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GHG accounting for mode choice in passenger transport

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Passenger Transport - Outline

1. **Motivation for new methodology**

2. **Estimation of behavioral responses**

   - **Aggregate data**
   - **Disaggregate data**
   - **Estimation procedure**

3. **Calculating GHG emissions**

Motivation

- Mandate for GHG analysis for transport and other sectors

- Standard tools for GHG analysis have shortcomings for transport

  - ✓ They strongly focus on universal, purely technical relations.
  - ✓ They don’t account for user behavior.
  - ✓ The disregard the value of mobility.

⇒ No need for local empirical analysis.

⇒ Reducing transport services has no visible downside.

Limits of methods adopted from other sectors

Standard approach relies entirely on physical accounting

$$G = A * S * I * F$$

F emissions per liter of fuel

I amount of liters per vehicle-mile

S amount of miles per vehicle

A number of vehicles

G total emission

Limits of methods adopted from other sectors

- This has been developed into large matrix expressions, differentiating
  - Types of fuel,
  - types of vehicles,
  - numbers of vehicles in different classes.

Limits of methods adopted from other sectors

- Approach can be used in cases where users do not have much discretion in consumption decisions but not in transport.
- Suggests that crucial parameters are purely technical, laboratory data.
- Policy or project intervention is reduced to the substitution of one or more of the parameters.
- GHG analysis consists mainly of tracing the consequences of parameter substitution.

Principles of framework design

- What is added

  - ✓ Simple tools for the estimation of user behavior.
  - ✓ Account for the central drivers of sector development that shape project and policy outcomes.
  - ✓ Capture dependence of technical relationships on the local sector situation.

- Application of tools require no technical expertise on econometrics.
- Tools do not require the implementation of costly software.

Principles of framework design

- Tools are intended to be adaptable to project context and cost-effective

  - ✓ Slides do not include land-use transport interactions. They can be added to the estimation procedure.
  - ✓ The framework focuses on changes in transport services, rather than levels to reduce data requirements.

Principles of framework design

- The basic drivers of modal transport demand are

  - ✓ aggregate income,
  - ✓ costs or prices of transport services,
  - ✓ time requirements for transport (congestion).

  Transport services are associated with GHG emissions through

  - ✓ fossil fuel used per vehicle-km
  - ✓ emissions per liter of fuel.

  The impact of transport interventions is traced through these variables.

Estimation of behavioral response

- Core of capturing user behavior is a benefit function

User benefits = modal fixed effect +
income parameter x income +
cost parameter x transport charge +
modal time parameter x transport time +
random coefficient.

Parameters are estimated using distributional assumption for the random term, and maximum likelihood estimation.

Estimation of behavioral response

a. Aggregate analysis; e.g. census data (Winston, Shirley)

Data for aggregate estimation of user response, per mode							
Year, ODM cell, distance class	Annual household income	Household size	Costs per mile	Travel time	Waiting time	Service quality	Route coverage

Estimation of behavioral response

b. Disaggregate data for the estimation of the behavioral response, individual data

Data for disaggregate estimation of user response							
individual	mode	choice	income	wait	vcost	travel	size
1	air	FALSE	35	69	59	100	1
1	train	FALSE	35	34	31	372	1
1	bus	FALSE	35	35	25	417	1
1	car	TRUE	35	0	10	180	1
2	air	FALSE	30	64	58	68	2
2	train	FALSE	30	44	31	354	2
2	bus	FALSE	30	53	25	399	2
2	car	TRUE	30	0	11	255	2
3	air	FALSE	40	69	115	125	1
3	train	FALSE	40	34	98	892	1
3	bus	FALSE	40	35	53	882	1
3	car	TRUE	40	0	23	720	1

Estimation procedure

- From the probability distribution of the ϵ_i, we have with three modes, for example

$$P_i = \frac{e^{V_i}}{\sum_{j=1}^{3} e^{V_j}} \text{ and } \sum_{j=1}^{3} P_j = 1.$$

- V_i indicates the consumer benefits for mode i, and is estimated from income, modal transport times and quality.
- The more attractive mode i becomes, the greater will be its probability or market share.
- Allows to calculate consumer benefits.

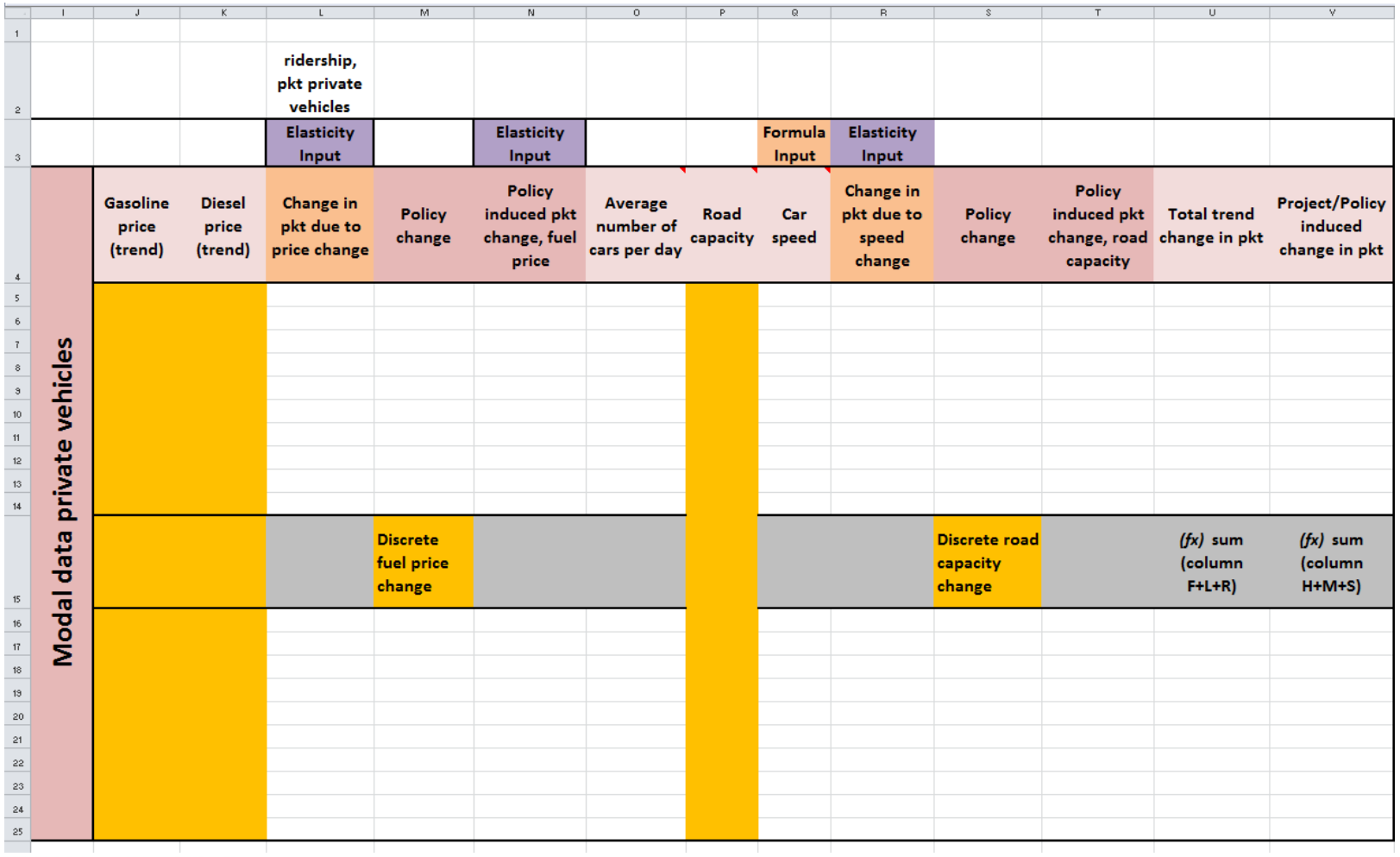
Calculating GHG emissions for all relevant modes

a. Socio-demographic part

	A	B	C	D	E	F	G	H
1	GHG Analysis for Mode Choice in Passenger Travel							
2						Initial ridership, pkt private vehicles		Initial ridership, pkt private vehicles
3						Elasticity Input		Elasticity Input
4		Year	Income per capita (trend)	Population (trend)	Aggregate income changes in %	Change in pkt due to income change	Policy change	Policy induced pkt change, income
5	Socio-demographic data	-10						
6		-9						
7		-8						
8		-7						
9		-6						
10		-5						
11		-4						
12		-3						
13		-2						
14		-1						
15		0					Discrete settlement change	
16		1						
17		2						
18		3						
19		4						
20		5						
21		6						
22		7						
23		8						
24		9						
25		10						

Calculating GHG emissions

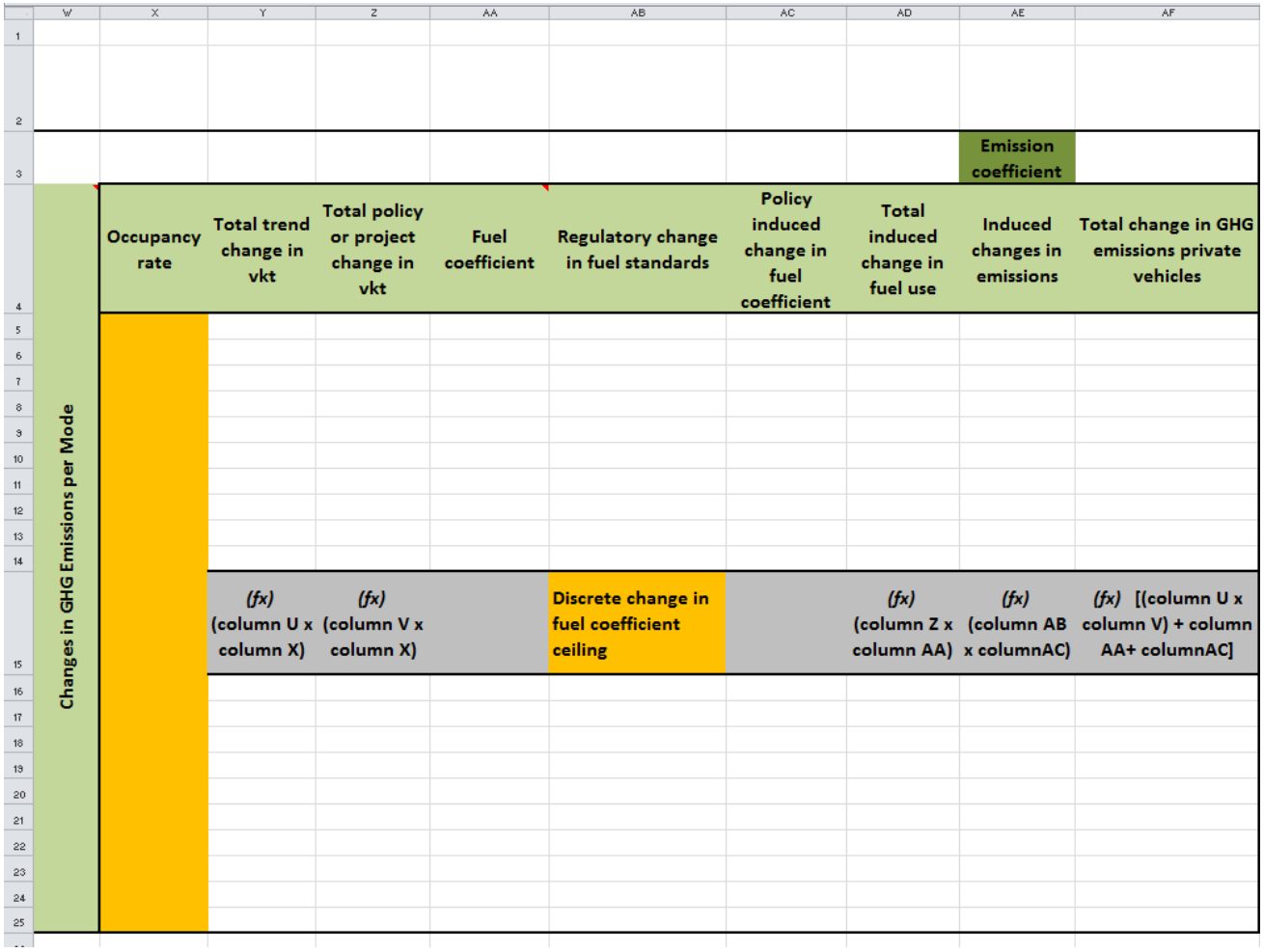
b. Modal characteristics part



	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1														
2				ridership, pkt private vehicles										
3				Elasticity Input		Elasticity Input			Formula Input	Elasticity Input				
4	Modal data private vehicles	Gasoline price (trend)	Diesel price (trend)	Change in pkt due to price change	Policy change	Policy induced pkt change, fuel price	Average number of cars per day	Road capacity	Car speed	Change in pkt due to speed change	Policy change	Policy induced pkt change, road capacity	Total trend change in pkt	Project/Policy induced change in pkt
5–14														
15					Discrete fuel price change						Discrete road capacity change		*(fx)* sum (column F+L+R)	*(fx)* sum (column H+M+S)
16–25														

Calculating GHG emissions

c. Fuel use and emissions part



	W	X	Y	Z	AA	AB	AC	AD	AE	AF
3									Emission coefficient	
4	Changes in GHG Emissions per Mode	Occupancy rate	Total trend change in vkt	Total policy or project change in vkt	Fuel coefficient	Regulatory change in fuel standards	Policy induced change in fuel coefficient	Total induced change in fuel use	Induced changes in emissions	Total change in GHG emissions private vehicles
15			*(fx)* (column U x column X)	*(fx)* (column V x column X)		Discrete change in fuel coefficient ceiling		*(fx)* (column Z x column AA)	*(fx)* (column AB x columnAC)	*(fx)* [(column U x column V) + column AA+ columnAC]

Calculating GHG emissions

d. Summary in cover sheet

COVERSHEET GHG Analysis for Mode Choice in Passenger Travel

	Year	Total Annual GHG Emissions from Cars (induced by project and policy changes)	Total Annual GHG Emissions from Taxis (induced by project and policy changes)	Total Annual GHG Emissions from Minibuses (induced by project and policy changes)	Total Annual GHG Emissions from Buses (induced by project and policy changes)	Total Annual GHG Emissions from Rail (induced by project and policy changes)	Total annual changes in GHG emissions across modes (tCO2/yr)
Historic	-10	0	0	0	0	0	0
	-9	0	0	0	0	0	0
	-8	0	0	0	0	0	0
	-7	0	0	0	0	0	0
	-6	0	0	0	0	0	0
	-5	0	0	0	0	0	0
	-4	0	0	0	0	0	0
	-3	0	0	0	0	0	0
	-2	0	0	0	0	0	0
	-1	0	0	0	0	0	0
Intervention year	**0**	**0**	**0**	0	0	0	0
Future	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
	7	0	0	0	0	0	0
	8	0	0	0	0	0	0
	9	0	0	0	0	0	0
	10	0	0	0	0	0	0

Calculating GHG emissions

- Dynamic baseline captures development without project or policy intervention, driven by

  - ✓ Income
  - ✓ Per distance unit costs of transport services
  - ✓ Travel times (congestion)
  - ✓ Quality of services

- Projects and policies change drivers, examples
  - ✓ Fuel taxes, congestion charges or parking fees change travel costs per km
  - ✓ Investment in road capacity or dedicated lanes for buses changes travel speeds
  - ✓ Increased security in metro stations increases quality of transit service.

Calculating GHG emissions

- Resulting changes in determinants change the modal split
- Changes in demand for modal transport services translate into changes in fossil fuel use per mode, accounting for load factors
- Changes in fossil fuel use lead to a reduction in emissions.
- Summing up across modes we obtain the total change in GHG emissions.
- The estimation of the changes in modal demand for services allows the calculation of the total change in GHG emissions.
- In general, the relevant lifecycle of a project is not fixed. It depends on when the intervention impact is exhausted by the baseline developments.

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Thank you!