Mobility Pricing Analysis with the RTM

TransLink Forecasting Group

Overview

Context

Determine Objectives

Define Metrics

Design Schemes

Measure Schemes

Context

The People

Stakeholders & Decision Makers

Mobility Pricing Independent Commission (MPIC) representing the public and recommending next steps to Mayor's Council/TransLink board

Project Team (Research)

Transportation experts and economists (WSP Toronto & Stockholm, McElhanney, TransLink, Metro Vancouver, Secretariat Staff)

The Project

Should we implement a regional mobility pricing scheme, and if so, **how**?

If yes, a scheme has two major components

- How to charge
- How *much* to charge

The Process

Define a set of Objectives

Current State (problem we face)

Ideal State (what we value – our objective)

Define Metrics

Something measureable and quantifiable about potential schemes that tells us how well we're meeting objectives

RTM can quantify things!

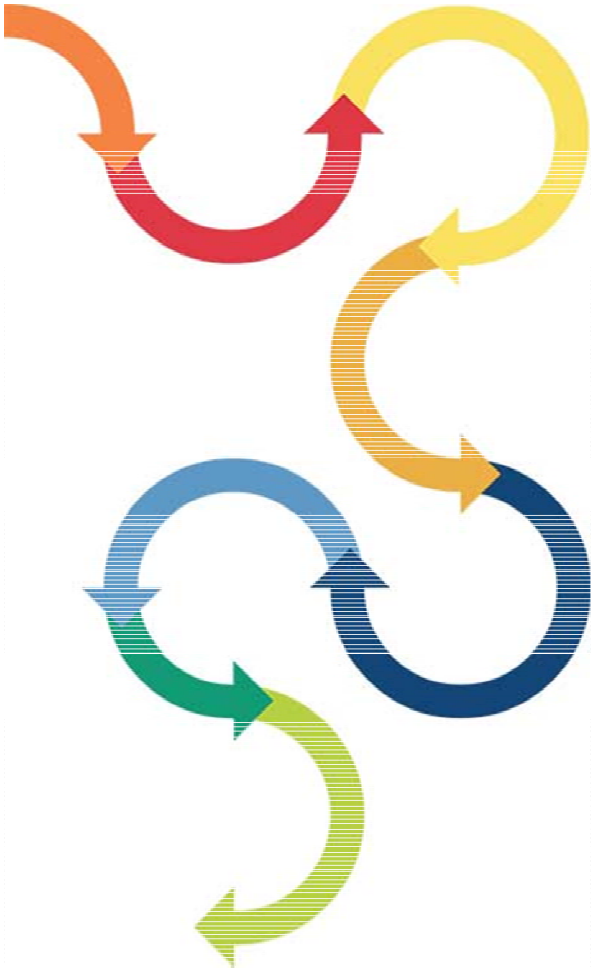
And So We Need to

Determine objectives

Define metrics

Design schemes (How and How *Much*)

Measure schemes against objectives using metrics



Determine Objectives & Define Metrics

Determine Objectives

Determined **3 primary objectives** during initial project phase, which included considerable public consultation

Manage congestion

Promote fairness

Support investment

Define Metrics

Define metrics from RTM to inform scenarios ability to meet these objectives

Two objectives are well, **objective**

Revenue for investment can be defined

Dollars raised can be quantified from RTM

Congestion, once defined can be estimated

Changes in travel time and congested minutes can be quantified from RTM, as can time lost to unreliable[#] travel

[#] More on reliability shortly

Metrics: Units of Measure

Note that both objective metrics are **transportation costs** expressed in different units: **Time** and **Dollars**

Value of travel time savings (**VOT**) is the relationship between these two forms of cost

- Different for different individuals
- Different for different trip 'reasons' for the same individual (purpose, time of day, etc)
- VOTs were estimated by trip purpose from the trip diary during RTM mode choice estimation

Use VOT to convert time to dollars for economic analysis

Define Metrics

Fairness is **subjective**

Should people pay for what they use?

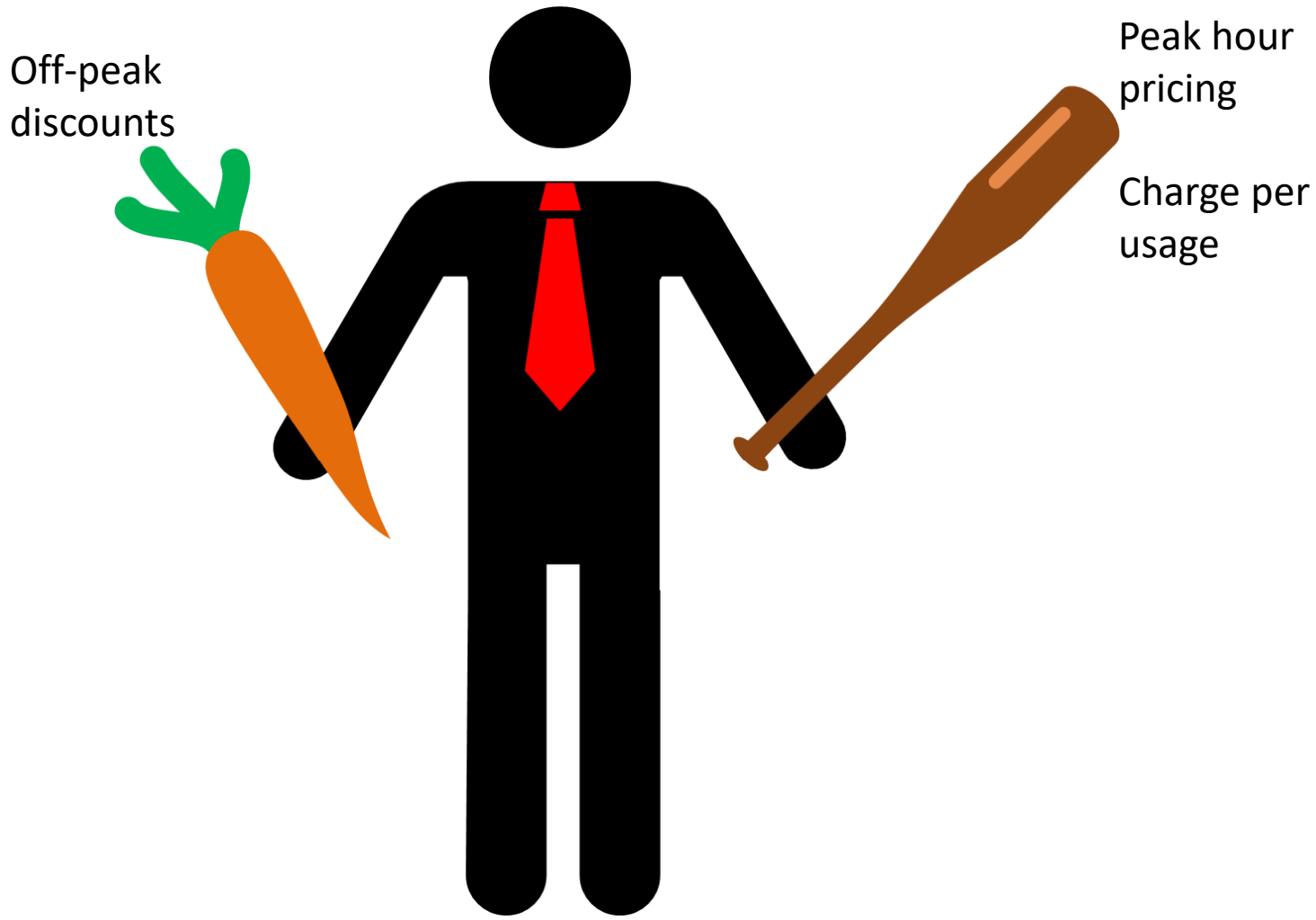
Or based on who benefits?

Or based on their ability to pay?

Or based on their available options?

Or…?

On the One Hand: Economists



On the Other Hand: Public

"**Taxing how much I pay based on how much I drive is completely unfair**. I don't have an option. I don't have another choice"

https://www.cbc.ca/news/canada/british-columbia/bc-roads-mobility-pricing-tax-singapore-stockholm-london-daniel-firth-1.4267748

Modelers

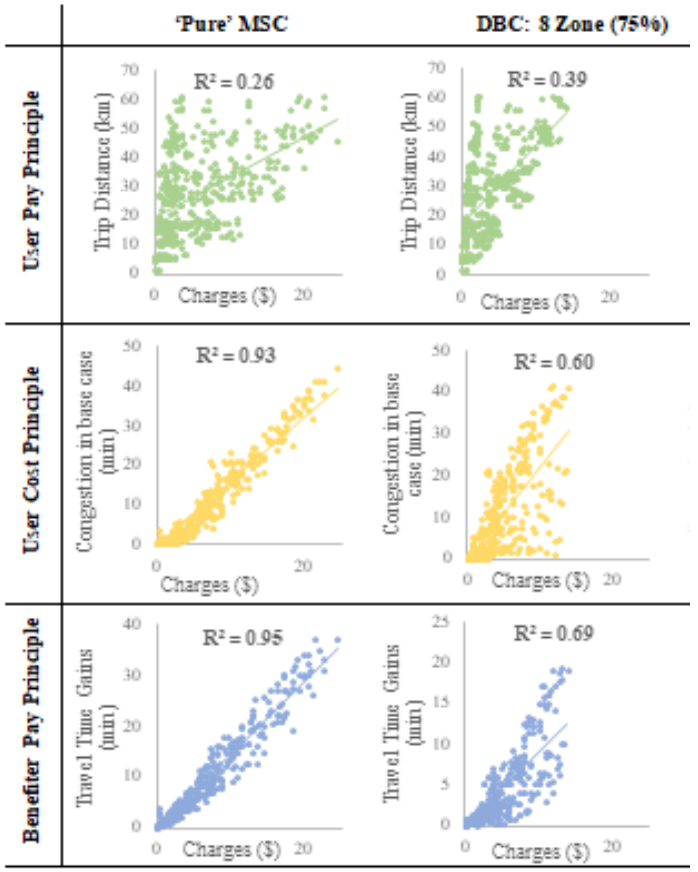
¯_(ツ)_/¯

Metrics: Fairness

User pay principle: that people should pay in proportion to how much they use the transportation system

User cost principle: that people should pay in proportion to the amount of congestion they contribute to, in other words the delays they impose on other users

Benefiter pay principle: that people should pay in proportion to the time savings they experience



More on fairness later

Reliability

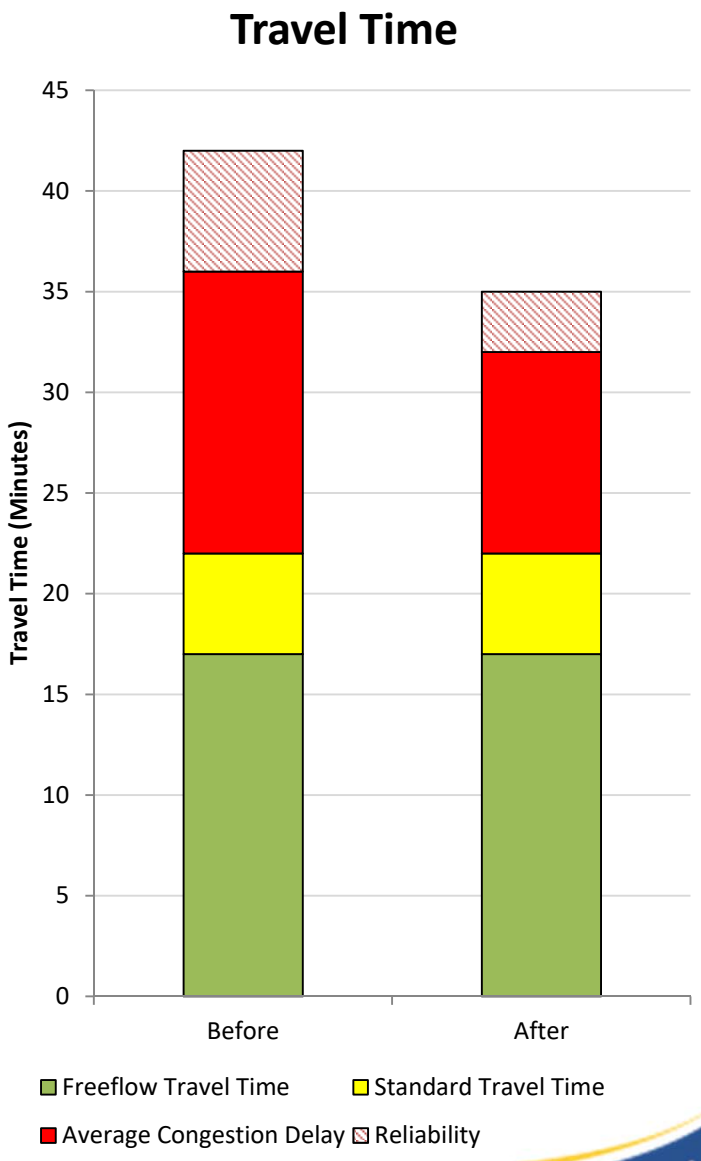
With reduced congestion increased reliability and less buffer time

Travel time reliability related to travel time index (**TTI)**

Created a separate model of travel time reliability based on RTM outputs using Google API travel time data

Applied off model to determine reliability minutes saved

Converted to dollar using value of reliability (VOR) set at 80% of VOT



TTI = congested speed / reference speed

Design Schemes

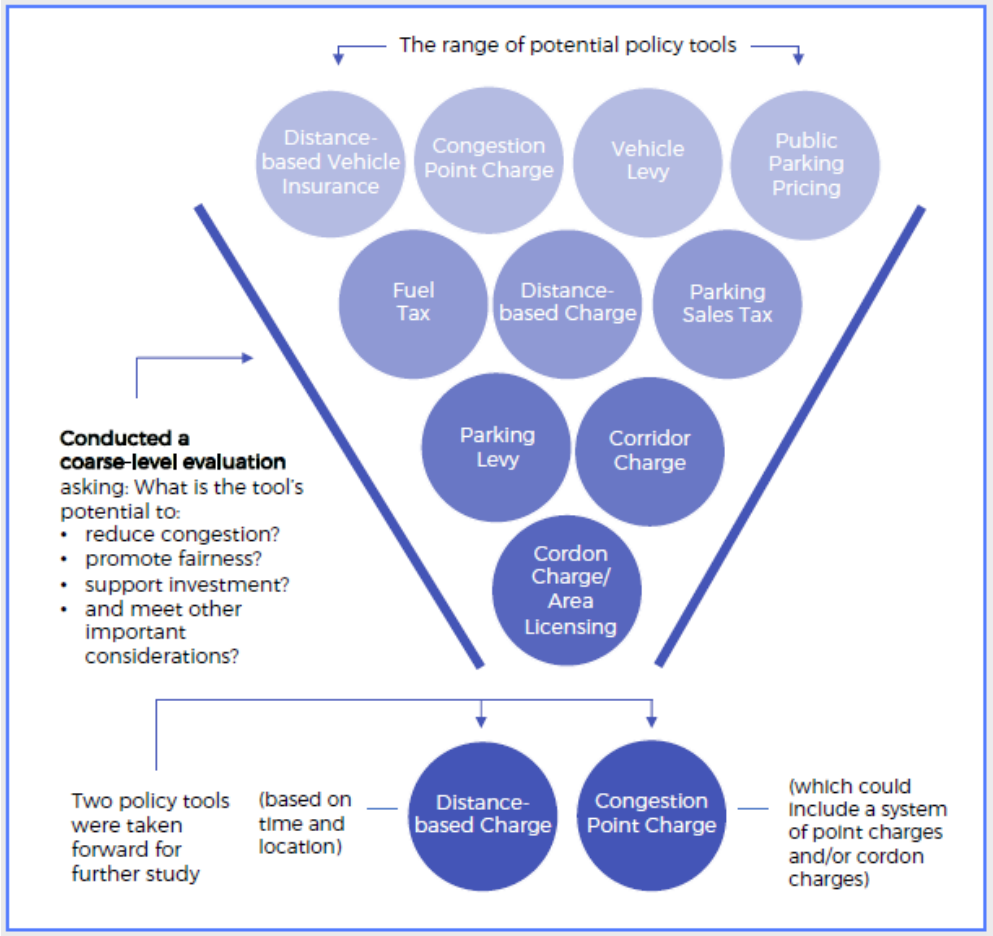
Design Schemes: How to Charge

Numerous policy tools considered

Most promising scenarios carried forward for further analysis

most promising = most likely to meet the 3 objectives based on the initial quantification

Some did well on one aspect, but not on others. For example, a parking charge or vehicle levy raises revenue but doesn't address peak hour congestion



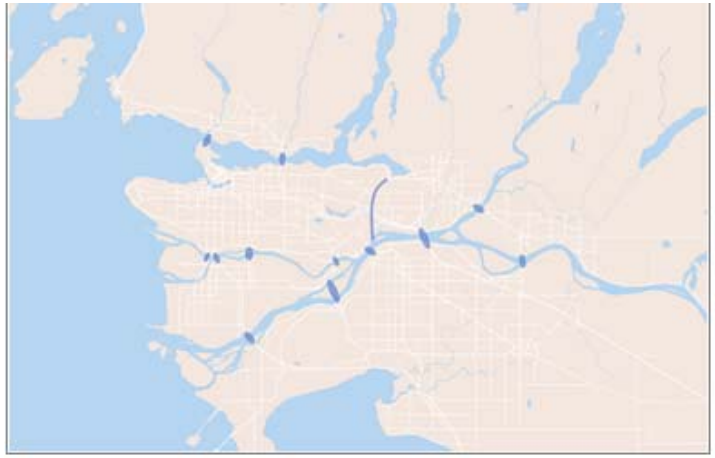
Design Schemes: Options

Ultimately took two potential implementations forward

System of point charges

Cordons area a subset

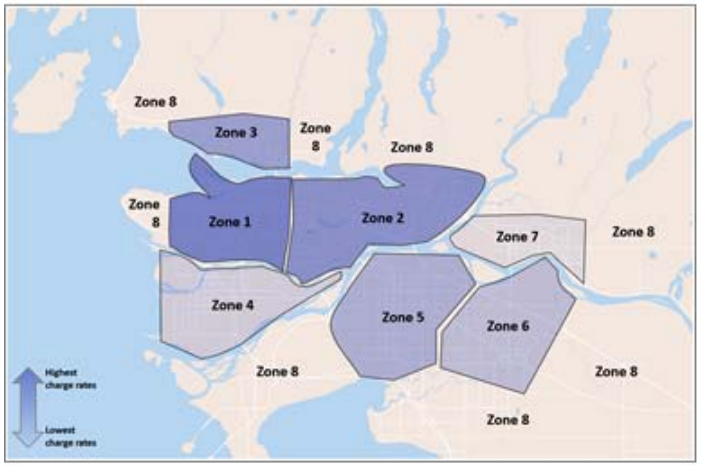
Can vary by time of day, direction, and location



Distance based charges (DBC)

$/km charges

Which can vary by time of day and location



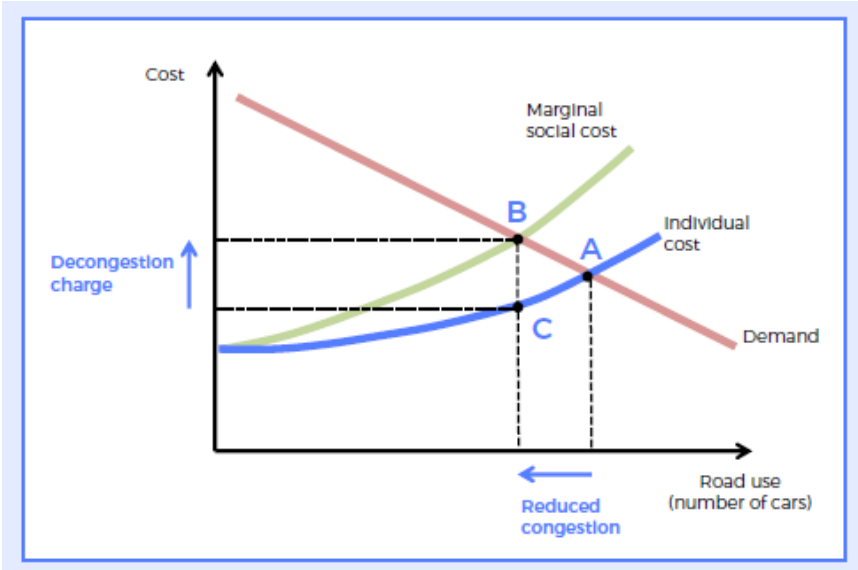
Design Schemes: How Much to Charge

In an ideal economic world (theory) we charge road users the **marginal social cost (MSC)** of their travel

This mean charging every road in every direction at every time of day based on the current usage of that road and all other roads

This leads to the system optimal solution

Note setting efficient rates does not preclude addressing equity/fairness concerns through other means



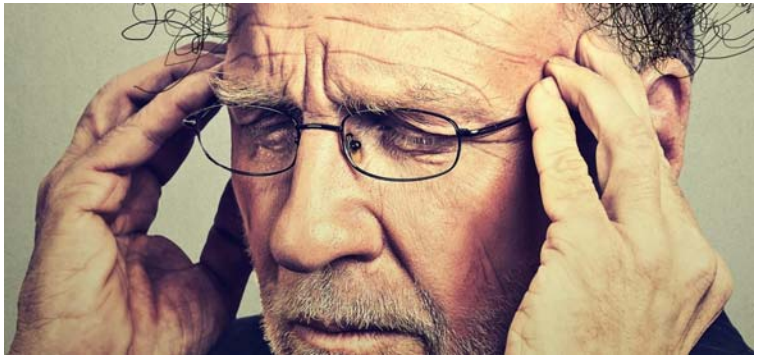
Design Schemes: How Much to Charge

MSC in practice

Implementation Challenges

Would need to measure all roads and all times, compute the correct costs, and inform users' in a timely manner that would allow them to act on that information

Ambiguity & Confusion



Like time cost now, users would not know the dollar cost of their trip before hand

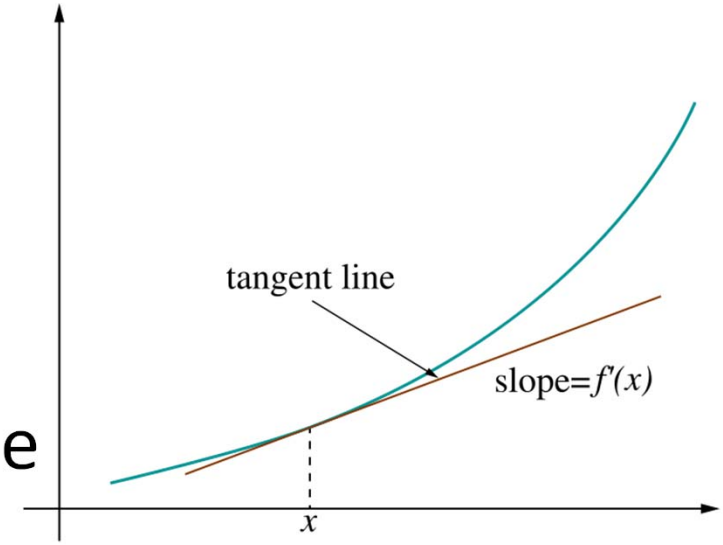
That said, MSC can be useful as a starting point to determine possible rates

Design Schemes: How Much to Charge

Non-linear relationship between traffic volume and congestion

We model this relationship in the RTM with **volume delay functions (VDFs)**

MSC is the first **derivative** of the volume-delay function with respect to volume

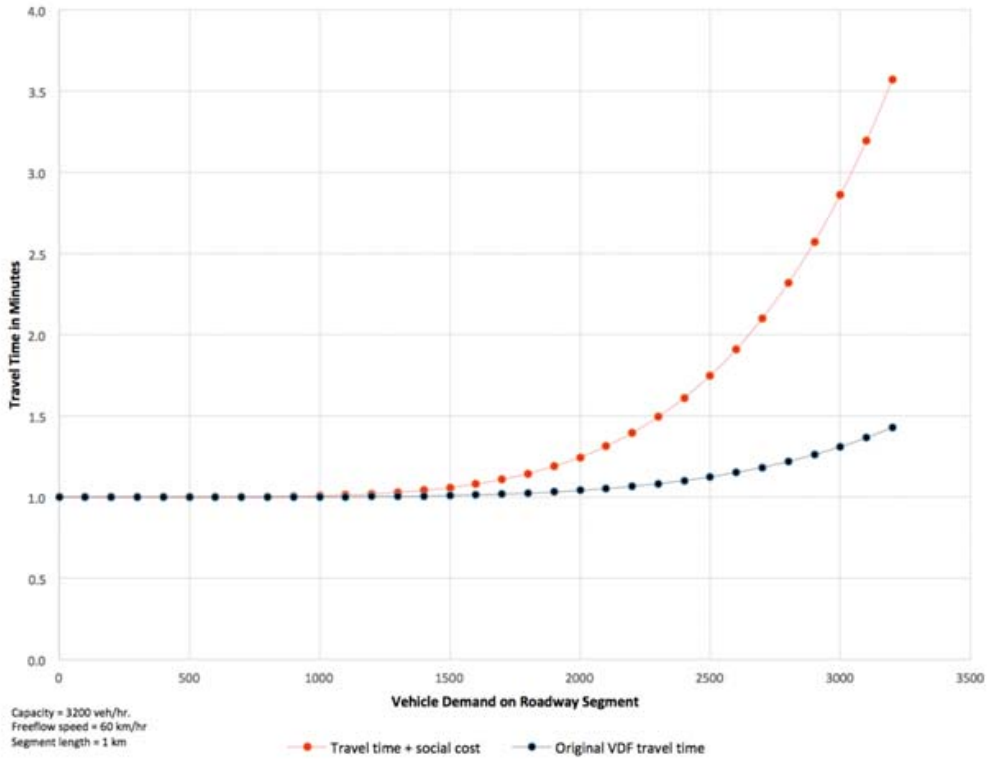


Design Schemes: How Much to Charge

Convert RTM VDFs to include this cost for all users

Vertical gap between MSC VDF and regular VDF is marginal social cost (in minutes)

Convert charge to dollars using weighted average VOT



Design Schemes: How Much to Charge

Charges determined in MSC scenario used to set rates for point charges and DBC scenarios by **averaging**

Lose some of the economic efficiency as some segments will be under or overcharged due to averaging

DBC (rates vary by time and location)

Road segments aggregated to a number of zones (2-8)

Weighted average charge per KM calculated for each zone

Point charges (rates vary by time, direction, location)

Points placed into groupings based on O/D patterns

For each grouping, a distribution of OD charges was created and rates set from the distribution

Design Schemes: How Much to Charge

Example of point charges derived from MSC scenario averaging

Charge levels used for the illustrative regional congestion point charge concept

Charge concept	Direction of travel	Time of Day	Congestion Point Charge Location					
			Lions Gate and Iron-workers	Arthur Laing, Oak and Knight	Queens-borough, Pattullo, and Port Mann	George Massey and Alex Fraser	Pitt River and Golden Ears*	North Road
Min	Inbound (towards Downtown Vancouver)	AM Peak	$3.55	$3.59	$4.25	$2.68	$2.80	$2.60
		Off Peak	$1.06	$0.91	$0.74	$0.76	$0.54	$0.36
		PM Peak	$4.92	$3.54	$3.54	$3.05	$2.41	$1.03
	Outbound (Away from Downtown Vancouver)	AM Peak	$4.30	$2.24	$2.17	$2.18	$2.72	$0.85
		Off Peak	$0.86	$0.81	$0.65	$0.55	$0.52	$0.41
		PM Peak	$4.59	$3.92	$5.52	$3.51	$4.15	$2.27
Min+	Inbound (towards Downtown Vancouver)	AM Peak	$5.32	$5.38	$6.37	$4.03	$4.19	$3.90
		Off Peak	$1.59	$1.36	$1.11	$1.13	$0.81	$0.54
		PM Peak	$7.38	$5.30	$5.30	$4.58	$3.61	$1.54
	Outbound (Away from Downtown Vancouver)	AM Peak	$6.45	$3.36	$3.25	$3.27	$4.08	$1.27
		Off Peak	$1.29	$1.21	$0.98	$0.83	$0.78	$0.62
		PM Peak	$6.89	$5.87	$8.27	$5.27	$6.23	$3.41

*For Golden Ears bridge, southbound is inbound, northbound is outbound, relecting the higher peak flows.

Example of distance based charges derived from MSC scenario averaging

Charge levels used for the illustrative multi-zone distance-based concepts

Charge concept	Time of Day	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
Min	AM Peak	$0.25/km	$0.20/km	$0.17/km	$0.12/km	$0.11/km	$0.14/km	$0.08/km	$0.02/km
	Off Peak	$0.07/km	$0.02/km	$0.02/km	$0.02/km	$0.02/km	$0.02/km	$0.02/km	$0.02/km
	PM Peak	$0.27/km	$0.22/km	$0.15/km	$0.11/km	$0.14/km	$0.12/km	$0.10/km	$0.03/km
Min+	AM Peak	$0.38/km	$0.30/km	$0.25/km	$0.17/km	$0.16/km	$0.20/km	$0.11/km	$0.03/km
	Off Peak	$0.11/km	$0.03/km	$0.03/km	$0.03/km	$0.03/km	$0.03/km	$0.03/km	$0.03/km
	PM Peak	$0.40/km	$0.32/km	$0.23/km	$0.17/km	$0.20/km	$0.18/km	$0.15/km	$0.04/km

Measure Schemes Against Objectives Using Metrics

Measurement

Many model runs!

80 stored, many others discarded or failed (at least 100 total runs)

Roughly 6 hours each run with additional skims

This means that model ran for 24 hours/day for at least 25 days during the course of the study

Model runs didn't start at the beginning of the project!

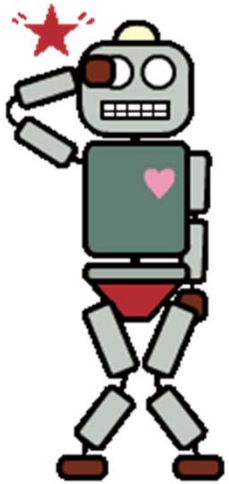
Measurement: Scenarios

Policy instrument	Scenario name	Scenario description
N/A – benchmark/ reference scenarios	Baseline 2030	This scenario includes baseline assumptions for what will happen in the region in 2030, assuming continued population and employment growth and including infrastructure changes, but in the absence of congestion charging. It is a benchmark for comparing the performance of other scenarios.
	MSC	This is the 'pure' Marginal Social Cost scenario, where prices are set at the road link level on a per km basis, and vary depending on the level of congestion – by time of day, location, and direction of travel. This scenario may be considered more theoretical as it would be difficult to implement in its purest form. Nonetheless it serves as a good benchmark upon which other MSC approximated scenarios can be compared against.
Congestion Point Charge (CPC)	CBD ($5)	This scenario involves point charges around the Central Business District (CBD, downtown Vancouver). Key assumptions include: • All Baseline conditions (fuel tax, infrastructure changes, etc.) • $5/passing at all point charge locations; chosen because it was believed $5/passing would reduce congestion and is in line with charges in other jurisdictions • The charge rate does not vary by location, time of day, or direction of travel
	Bridges ($5)	This scenario involves point charges at twelve major bridges throughout the region: (1) Lions Gate; (2) Ironworkers/2nd Narrows; (3) Arthur Laing; (4) Knight; (5) Oak; (6) Queensborough; (7) George Massey (in the 2030 Baseline the tunnel has been replaced by a 10-lane bridge); (8) Alex Fraser; (9) Pattullo (in the 2030 Baseline this bridge has been replaced by a new 4-lane bridge); (10) Port Mann; (11) Pitt River; (12) Golden Ears. Key assumptions include: • All Baseline conditions (fuel tax, infrastructure changes, etc.) • $5/passing at all point charge locations; chosen because it was believed $5/passing would reduce congestion and is in line with charges in other jurisdictions • The charge rate does not vary by location, time of day, or direction of travel
	Bridges ($1)	This scenario is identical to Bridges ($5/passing) except that the charge is reduced to $1/passing. This rate was chosen because charging 'a buck-a-bridge' was an idea frequently raised by stakeholders and the public during engagement, and allows a direct comparison of the effect of different charge levels.
	CBD (MSC)	Charges in the CBD cordon that vary rates by time of day and direction to approximate MSC charge levels. The charge rate is consistent across all entry/exit points to/from the CBD.
	Bridges (TOD)	Same as Bridges ($5), except the rates vary by time of day (TOD). Charges only applied during AM and PM peak periods. No charge for off-peak periods.
	Bridges (TOD + Direction)	Same charging locations as other Bridges scenarios but varies rates by time of day and direction: • AM peak: $6.50 per passage inbound (towards Vancouver CBD) and $3.25 per passage outbound. • PM peak: $3.25 per passage inbound and $6.50 per passage outbound. • Off-peak: No charge. For the Golden Ears Bridge, inbound is defined as southbound, outbound is defined as northbound.
	Bridges (MSC)	Same charging locations as other Bridges scenarios but rates vary by point location, time of day, and direction to approximate MSC charge levels.
	Bridges (25%, 37.5%, 50%, 75%, 100%)	Charges applied to all 12 major regional bridges. Charges vary between bridges, as well as by time of day and by direction. Five charge levels based on a percentage of the MSC (25%, 37.5%, 50%, 75%, and 100%) were assessed. This scenario maintained the fuel tax at current rates to meet the user pay principle.
	Bridges + NR (25%, 37.5%, 50%, 75%, 100%)	Similar to the Bridges scenario above, but with an additional cordon charge on the Burrard Peninsula applied along North Road (NR) which forms the boundary between Burnaby and New Westminster to the west and Port Moody and Coquitlam to the east. Five charge levels based on a percentage of the MSC (25%, 37.5%, 50%, 75%, and 100%) were assessed. This scenario was assumed to exist alongside the fuel tax at current rates to meet the user pay principle.
	Regional CPC (Min, Min+)	This scenario is simply a repackaging of the Bridges + NR scenario, where 'Min' represents the charge rates required to produce the minimum level of congestion benefits judged to be meaningful, while 'Min+' represents the rates required to achieve a somewhat more ambitious level of congestion reduction. The rates required to achieve Min and Min+ congestion reductions are approximately 50% and 75% of the MSC, respectively. The fuel tax is maintained once more in order to meet the user pay principle.
Distance-Based Charge (DBC)	DBC ($0.15/km)	This scenario involves charging vehicles a flat per km rate based on distance travelled. Key assumptions include: • All Baseline conditions (fuel tax, infrastructure changes, etc.) • $0.15/km across the region was chosen because it was believed it would reduce congestion based on previous modelling analysis • The charge rate does not vary by location, time of day, or direction of travel
	DBC (TOD)	Distance-based charge where the rates vary by time of day (TOD). $0.15/km fee in AM and PM peak periods. No charge for off-peak periods.
	DBC (TOD – 2 zones)	$0.20/km fee inside the Burrard Peninsula and $0.10/km outside the Burrard Peninsula in the AM and PM peak periods only
	DBC 2 Zones Transit (25%, 37.5%, 50%, 75%, 100%)	Distance-based charge for two zones that varies by time of day. A higher per km rate was applied to an "inner zone" that has generally more density, better transit accessibility, and greater congestion, with a lower per km rate applied to an "outer zone". Five charge levels based on a percentage of the MSC (25%, 37.5%, 50%, 75%, and 100%) were assessed. This scenario was assumed to replace the fuel tax, using a low per km charge in the off-peak period to meet the user pay principle.
	DBC 8 Zones (25%, 37.5%, 50%, 75%, 100%)	Distance-based charge for eight zones based on aggregating areas with similar MSC rates that varies by time of day. Five charge levels based on a percentage of the MSC (25%, 37.5%, 50%, 75%, and 100%) were assessed. This scenario was assumed to replace the fuel tax, using a low per km charge in the off-peak period to meet the user pay principle.
	DBC Flat	Two charge levels were assessed based on flat rates of $0.10/km and $0.12/km. This scenario maintained the fuel tax at current rates. This scenario did not align with Commission direction from Round 2 but was run for comparison purposes.
	Multi-zone DBC (Min, Min+)	This scenario is simply a repackaging of the DBC 8 Zones scenario, where 'Min' represents the charge rates required to produce the minimum level of congestion benefits judged to be meaningful, while 'Min+' represents the rates required to achieve a somewhat more ambitious level of congestion reduction. The rates required to achieve Min and Min+ congestion reductions are approximately 50% and 75% of the MSC, respectively. The fuel tax is eliminated once, and instead the user pays principle is achieved by applying a low per km charge in the off-peak period.
Hybrid (CPC+DBC)	Hybrid	A flat DBC of $0.08/km combined with a $3 charge on all bridges in the AM and PM peak hours only. This scenario replaced the fuel tax

How Did We Run So Many Scenarios?

Automation!

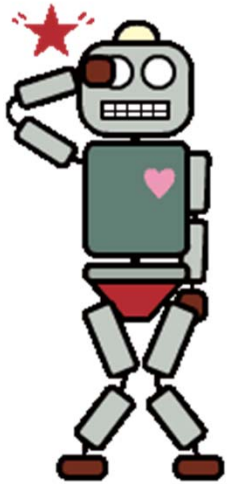
- Automated network coding
- Automated scalar definition
- Automated attributes
- Multi-run batches



How Did We Run So Many Scenarios?

Automation!

- Automated network coding
- Automated scalar definition
- Automated attributes
- Multi-run batches
- Most of above available in the RTM 3.2 release

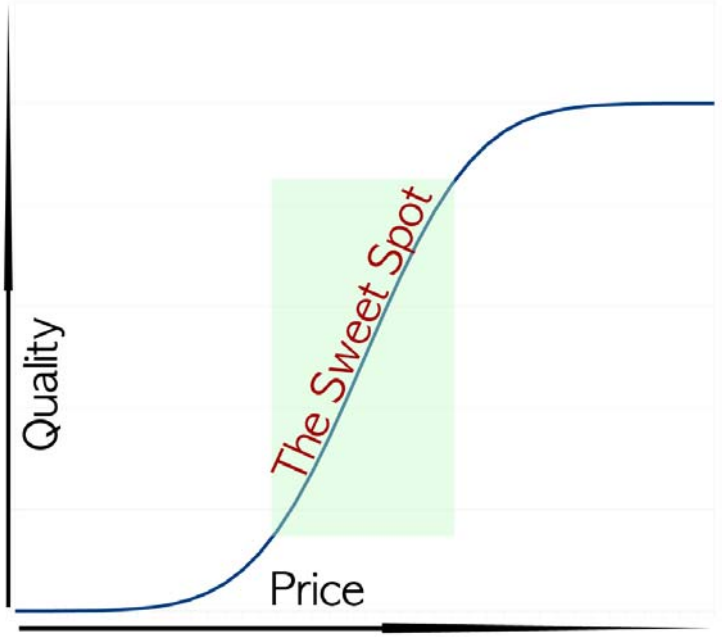


Why So Many Runs?

Determine promising scenarios

In depth analysis of the two main scenario families

Test charge levels to determine where congestion benefits accrue looking for a sweet-spot



Measurement: Household Analysis

Linking data to trip diary to perform household level analysis

Trip diary has household dimensions that the RTM does not consider

- Location, income, composition for all trips and purposes
- Links NHB travel back to the household

This **analysis considers the cost for households to maintain their choices**

- Updating costs for the trips they reported
- No opportunity to change decisions (like switch destinations or modes)

Figure 9: Boxplots for annual household charges as a % of annual income (includes fuel tax)

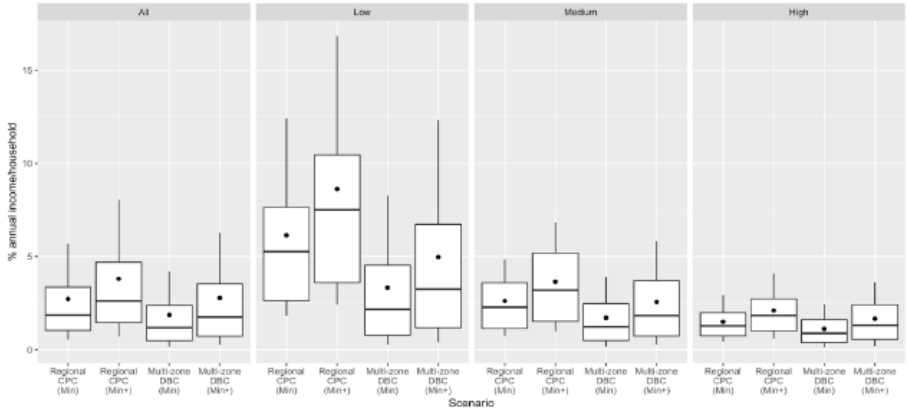
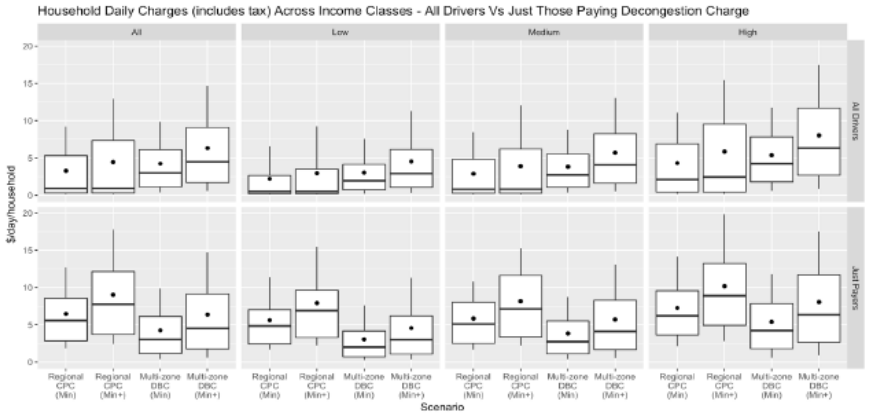


Figure 7: Boxplots for household daily charges (includes fuel tax) by Drivers/Payers and by income level.

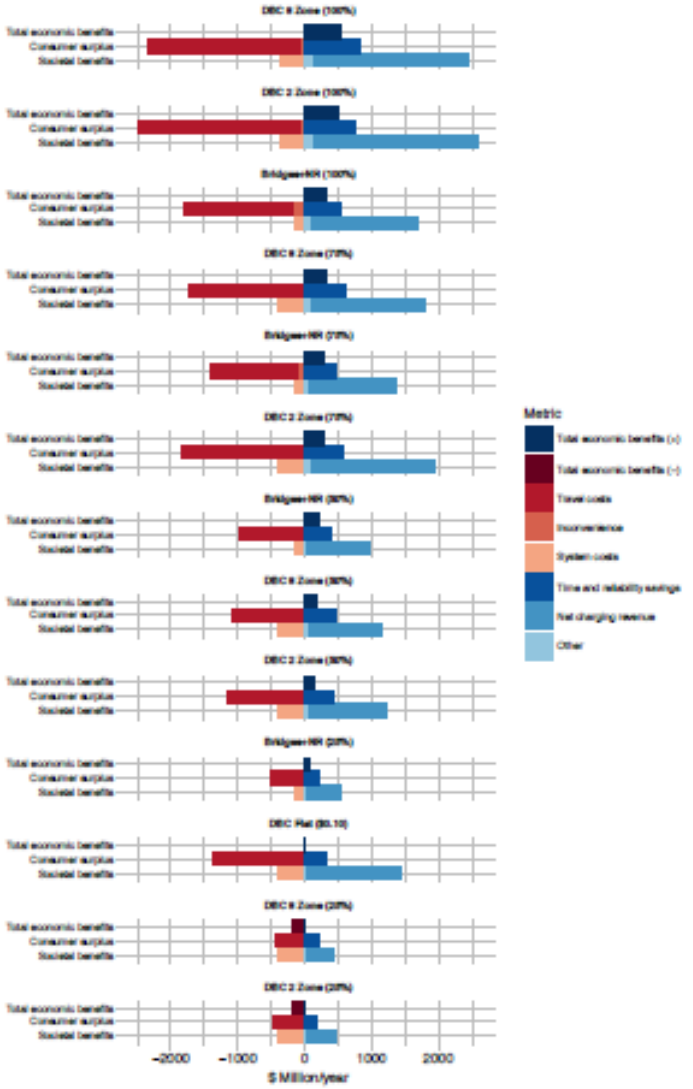


On-going work to define and measure fairness

Measurement: Economic Analysis

RTM data used to perform economic welfare analysis

See MPIC final report for details



Conclusions

Read the report!

Detailed results are all in there!

https://www.itstimemv.ca/uploads/1/0/6/9/106921821/mpic_full_report_-_final.pdf