doubles to 10,000 per day (a small percentage of total commuters), the infrastructure cost will be substantially lower.

Other aspects to consider (mostly indirect costs)

The following costs are mostly indirect societal costs that are harder to quantify. Some studies have estimated these societal costs and they were applied to this study where possible.

Safety

In 2002[17], All the roadway accidents in Alberta cost the Province $4.68 Billion. This includes direct medical costs and indirect costs of disabilities or loss of human lives. We can estimate this for Calgary to $1.5 billion per year (one third of Alberta's population).

In addition, Alberta Transportation reported the following collision statistics for 2004[18]:

- 0.3% - Transit Busses involved in injury accidents
- 1.9% - Cyclists involved in injury accidents
- 91.6% - Motorists involved in injury accidents
- 6.2% - Others

We can estimate that commuters in Calgary account for roughly a third of the road users per year and will account for a third of the accidents. (This was calculated by taking the number of commuters, multiplied by 24 km commuting per day, divided by total kilometers driven on Calgary's roads.)

Total societal cost in Calgary, allocated to commuters, for traffic accidents, can therefore be calculated at $ 408 million per year.

Also noteworthy is that personal auto insurance costs makes provision for traffic accident costs and were included in the personal cost section. This amounts to approximately 10c per km (CAA's rates**Error! Bookmark not defined.** of $1777 / 18000 in this example) and was deducted for auto users.

The calculations below provide a rough estimate of the costs. There is however, some evidence that commuters will have a lower fatality risk than highway and rural drivers. The assignment of costs may therefore be somewhat overstated. Most transit accidents will occur during commuting hours and should probably be higher than the analysis shows. Using the data above, we can compile the following table:

Table 9: Traffic Accident Costs per Transportation Mode

Costs	**Transit**	**Auto**	**Cyclist**
Total Accident Cost	$408M	$408M	$408M
Average Injury Accidents in Alberta per mode	0.30%	91.60%	1.90%
Total Costs per mode in Calgary (Accident percentage x Cost)	$1,224,122	$373,765,204	$7,752,772
Number of Commuters per mode (extrapolated with 8% from 2001 survey[5])	71280	365580	5184
Cost per Commuter per year	$17	$1022	$1495
Insurance fees		$0.10/km	
Cost per Commuter per day (Cost per commuter / 238 commuting days)	$ 0.07	$ 4.20	$ 6.28

Health

According to Katzmarzyk & Jansen[19], the total societal costs for inactivity in Canada (2001) was $5.3 billion. Of this cost, $1.6 billion are direct and $3.7 billion are indirect costs. They further claim Statistics Canada estimates that 53% of people are inactive in Canada. This is nearly 17.12 million of Canada's 32 million population[20].

This 17.12 million people therefore costs Canada $309.58 per year (5300 / 17.12 million), or $1.30 per commuter per day (309.58 / 238 commuter days).

By using a physically active transportation mode to work will eliminate the cost associated to being inactive. Cyclists will therefore avoid this cost.

Note that it is not implied that other commuters do not participate in some form of active lifestyle choices, but we can say for sure that cyclists will avoid this specific cost.

Table 10: Health Avoidance Costs

Mode	Health Avoidance costs
Transit	$ 0
Auto	$ 0
Cyclist	($1.30) per day (Saving)

The health cost of being stressed in traffic was not included. Some people will find it less stressful to drive and will prefer transit, walking or cycling.

Environmental Impact

The true cost of Green House Gases (GHG) to the environment is difficult to determine in terms of the long term effects. For example, what is the impact of climate change? The Kyoto protocol will allow nations and industries to trade GHG credits. A cost for this has been estimated by some agencies and was used in this study.

This cost does however not reflect the true societal costs on the environment. Additional health costs from pollution, depleting fossil fuels and other environmental impacts must be added, but are difficult to quantify. It was therefore not included in this study.

According to city officials[Error! Bookmark not defined.], the average vehicle in Calgary emits 6.3 kg of Carbon Dioxide (CO_2) per commuting trip (Transportation Canada[21] estimates a National average of 4.2kg). This is 0.53 kg per commuting kilometer (6.3kg/12km). A bus will emit only a quarter of this per passenger kilometer[22] or 0.13 kg per passenger kilometer.

Natsource LLC[23] estimates that GHG credits under the Kyoto protocol will sell between $2.5 and $9 per tonne on the global market. A $5 average per ton was used for this study (or $0.005 per kilogram).

Using this data and previous tables, we can compile the following.

Table 11: Environmental Cost of Transportation Modes

Costs	**Transit**	**Auto**	**Cyclist**
CO_2 Credits / kg	$ 0.005	$ 0.005	$ 0.005
CO_2 Emissions / passenger km	0.13	0.53	0
Total CO_2 emissions per day (24 km per commuting day)	3.12 kg	12.72 kg	0 kg
GHG Credit costs per day / commuter	$ 0.02	$ 0.06	$ 0.00

Total Costs (direct and indirect costs)

Based on the previous calculations the following table was constructed:

Table 12: Total Societal Cost per Commuting Option

Total Costs (per day)	**Transit**	**Auto**	**Cyclist**
Infrastructure Costs	4.91	0.71	5.84
Direct Personal Costs	Included Above	25.02	2.43
Traffic Accidents	0.07	4.20	6.28
Health			(1.30)
GHG Emission Credits	0.02	0.06	0.00
Total Societal Cost (per day per commuter)	$5.00	$30.00	$13.25

Analysis of results and some conclusions

This data can be useful to compare the relative impact of many indirect transportation costs on society. Below are some conclusions that can be drawn from the data.

The majority of commuters still use their personal vehicles for commuting. One reason for this is that they do not realize what the full cost of commuting is. Using the data above can illustrate the full cost to the public.

We may also conclude that many people are willing to pay the additional $25 dollars a day (or $12 dollars a day if parking is excluded) for the convenience of using a personal vehicle. This analysis did not include the economic value of time for commuters and it may be one of the reasons that people are willing to spend an additional $25 for using their personal vehicle. Commuters are probably also willing to pay additional charges for this convenience, in the form of tolls or other fee structures. Determining the price elasticity is key to know how much commuters are willing to pay more.

Some of the reasons that commuters do not use public transit are that Transit does not service the commuter's route adequately with capacity or because the commuter needs additional time for their trip (no direct service).

If transit service is expanded and more people use it, there will be a $12 to $25 saving per additional customer round trip, per day. Transit can therefore motivate any expansion plans with the savings that will result from every additional customer. As an example, by adding 10,000 commuters to the system, Calgary's citizens will save $28.5 million per year (10,000 x 12 x 238 days) or $285 million in 10 years.

From the analysis it is clear that traffic safety should be one of the main concerns for city planners and policy makers (14% of total societal cost for auto users and 47% for cyclists). If The City can prevent 10% of the accidents per year, it will amount to $150 million in savings to society. The cost of transportation system upgrades should therefore be compared to the possible savings from fewer traffic accidents.

Infrastructure costs are relatively low for auto users but high in comparison for cyclists. The easiest way to reduce the infrastructure cost per bicycle commuter is by increasing the number of pathway users. Secondly, cyclists are more vulnerable traffic users and their accident costs are the highest per commuter. This cost should be addressed to encourage more bicycle users.

Lastly, it should be noted that this study focused on the cost of commuting and the savings that can result from improving the options for commuters. It did however not address business costs associated to the transportation network and the benefits to society from road projects.

Recommendations for further studies

One of the factors not discussed in this study was the effect of economic values of time for commuters. The first assumption would be that people use their own vehicles because of their valuable time they loose using Transit or cycling. This assumption needs to be evaluated by some research studies, considering few scenarios and cases.

Cost of infrastructure differs from a city to city. This study did not compare cities in this regard. There is a possibility that transportation infrastructure costs highly depends on the urban development pattern. This, however was not addressed in this study.

This study could be enriched further by selecting certain routes and compare travel costs using Transit, Automobile and Cycle. More accurate conclusions can be drawn when infrastructure costs are based on the same route, rather than accumulative travel costs for the whole city.

Property and land use cost for developing roads and pathways are not considered. In order to achieve a more realistic estimations, those costs should also be considered.

This study excluded the weather conditions on using Transit, Automobile or Cycle. Apparently, the weather condition plays an important role in selecting the method of traveling. To obtain more accurate conclusions, the study should differentiate between traveling seasons.

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