(Unintended) Transport Impacts of an Energy-Environment Policy: The Case of CNG Conversion of Vehicles in Dhaka

Zia Wadud
University Research Fellow in Transport & Energy
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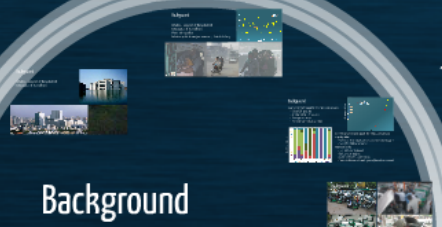
TRB/2014

Background



Transport Impacts

Ownership Impacts

Travel Impacts

Air Quality Impacts

GHG Impacts

Conclusions

Example of successful transition
Vehicle ownership did not increase
..... But vehicle travel did
Congestion costs nullify some benefits
.....But still only two-fifth of health benefits

Maintain CNG price differential
..... Address congestion by other means

Health benefits may decrease in future
..... As vehicles get cleaner

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Exampl
Vehicle

Conges
...

Mainta
.....

Heal

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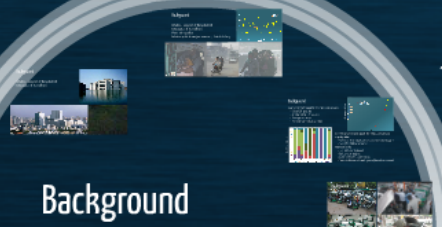

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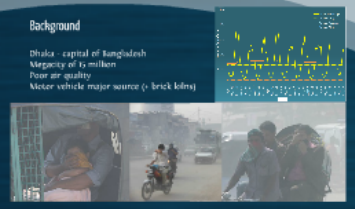
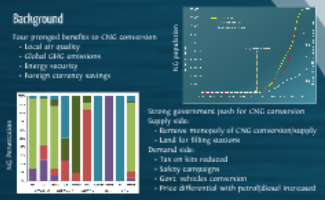
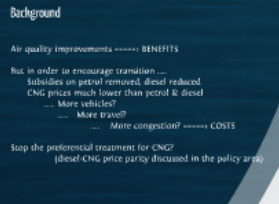






Objectives

(What are the AQ benefits?
What are the GHG benefits)

What are the impacts on congestion
(if any)?

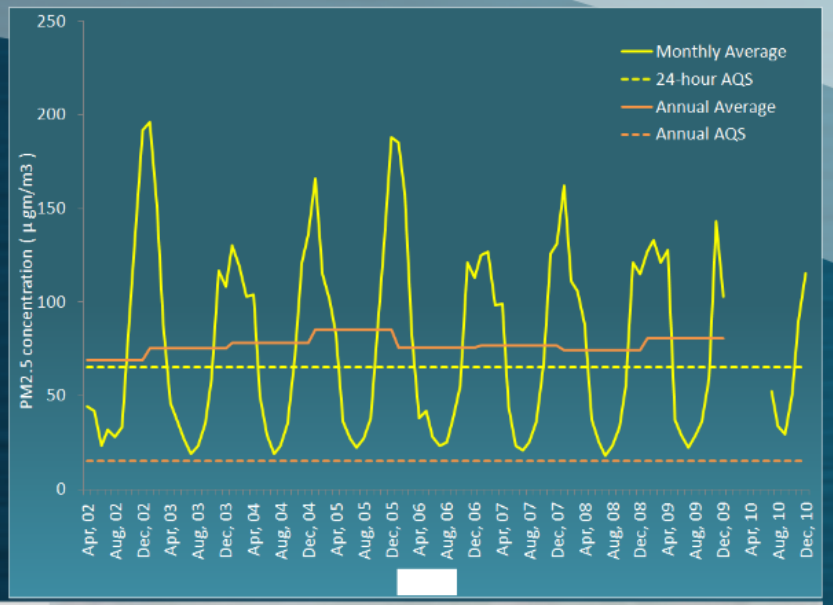
Did vehicle ownership increase?
Did individual vehicle travel increase?

Background

Dhaka - capital of Bangladesh
Megacity of 15 million

Background

Dhaka - capital of Bangladesh
Megacity of 15 million
Poor air quality
Motor vehicle major source (+ brick kilns)

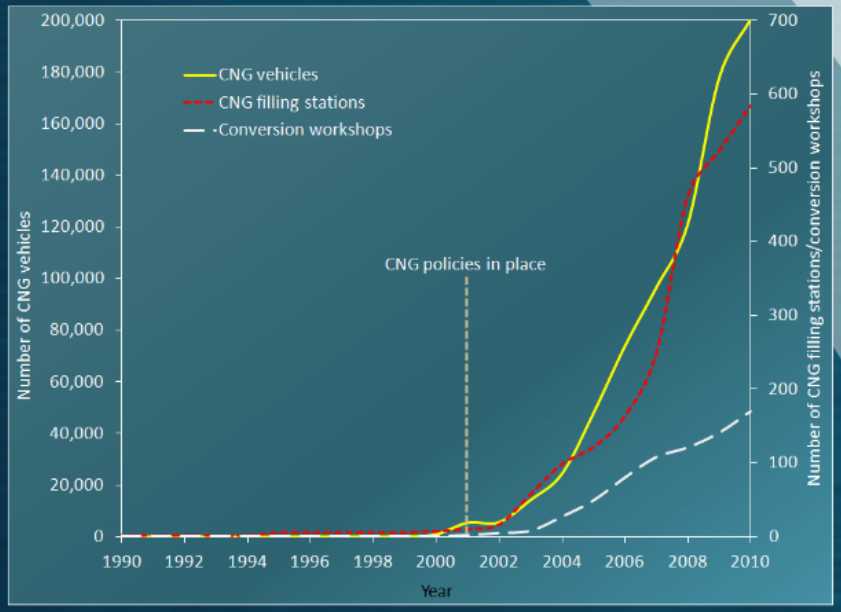


Background

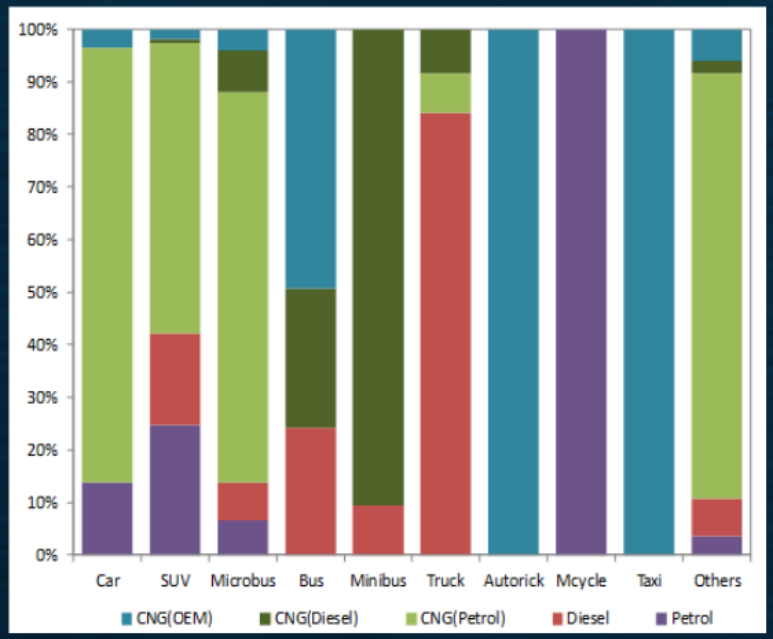
Four pronged benefits to CNG conversion

- Local air quality
- Global GHG emissions
- Energy security
- Foreign currency savings

NG population



NG Penetration



Strong government push for CNG conversion

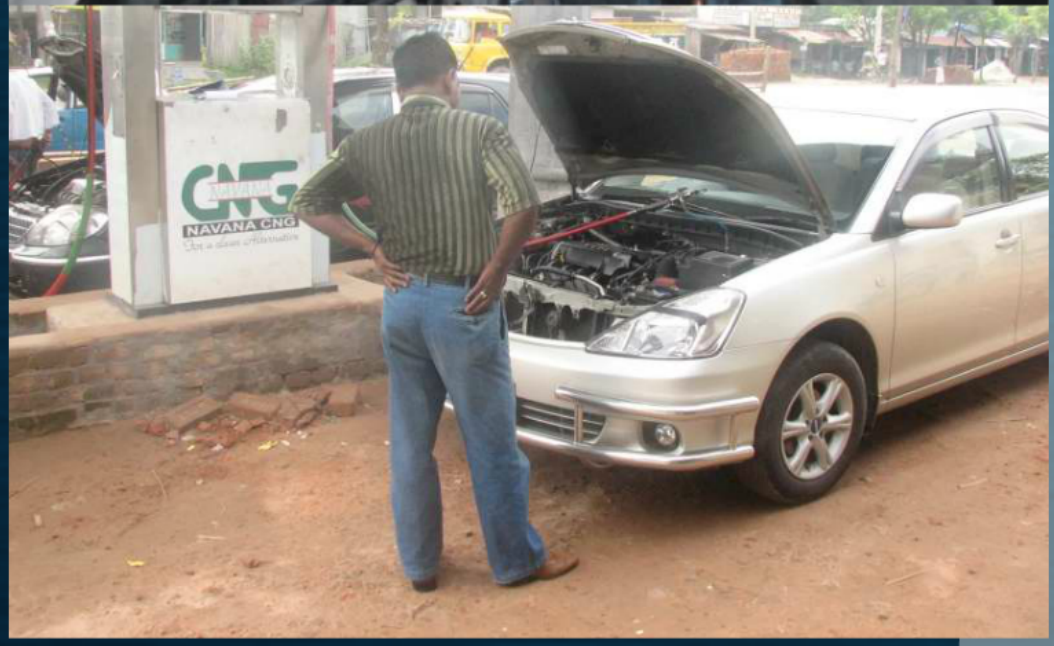
Supply side:

- Remove monopoly of CNG conversion/supply
- Land for filling stations

Demand side:

- Tax on kits reduced
- Safety campaigns
- Govt. vehicles conversion
- Price differential with petrol/diesel increased

Background



Background

Air quality improvements =====› BENEFITS

But in order to encourage transition .....
Subsidies on petrol removed, diesel reduced
CNG prices much lower than petrol & diesel
..... More vehicles?
..... More travel?
..... More congestion? =====› COSTS

Stop the preferential treatment for CNG?
(diesel-CNG price parity discussed in the policy area)

Objectives

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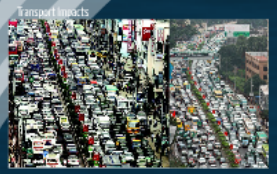
Did vehicle ownership increase?
Did individual vehicle travel increase?



Transport Impacts

Transport Impacts Summary

Vehicle ownership did not increase

Vehicle travel increased

Congestion increased

-USD 160M (80-420M) additional congestion costs

Transport Impacts

Transport Impacts

Ownership Impacts

Did ownership increase?

Intervention analysis on personal vehicles (car, SUV, Station wagon)
Vehicle number ~ f(GDP, population)
Dynamic autoregressive, distributed lag model
Approach 1 (Model A):

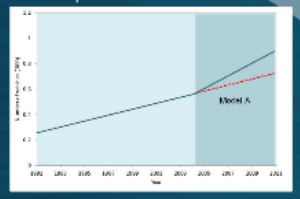
$$LV_t = \alpha + \sum_{i=1}^{p} \varphi_i LV_{t-i} + \sum_{i=0}^{q} \beta_i LGDP_{t-i} + \sum_{i=0}^{r} \gamma_i LP_{t-i} + \varepsilon_t$$

Run on a subsample till 2004, then predict till 2010, compare with real

Approach 2 (Models B, C, D):

$$LV_t = \alpha + \sum_{i=1}^{p} \varphi_i LV_{t-i} + \sum_{i=0}^{q} \beta_i LGDP_{t-i} + \sum_{i=0}^{r} \gamma_i LP_{t-i} + \text{Dummy} + \varepsilon_t$$

Did ownership increase?



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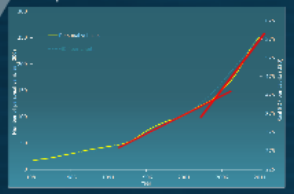

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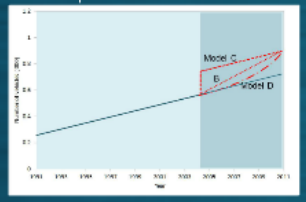
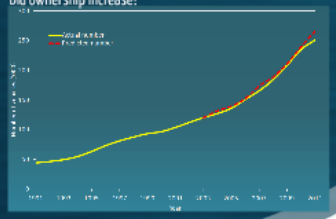


Did ownership increase?

Parameter	A	B	C	D
Dummy	None	$D_t=0$ if $t<2005$ else $D_t=1$	$D_t=0$ if $t<2005$ else $D_t=1$	$D_t=0$ if $t<2005$ else $D_t=t-2004$
p	2	2	2	2
q, r	0	0	0	0
LV_{t-1}	1.475***	1.497***	1.494***	1.495***
LV_{t-2}	-0.755***	-0.796***	-0.793***	-0.793***
$LGDP$	0.368**	0.307**	0.385***	0.303***
LP	0.386**	0.376***	0.437***	0.437***
D_t or $D_t t$	-	-0.006	-0.007*	-0.000
constant	-4.754**	-4.416***	-5.068***	-5.056***
N	29	29	29	29

Did ownership increase?



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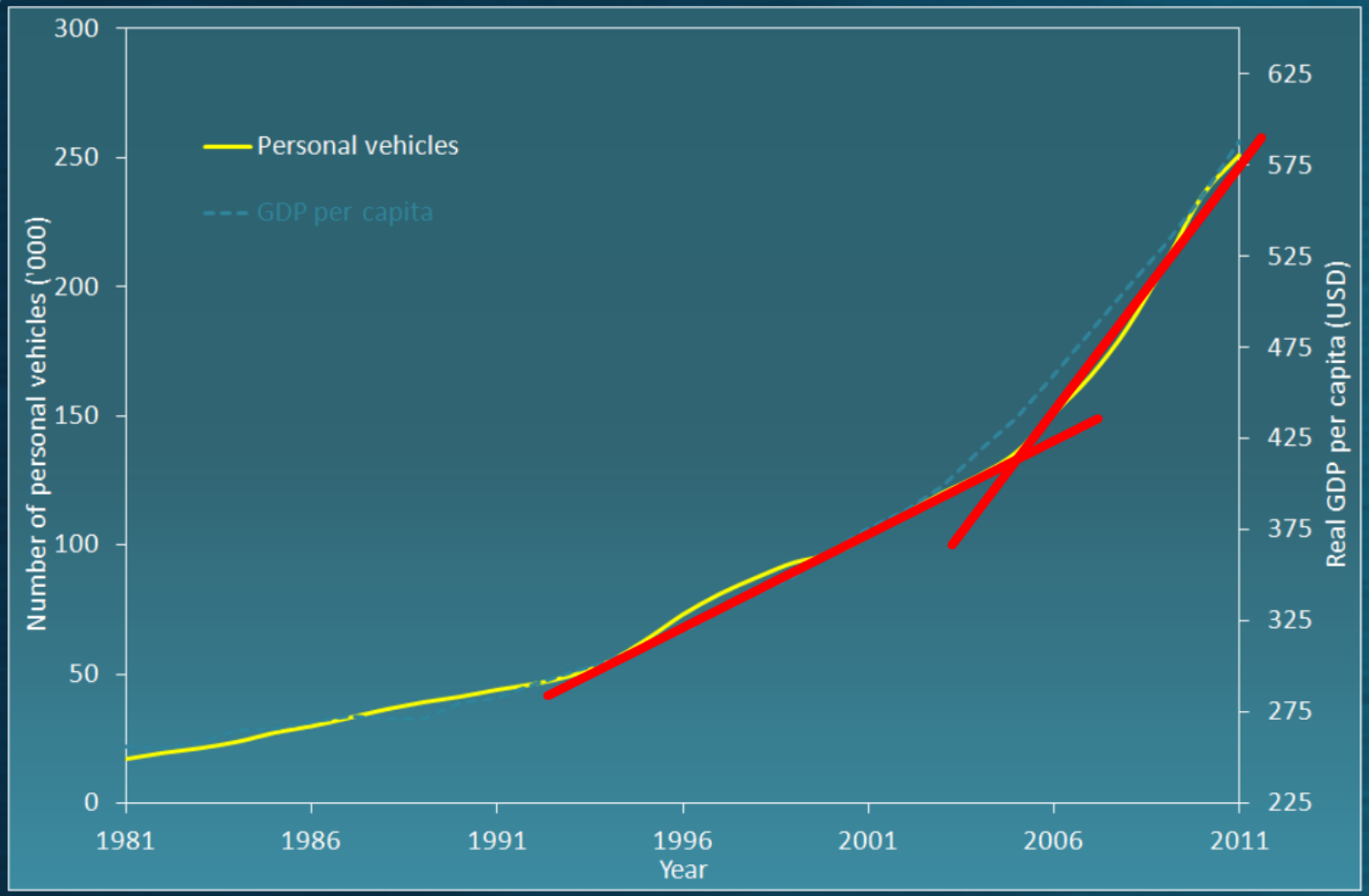

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$$lnV_t = \kappa + \sum_{i=1}^{l} \alpha_i lnV_{t-i} + \sum_{j=0}^{m} \beta_j lnGDP_{t-j} + \sum_{k=0}^{n} \gamma_k lnP_{t-k} + \varepsilon_t$$

Run on a subsample till 2004, then predict till 2010, compare with real

Approach 2 (Models B, C, D):

$$lnV_t = \kappa + \sum_{i=1}^{l} \alpha_i lnV_{t-i} + \sum_{j=0}^{m} \beta_j lnGDP_{t-j} + \sum_{k=0}^{n} \gamma_k lnP_{t-k} + Dummy + \varepsilon_t$$

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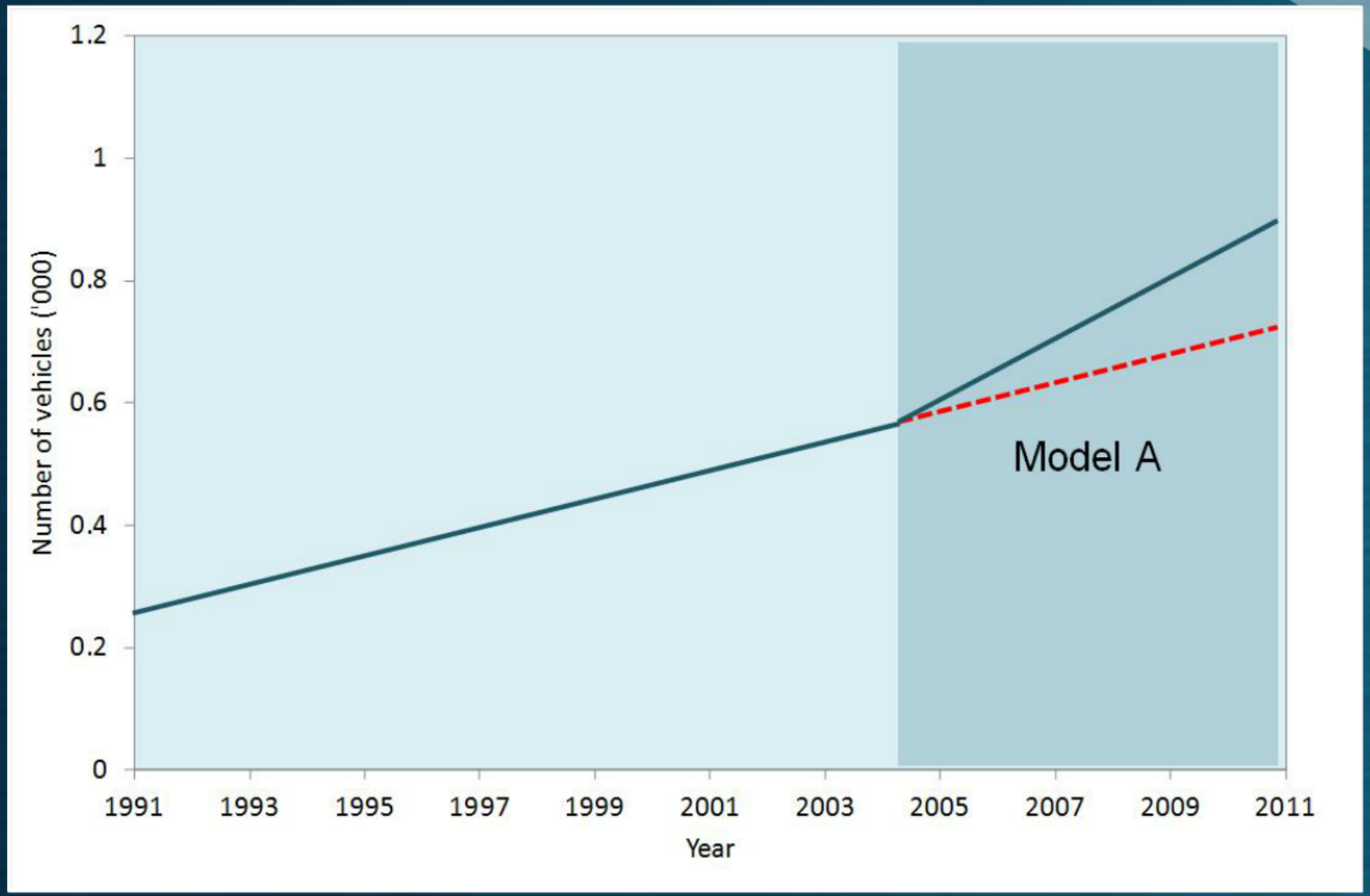

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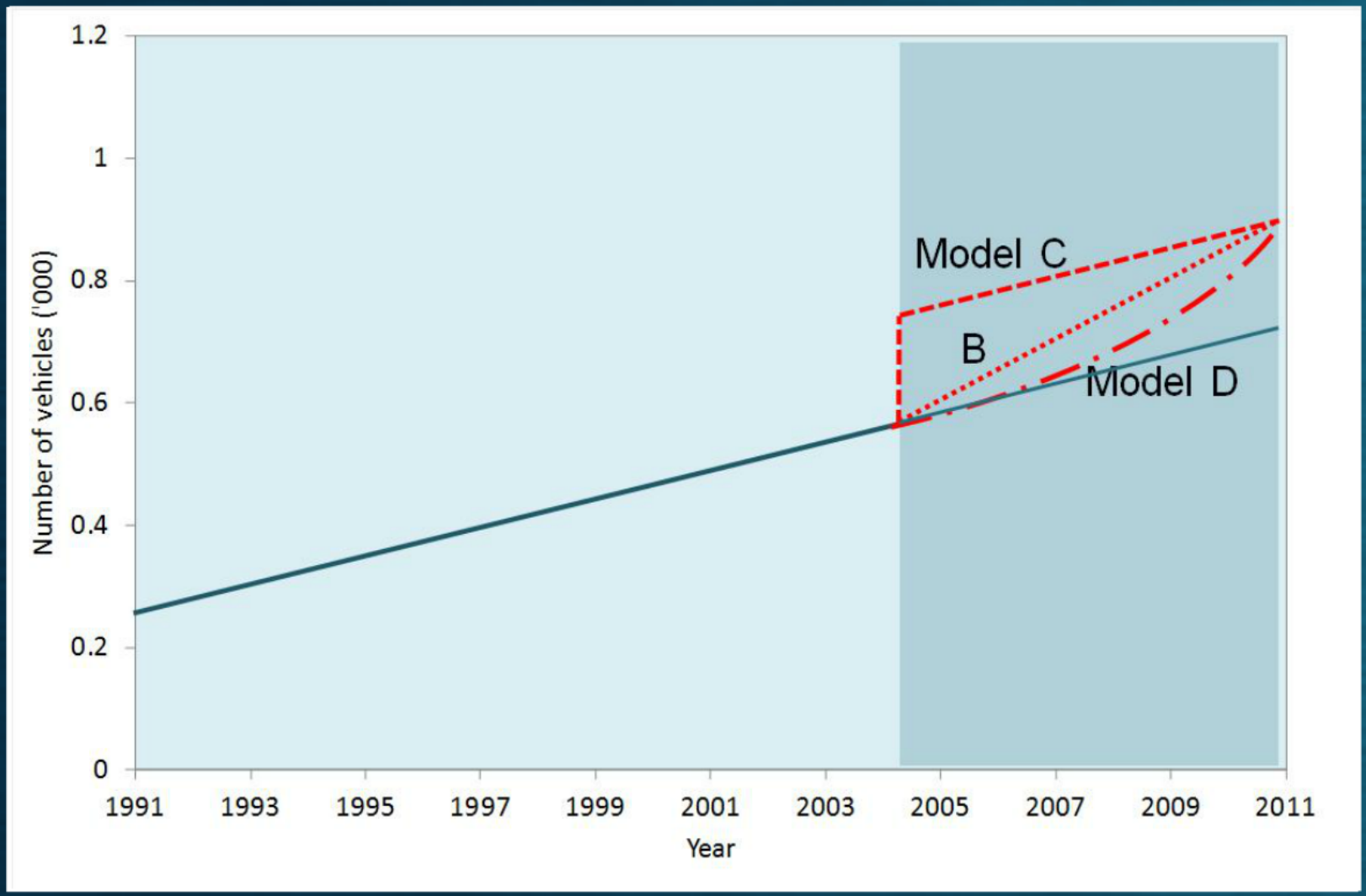
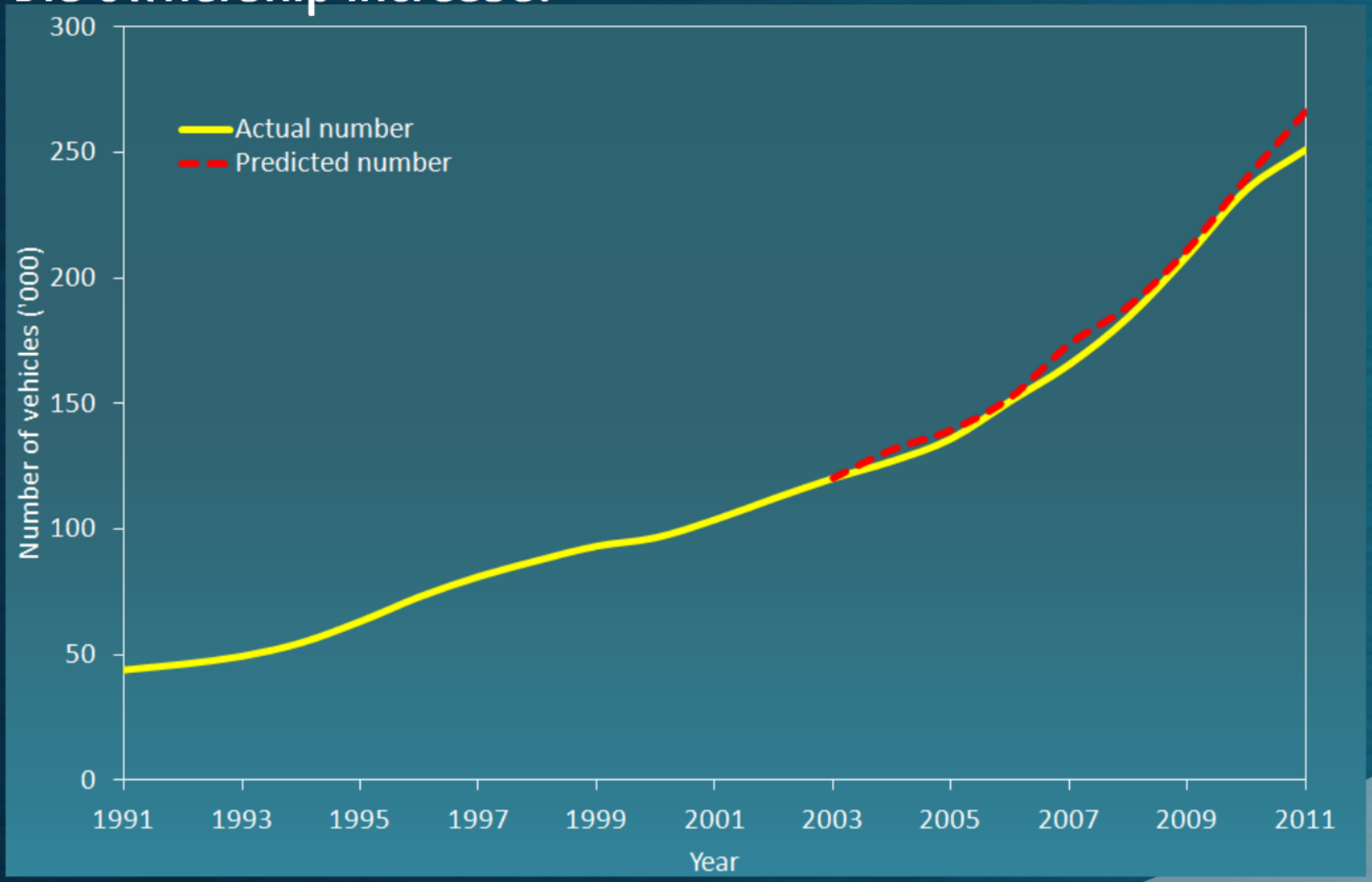


Did ownership increase?

Parameter	A	B	C	D
Dummy	None	D_g=0 if t<2004 =t-2004, else	D_s=0 if t<2004 =1, else	D_{int}=D_s×lnGDP
l	2	2	2	2
m, n	0	0	0	0
lnV_{t-1}	1.475***	1.497***	1.434***	1.435***
lnV_{t-2}	-0.795***	-0.799***	-0.790***	-0.793***
lnGDP	0.369**	0.307**	0.388***	0.393***
lnP	0.386**	0.376***	0.437***	0.437***
D_g/D_s/D_{int}	-	-0.002	-0.027	-0.005
constant	-4.734**	-4.416***	-5.268***	-5.286***
N	21	29	29	29

Did ownership increase?



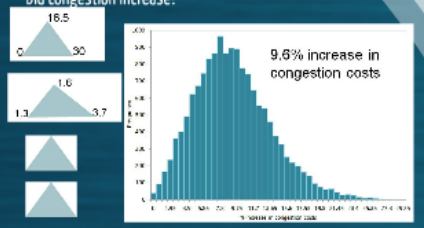
Travel Impacts

Did congestion increase?

VKT-congestion; speed-flow-density – city specific
No such relationship available in Dhaka
Elasticity of congestion/delay w.r.t. VKT: 0.3 to 6.2
Deakin and Harvey (1997): 1.6

7.4% increase in congestion costs due to price-effect

Did congestion increase?



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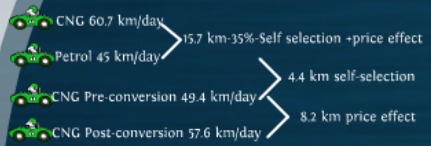

Pre-conversion large sample = f(pre-conversion small sample)
Price effect 8.6 km/day; self-selection 7.1 km/day
4.7% increase in total VKT

Did travel increase?

Questionnaire survey

On-road CNG vehicles travel 35% more than on-road petrol vehicles

Difference due to price effect + self selection
(some similarity with diesel in Europe?)

Price effect matters for this analysis

Did travel increase?

Questionnaire survey

On-road CNG vehicles travel 35% more than on-road petrol vehicles

Difference due to price effect + self selection
(some similarity with diesel in Europe?)

Price effect matters for this analysis

Did travel increase?

CNG 60.7 km/day

Petrol 45 km/day

15.7 km-35%-Self selection +price effect

CNG Pre-conversion 49.4 km/day

4.4 km self-selection

8.2 km price effect

CNG Post-conversion 57.6 km/day

Pre-conversion large sample = f(pre-conversion small sample)

Price effect 8.6 km/day; self-selection 7.1 km/day

4.7% increase in total VKT

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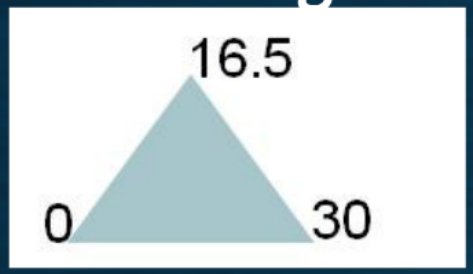

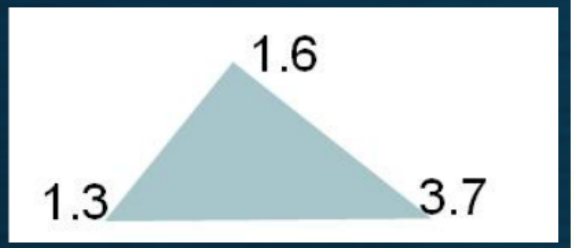

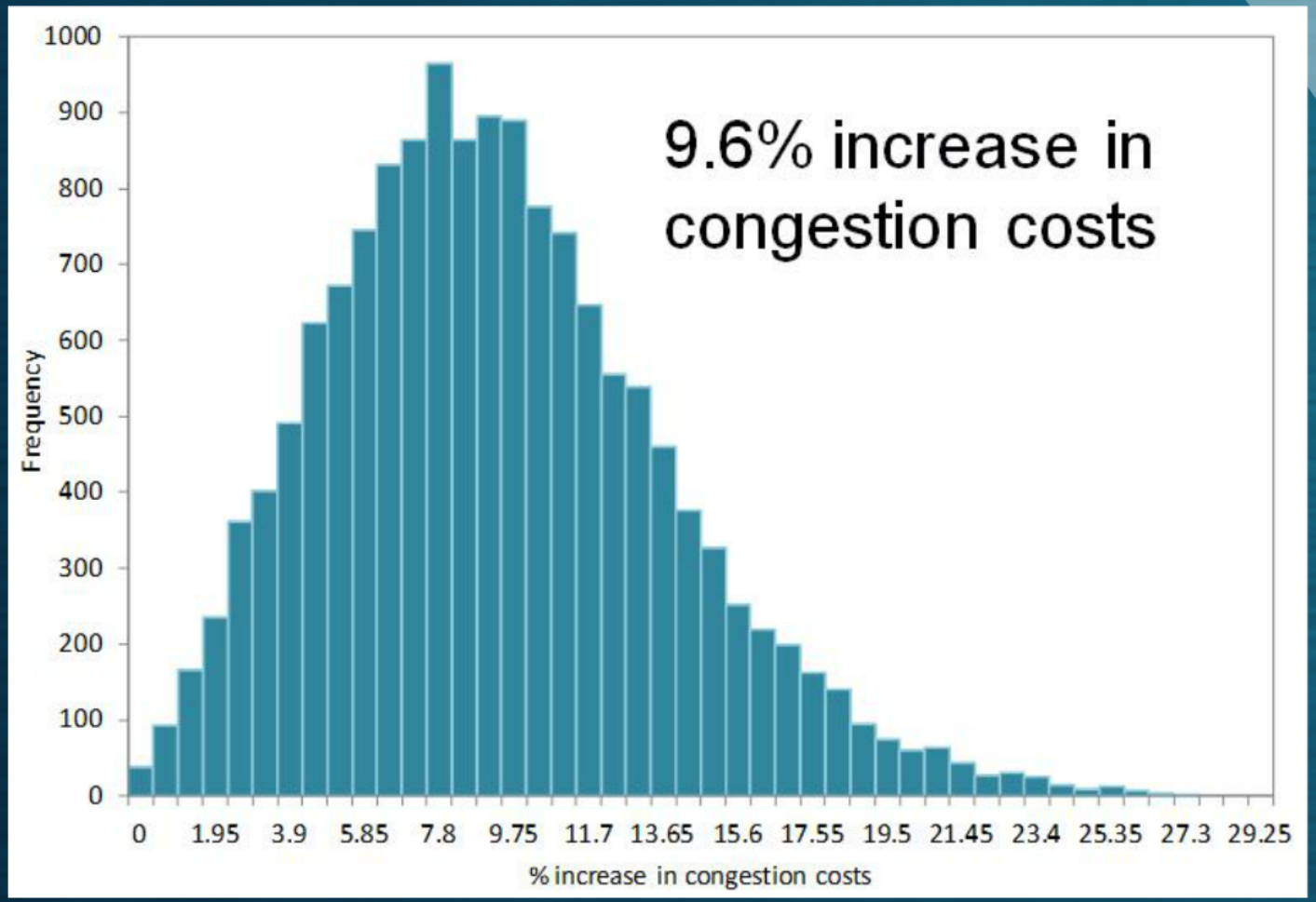

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Air Quality Impacts
Summary

0.01 g/m3 reduction in ambient PM2.5

~ 1,965 premature mortality avoided

@ USD 200,000 VSL ==› USD 400M

VSL & non-linearity of Concentration-Response functions major uncertainty

GHG Impacts
Summary

Reductions in CO_2, Black Carbon (Good!)

Reductions in SO_2 & Organic Carbon (Not good!)

Increase in Methane (Not good!)

Net effect still uncertain, minor/ neutral

Petrol conversions not good

Conclusions

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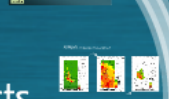


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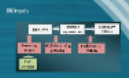


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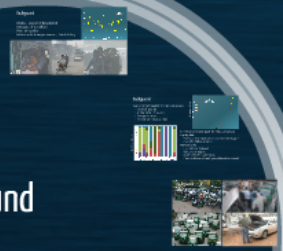


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