Policy Instruments for Increasing Demand for Public Transport in India

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Motivation

- Rapid economic development in India → increasing mobility demand

- Rising share of personal vehicles
  - Lower share of public transport
  - Higher energy consumption, emissions, noise, waste, etc.
  - Social & political impact

- Strategy: increase share of public bus transport in passenger transport
  - Increase capacity
  - Improve quality

…motivation

- How best to influence demand
  - Price of transport – the bus fare
  - Impact of non–price variables such as quality
  - Cost implications?
- Need for investments → financial viability
  - Improvements in farebox collections → Tariff reforms
- Trade–off between efficiency & access?
  - Developing country context
  - Sustainability targets

Choice…

- Personal transport is more expensive (??)

$$Rupees_{private} >> Rupees_{public}$$

- Travel demand met is the same

$$Travel_{private} = Travel_{public}$$

- Quality of public transport is poorer

$$Quality_{personal} >> Quality_{public}$$

…influencing modal choice

↓ for public modes

Price / Cost of travel

↑ for personal modes

↓ for personal modes

Quality parameters

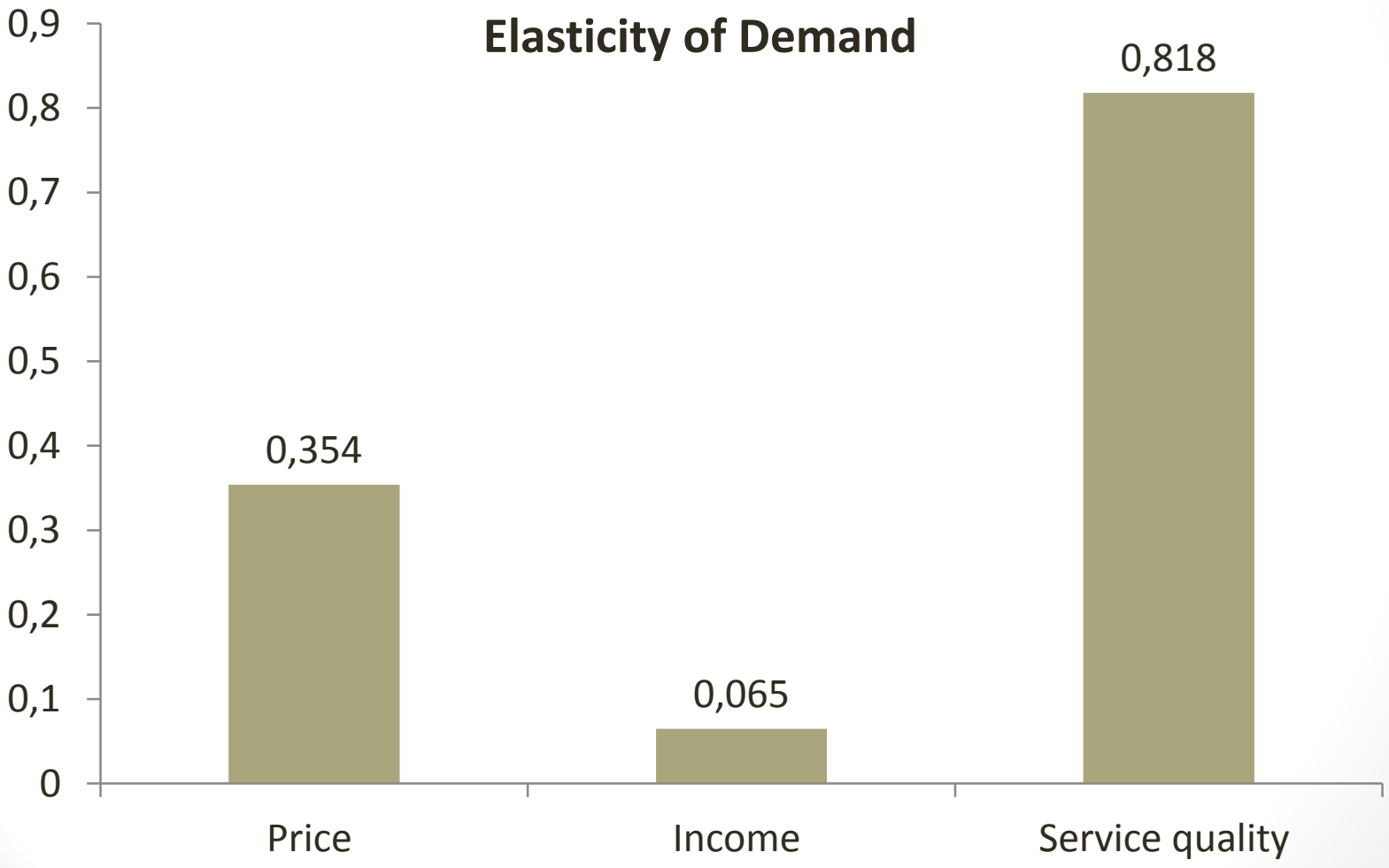
↑ for public modes

Demand specification

- Aggregate demand function
  - Travel demand as a continuous variable
  - Not as a demand system, only public bus travel demand
  - Dynamic & static panel data models
- Specification issues
  - Using pkm reflects actual market transactions
  - Price & income as monetary variables
  - Service quality to reflect access: network length per unit area
  - Demographic variables: labour force, literacy rate
  - Log linear
- Dataset
  - All states with public transport in India
  - Unbalanced panel: 22 states over 10 years

$$pkm = f\left(p, w, q, s, pop, work, lit\right)$$

Factors Affecting Demand



Economically Viable Prices: Social Impacts

Optimal pricing of public bus transit in India

- Pricing reforms motivated by continued losses
  - Cost–based pricing would incentivize efficiency, ensure revenue adequacy
- However, public transit pricing can have other objectives
  - Ensure access
  - Environmental, energy consumption goals, etc
  - Ignored in this analysis, and by analysts in general?

…optimal pricing

- First best pricing: Marginal cost pricing

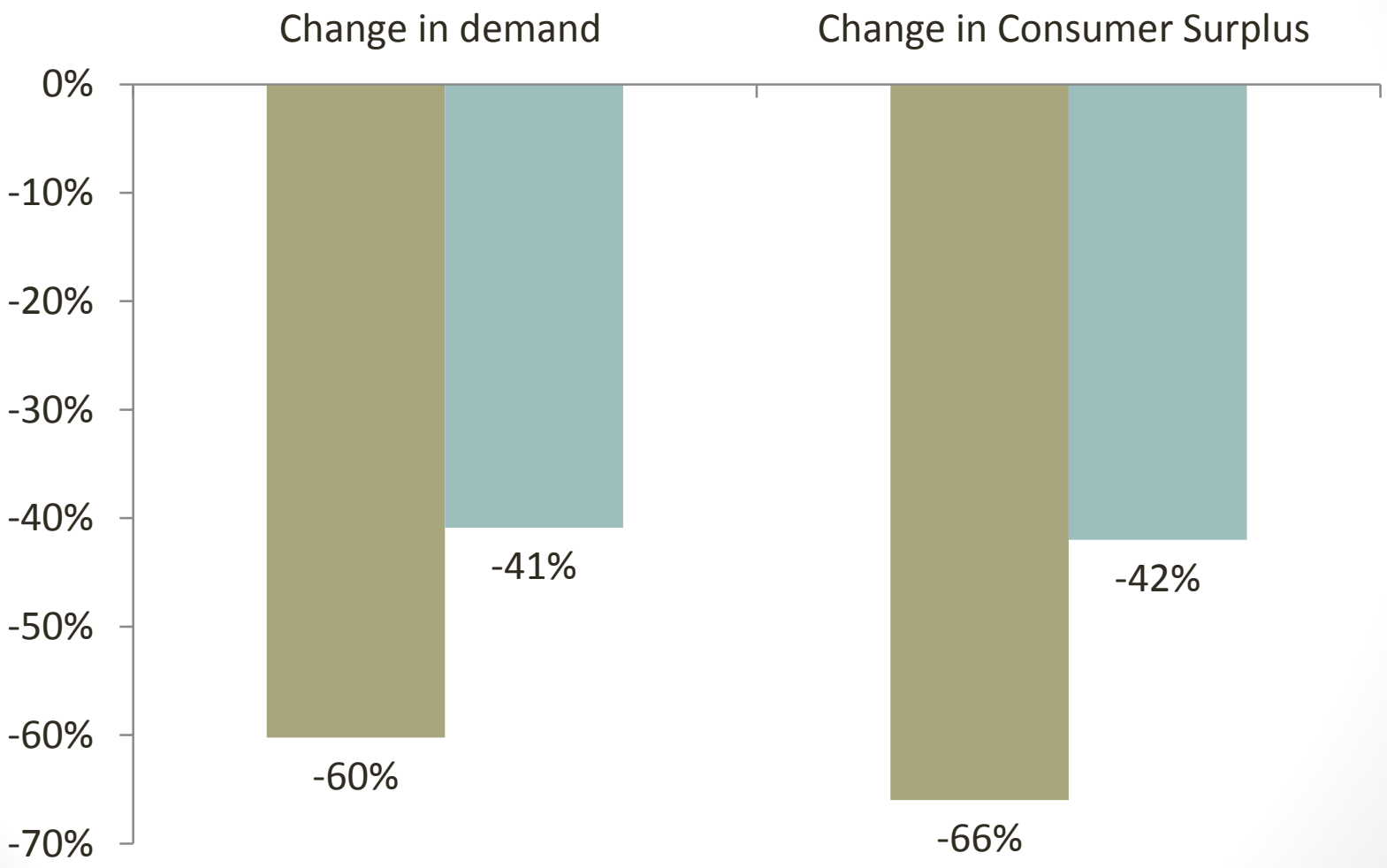
$$p(x) = MC(x)$$

- Second best pricing:
  - Two-part tariff

$$p_v = MC(x)$$

$$p_F = \frac{C(x) - p_v x}{I}$$

…optimal pricing

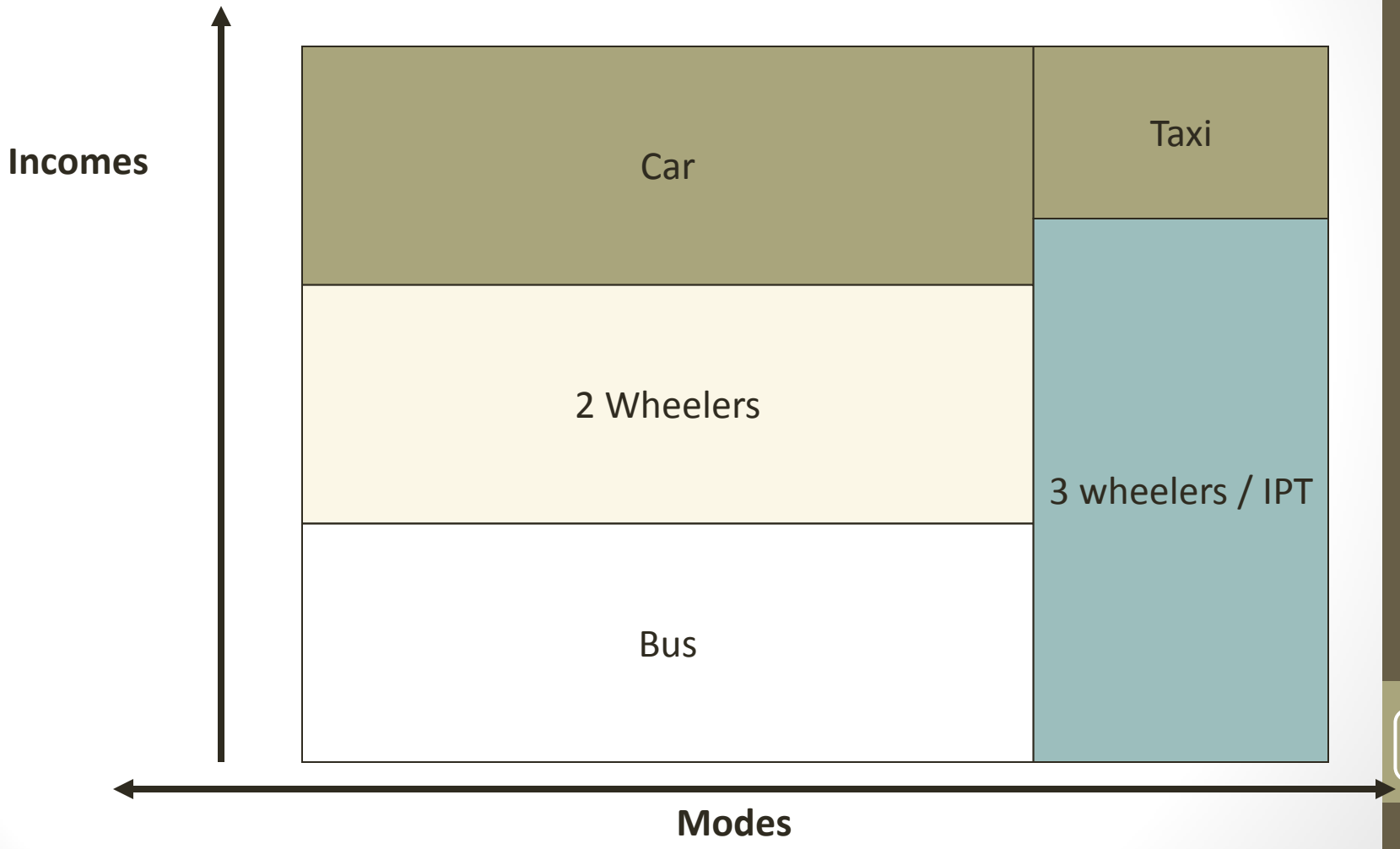


Take Home

- Access to service more important than transit fares
  - Could reduce generalized travel cost
- Price reforms can achieve efficiency gains but lead to fall in demand & consumer surplus
  - Trade–off between efficiency & access
  - Fall in demand could have significant environmental & social costs
- Public transport is a policy instrument, not just a business.

Back up slides

Commuter Categories



Defining output

- Supply based or demand based or a mix
- Supply based (vkm, skm, etc.)
  - Highly correlated with inputs
  - Don’t reflect actual market transactions
- Demand based (pax, pkm, etc.)
  - Less correlation with input use, but reflect market transactions
  - Heterogeneity issues, need to be addressed using more variables
- pkm used as output measure
  - Highly correlated with vkm
  - Easy correspondence with demand measures
  - Rich specification used to control for heterogeneity

Estimation methods – static models

- Fixed Effects AR(1)

$$y_{it} = \alpha_0 + \mathbf{X}_{it}\boldsymbol{\alpha}_1 + \nu_i + \varepsilon_{it}$$

$$\varepsilon_{it} = \rho\varepsilon_{i,t-1} + \eta_{it} \mid \eta_{it} \sim \left(0, \sigma_\eta^2\right)$$

- Random Effects AR(1)

$$y_{it} = \alpha_0 + \mathbf{X}_{it}\boldsymbol{\alpha}_1 + \nu_i + \varepsilon_{it}$$

$$\nu_i \sim \left(0, \sigma_\nu^2\right) \mid \varepsilon_{it} = \rho\varepsilon_{i,t-1} + \eta_{it} \mid \eta_{it} \sim \left(0, \sigma_\eta^2\right)$$

$$Cov(\nu_i + \varepsilon_{it}, \nu_j + \varepsilon_{js}) = \begin{cases} \sigma_\nu^2 + \sigma_\varepsilon^2 \text{ if } i = j \text{ and } s = t \\ \sigma_\varepsilon^2 \text{ if } i \neq j \text{ or } s \neq t \end{cases}$$

- PCSE

$$y_{it} = \alpha_0 + \mathbf{X}_{it}\boldsymbol{\alpha}_1 + \varepsilon_{it}$$

$$\varepsilon_{it} = \rho_i\varepsilon_{i,t-1} + \mu_{it} \mid E\left[\mu_{it}^2\right] = \sigma_i^2$$

Estimation methods – dynamic models

$$y_{it} = \alpha_0 + \gamma y_{it-1} + \mathbf{X}_{it}\boldsymbol{\alpha}_1 + \nu_i + \varepsilon_{it}$$

- Arellano–Bond
  - Using first differences, remove individual effects.
  - Still correlation between the independent variables and the errors
  - Use deep lags of levels as instruments in the **differences equation**
  - But
    - It is not possible to estimate the effect of time invariant factors
    - Observations are dropped
- Blundell–Bond
  - Use lagged differences as instruments in the **levels equation**
- Corrected LSDV
  - FE estimates are biased
  - Bun et. al. (2003) correct for bias & show with MC that estimates 'very accurate'

Regression results

	Fixed Effects	Random Effects	PCSE	Arellano–Bond	Blundell–Bond
F statistic	366.57***				
R^2	0.8939		0.9874		
Wald chi^2		1635.03***	3784.45***	662.94***	69,650.56***
Sargan chi^2				47.40	77.01***
AR (1)				−1.72	−5.73***
AR (2)				0.16	0.88

Regression results: Static Models

	Fixed Effects	Random Effects	PCSE
Price	−0.460***	−0.354***	−0.359***
Income	−0.020	−0.065	−0.061
Density of coverage	0.834***	0.818***	0.754***
Per capita private vehicles	−0.028	−0.106***	−0.212***
Population	0.662***	0.938***	1.026***
Proportion of labour force	6.770***	6.798***	11.797***
Literacy rate	−4.089***	−3.665***	−1.099***
Persistence			
Constant	1.273***	−3.350***	−8.829***

Regression results: Dynamic Models

	Arellano–Bond	Blundell–Bond	Corrected–LSDV
Price	−0.420***	−0.262***	−0.374***
Income	−0.016	−0.058	−0.027
Density of coverage	0.691***	0.160***	0.676***
Per capita private vehicles	−0.003***	−0.118*	0.037
Population	−1.662***	0.099*	−0.500*
Proportion of labour force	3.711***	2.674**	2.450*
Literacy rate	−4.140***	−0.787*	−1.974***
Persistence	0.119	0.886	0.294***
Constant	0.042***	−1.060	

Individual effects

	Model 1
Fixed Effects	
Sigma u_i	0.797
F stat	71.41 ***
Random Effects	
Sigma u_i	0.384

Demand Elasticities

	Fixed Effects	Random Effects	PCSE	Corrected LSDV	
				Short run	Long run
Price	−0.460***	−0.354***	−0.359***	−0.374***	−0.523***
Income	−0.020	−0.065	0.061	−0.027	−0.038
Service quality	0.834***	0.818***	0.754***	0.676***	0.957***

- Price inelastic demand
  - Relatively low long run value could reflect continued importance of public transit and lack of public transport alternatives to buses
- Income elasticities not significant
- Access to network significant and important
  - More important policy variable compared to price
  - May reflect importance of generalized transport costs