

# Transport Sustainability...What it is, how it is measured, and how to achieve it.....

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**Faculty of Built Environment and Engineering**

Professor Simon Washington

Queensland TMR Chair of Transport

Centre for Accident Research & Road Safety - Queensland

CARRS-Q is a joint venture initiative of the  
Motor Accident Insurance Commission  
and Queensland University of Technology



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CRICOS No. 00213J

Before we get started  
a pressing matter....

# Question 1:

“Which direction is north in Australia?”

## Question 2:

“Can you give me some information about hippo racing in Australia?”

## Question 3:

“I have developed a new product that is the fountain of youth. Can you tell me where I can sell it in Australia?”

## Question 4:

“Can you send me the Vienna Boys' Choir schedule?”

# Let's focus the discussion....

Metropolitan urban areas (developed countries)

Marginal growth and planning paradigm

We seek first to understand, then 'forecast', then implement

Doing the same will produce the same.....

# Objectives.....

- Identify **determinants of transport sustainability**
- Use **fundamental principles** to build a platform for a 'sustainable' way forward
- Discuss **essential tools** for becoming more sustainable
- In the process, highlight the “**state of the knowledge**”, even the unsavory
- Review decision making processes, and **propose a way forward**

# Determinants of Transport Sustainability

*Regional*

*Localized/corridor*

*Individuals*

(Government)  
Planners  
Roads  
Transport  
Rail  
Airports  
Seaports

Schools

Businesses

# Transport System (influences)

You and I

Private Managers

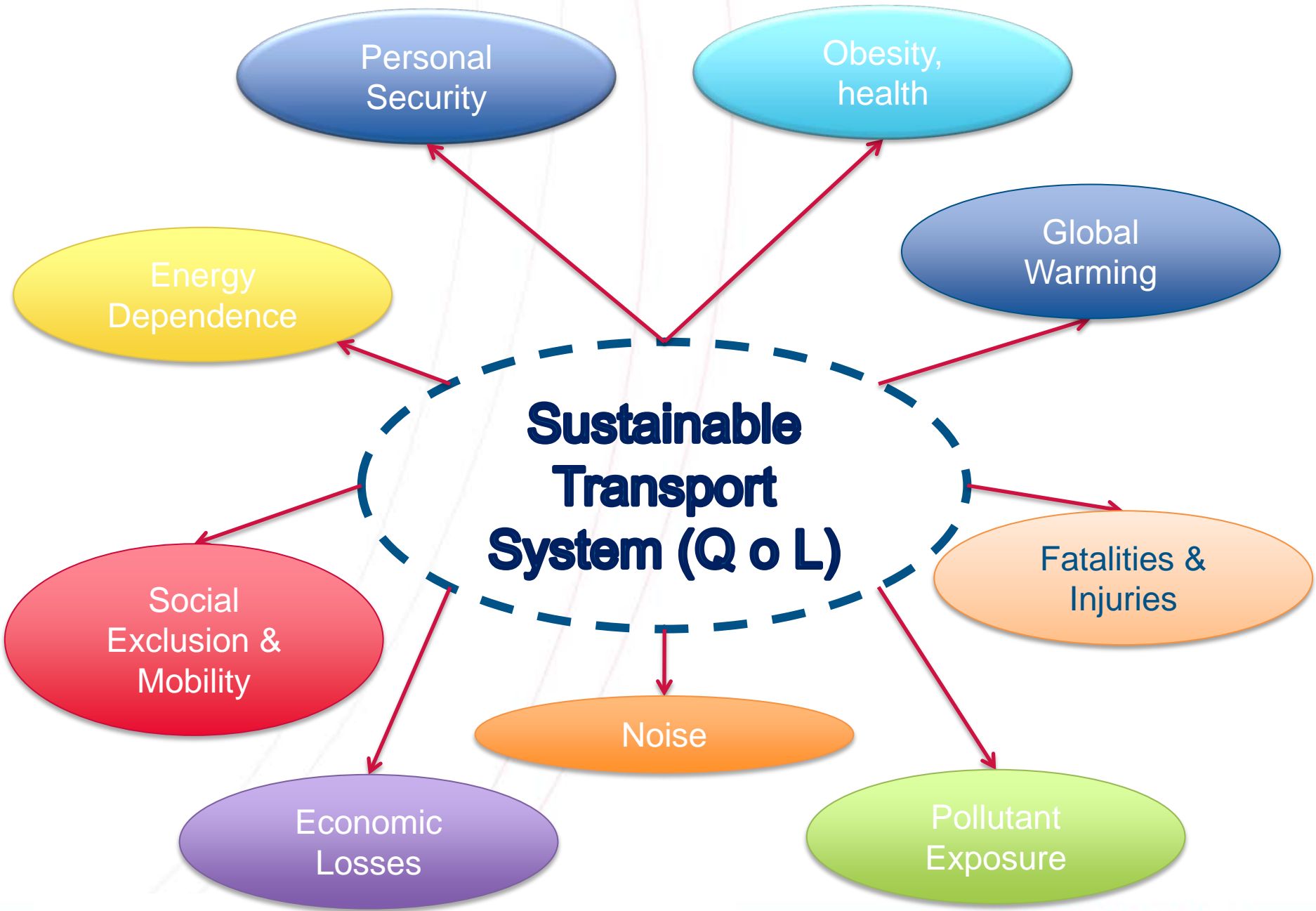
Hospitals

Fleet Operators

Universities

Property  
Developers

Stadiums, libraries,  
museums, etc.



# Fundamental Principles: for informing sustainability

# Tragedy of the Commons

The **tragedy of the commons** is a dilemma arising from the situation in which multiple individuals, acting independently, and solely and rationally consulting their own self-interest, will ultimately deplete a shared limited resource even when it is clear that it is not in anyone's long-term interest for this to happen.

Wikipedia

# Tragedy of commons (cntd.)

“The **benefits of exploitation accrue to individuals or groups**, each of whom is motivated to **maximize use** of the resource to the point in which they become reliant on it, while the **costs of the exploitation** are **borne by all** those to whom the resource is available (which may be a wider class of individuals than those who are exploiting it)”

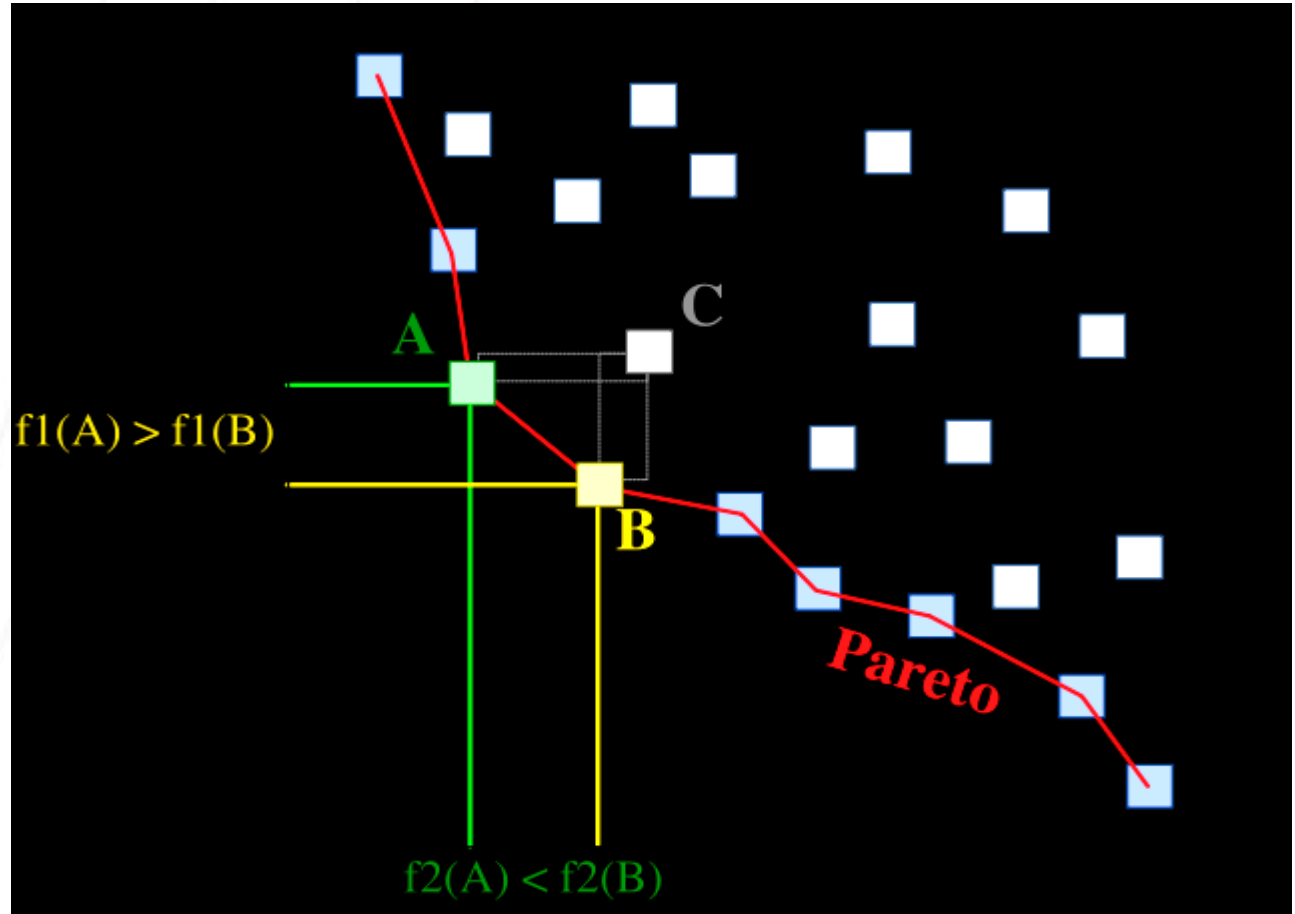
Daniels, 2007.

# Evidence of “tragedies”

- The world’s fish population
- Global warming
- Nuclear proliferation
- The use of fossil fuels
- **Transport systems in populated/growing urban regions**

# What we know about optimization

Air Pollution



Congestion

# Induced demand, suburban growth, & travel

“Congestion relief, however, does not necessarily make for a sustainable and livable metropolis. Thus residents of places that are able to build themselves out of traffic congestion might not necessarily like what they get”.

Robert Cervero, 2003



# Message from fundamentals

- ‘Commons’ need to be effectively managed, not necessarily privatized
- Transport models reveal time and again that ‘individual’ and ‘system’ optimums are not the same (e.g. travel time)
- Transport systems are complex, multi-objective optimization problems

# Message from fundamentals (cntd)

- 'Multiple objectives for the transport system necessarily means living with sub-optimal solutions measured on an individual criterion
- Transport infrastructure and policy decisions will differ by value priorities given to externalities
- It is difficult for the general public to comprehend sub-optimal solutions

# Essential tools for becoming more sustainable

# Essential tools.....

1. Understand travel behaviour
2. Economic
3. Active transport
4. Public transport
5. Land use policies
6. Technology
7. Travel demand management
8. Alternative fuels/renewable energy
9. Efficiency improvements

# 1. Understanding travel behaviour

# How people in Brisbane travel

**Table 1 Mean travel distance and mean travel time, by mode, for a weekday – SEQTS 2003/04**

	Number of trip stages per person per day	Proportion of trip stages made by all modes	Mean travel distance (km per person per day)	Proportion of travel distance by all modes	Mean travel time (minutes per person per day)	Proportion of travel time by all modes
Motor vehicle (driver + passenger)	2.8	69.8%	29.7	83.0%	52.2	74.4%
Public transport <sup>1</sup>	0.3	8.4%	3.8	10.6%	8.1	11.6%
Walking	0.4	20.4%	0.6	1.8%	8.3	11.8%
Cycling	0.0	1.0%	0.1	0.4%	0.8	1.1%
Other <sup>2</sup>	0.0	0.5%	1.5	4.3%	0.8	1.1%
<b>TOTAL</b>	<b>3.5</b>	<b>100%</b>	<b>35.7</b>	<b>100%</b>	<b>70.2</b>	<b>100%</b>

<sup>1</sup>Includes train, bus, ferry and taxi

<sup>2</sup>Includes motorcycle and any other modes not mentioned above

Burke and Brown, 2007

# Understanding Individuals

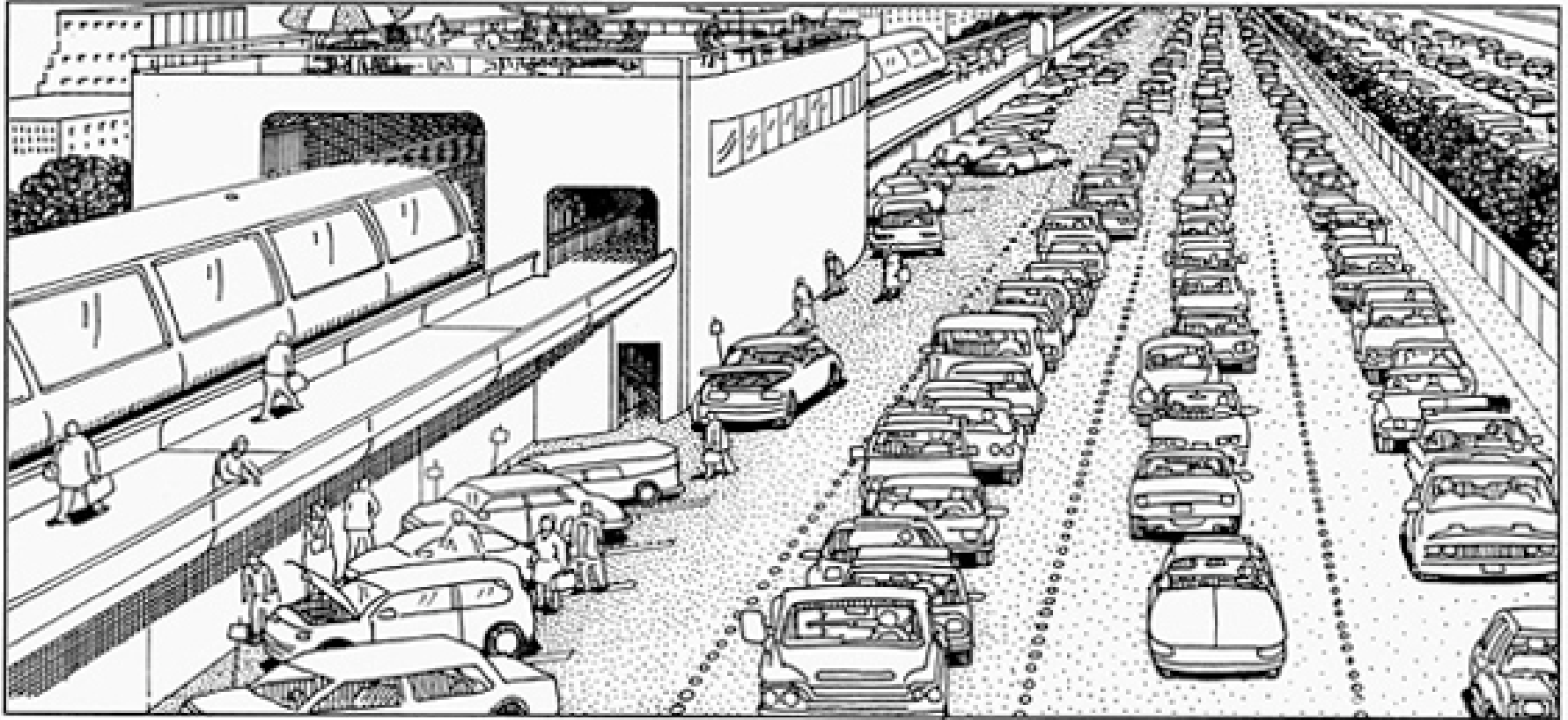
- The field of travel behavior research continues to evolve
- Understanding 'trip generation' is not sufficient for exploring fundamental issues of transport system change
- The fundamental unit of understanding is 'activity fulfillment'

# Understanding Individuals (cntd)

- To understand reactions to sustainable transport solutions we must understand:
  - Activity fulfillment needs and markets
  - Household structure and dynamics
  - Residential location decisions
  - Vehicle purchase decisions
  - Elasticities to price, travel time, income, congestion, parking availability, perceived safety and security, etc.
  - Attitudes, preferences, and motives

# Elasticities inform us about trade-offs between modes.....

## **AUTOMOBILE ABANDONMENT ZONES**



Auto abandonment zones are built to accommodate growing numbers of drivers who lose the will to proceed further in bumper-to-bumper, freeway traffic. Drivers may pull off, leave car keys with an Abandonment Officer, and board a nearby train, phone relatives, or calm themselves in "parks."

# **2. Harnessing economic tools and theory**

# Several generally accepted economic truths.....

- The full social costs of motor vehicle travel and not borne by users
- Auto use is subsidized by governments
- Price signals are generally under-utilized to assist in transport sustainability objectives

Non-monetary externalities of motor vehicle use, 1990-1991. US \$Billion

<i>Cost item</i>	<i>Low</i>	<i>High</i>
Accidental pain, suffering, death, and lost nonmarket productivity not accounted for by economically responsible party	9.5	97.7
Travel delay, imposed by others, that displaces unpaid activities	22.5	99.3
Air pollution: human mortality and morbidity due to particulate emissions <sup>b</sup> from vehicles	16.7	266.4
Air pollution: human mortality and morbidity due to all other pollutants from vehicles	2.3	17.1
Air pollution: human mortality and morbidity, due to all pollutants from upstream processes	2.3	13.0
Air pollution: human mortality and morbidity, due to road dust	3.0	153.5
Air pollution: loss of visibility, due to all pollutants attributable to motor vehicles	5.1	36.9
Air pollution: damage to agricultural crops, due to ozone attributable to motor vehicles	3.3	5.7
Air pollution: damages to materials, due to all pollutants attributable to motor vehicles	0.4	8.0
Air pollution: damage to forests, due to all pollutants attributable to motor vehicles	0.2	2.0
Climate change due to lifecycle emissions of greenhouse gases (U. S. damages only)	0.0	3.5
Noise from motor vehicles	0.5	15.0
Water pollution: health and environmental effects of leaking motor-fuel storage tanks	0.1	0.5
Water pollution: environmental and economic impacts of large oil spills	0.2	0.5
Water pollution: urban runoff polluted by oil from motor vehicles, and pollution from highway deicing	0.7	1.7
Nonmonetary costs of net crimes related to using or having motor-vehicle goods, services, or infrastructure	0.7	2.8
Nonmonetary costs of fires related to using or having motor-vehicle goods, services, or infrastructure	0.0	0.2

# Most comprehensive study to date on motor vehicle costs

Delucchi, 1998 revised 2004

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# Costs of oil use.....

TABLE 1-A3. SUMMARY OF THE EXTERNAL COSTS OF OIL USE (1991\$/END-USE GALLON)

Cost category	Gasoline vehicles	Diesel vehicles	All vehicles	Cost basis <sup>a</sup>
Strategic Petroleum Reserve - low	0.0004	0.0006	0.0005	Middle-East oil?
Strategic Petroleum Reserve - high	0.0052	0.0064	0.0054	Middle-East oil?
Defense expenditures - low	0.0056	0.0071	0.0059	Middle-East oil
Defense expenditures - high	0.0631	0.0779	0.0661	Middle-East oil
Pecuniary externality - low	0.0285	0.0350	0.0298	U.S. oil use
Pecuniary externality - high	0.0596	0.0730	0.0623	U.S. oil use
Price-shock cost to GNP - low	0.0189	0.0231	0.0198	U.S. oil use
Price-shock cost to GNP - high	0.1889	0.2314	0.1976	U.S. oil use
Water pollution - low <sup>b</sup>	0.0023	0.0026	0.0023	U.S. oil use
Water pollution - high <sup>b</sup>	0.0076	0.0084	0.0078	U.S. oil use
<i>All costs - low</i>	<i>0.056</i>	<i>0.068</i>	<i>0.058</i>	
<i>All costs - high</i>	<i>0.324</i>	<i>0.397</i>	<i>0.339</i>	

# Other economic tools—pay as you go driving costs

The bulk of price signals that most motorists receive are fixed (insurance, capital cost of vehicle), which *encourage use*.

Out of pocket, or pay-as-you-go (PAYG) expenses, such as petrol, parking, and tolls, *encourage thrift*.

Innovative policies that shift costs from fixed to PAYG may be instrumental in reducing high impact travel.

# Market segments and price signals

“Identifying the behavior within sub-groups that are most sensitive to *pricing signals* would enable traffic authorities to implement strategies to achieve more efficient results than those obtained when viewing travel demand from an aggregate perspective.”

Hensher and Puckett (2006)

# Economic tools.....summary

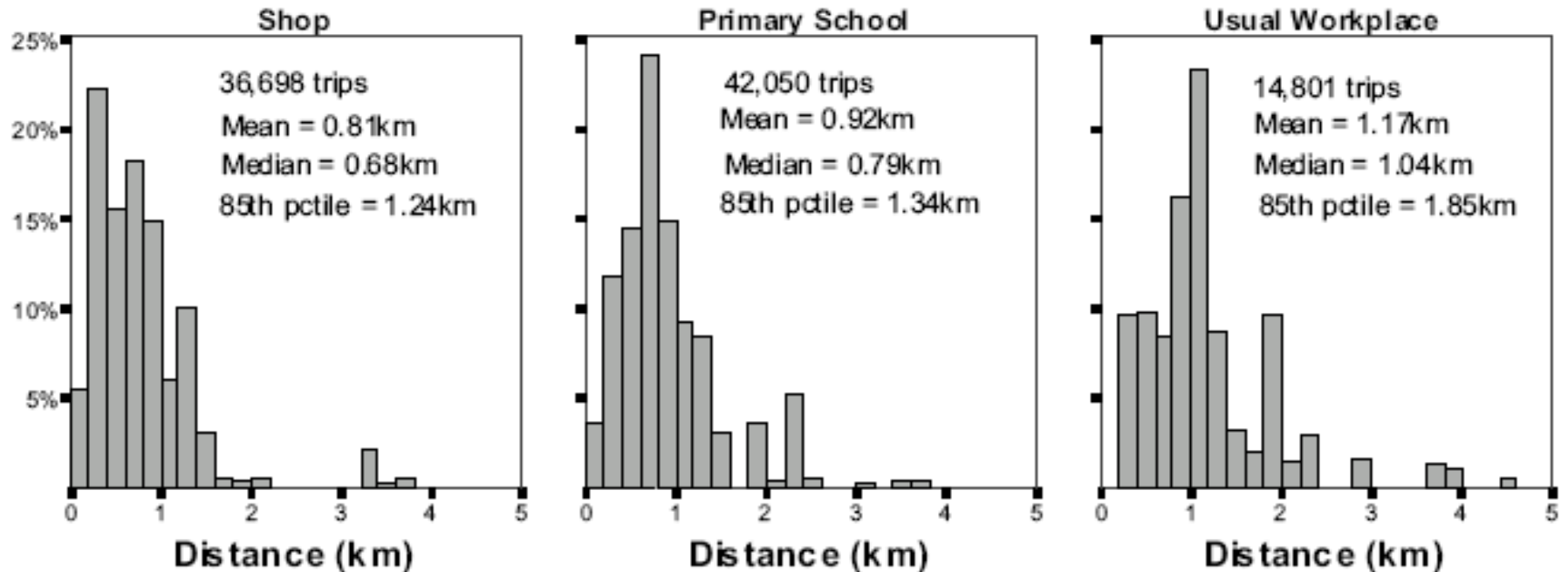
- Much more can be done with economic tools
- PAYG schemes, parking pricing, full social cost pricing, variable cost tolling, and subsidies to more 'sustainable' modes all reveal promise
- Equity issues remain a challenge with economic tools

# **3. Heavy focus on active transport**

# What we know.....

- Short travel distances are conducive to active transport
- Wait time = 3 to 4 x time weight while moving
- Safety and security are paramount
- Continuous, coordinated, and contiguous are key features
- Esthetics and pedestrian scale are keys

# Typical walking distances (Brisbane, 2003-4)



Burke and Brown, 2007

# How to motivate mode shift

- Behavioral change programs at target markets (see Taylor and Ampt, 2003)
- Provide coordinated, safe, secure, pedestrian/bicycle infrastructure (including work trip end facilities)
- Provide monetary incentives (perhaps cross subsidized)

# motivating mode shift (cntd)

- Identify different user markets and activities used for walking/bicycling
- Recognize time sensitivity of mode (minimize wait times)
- Give pedestrian/bike priority over higher social cost modes

# **4. Offering competitive, safe public transport**



# Transport use impediments

- Household demographics and complexity influence transit use
- Urban sprawl (dispersed origins and destinations)
- Multi-income households and the need to ‘chain’ trips (e.g. daycare, grocery shop, dry cleaners, etc.) deters transit use (see Hensher and Reyes, 2006)
- Travel time is key—it must often be superior to the private auto to be viable

# Things to consider.....

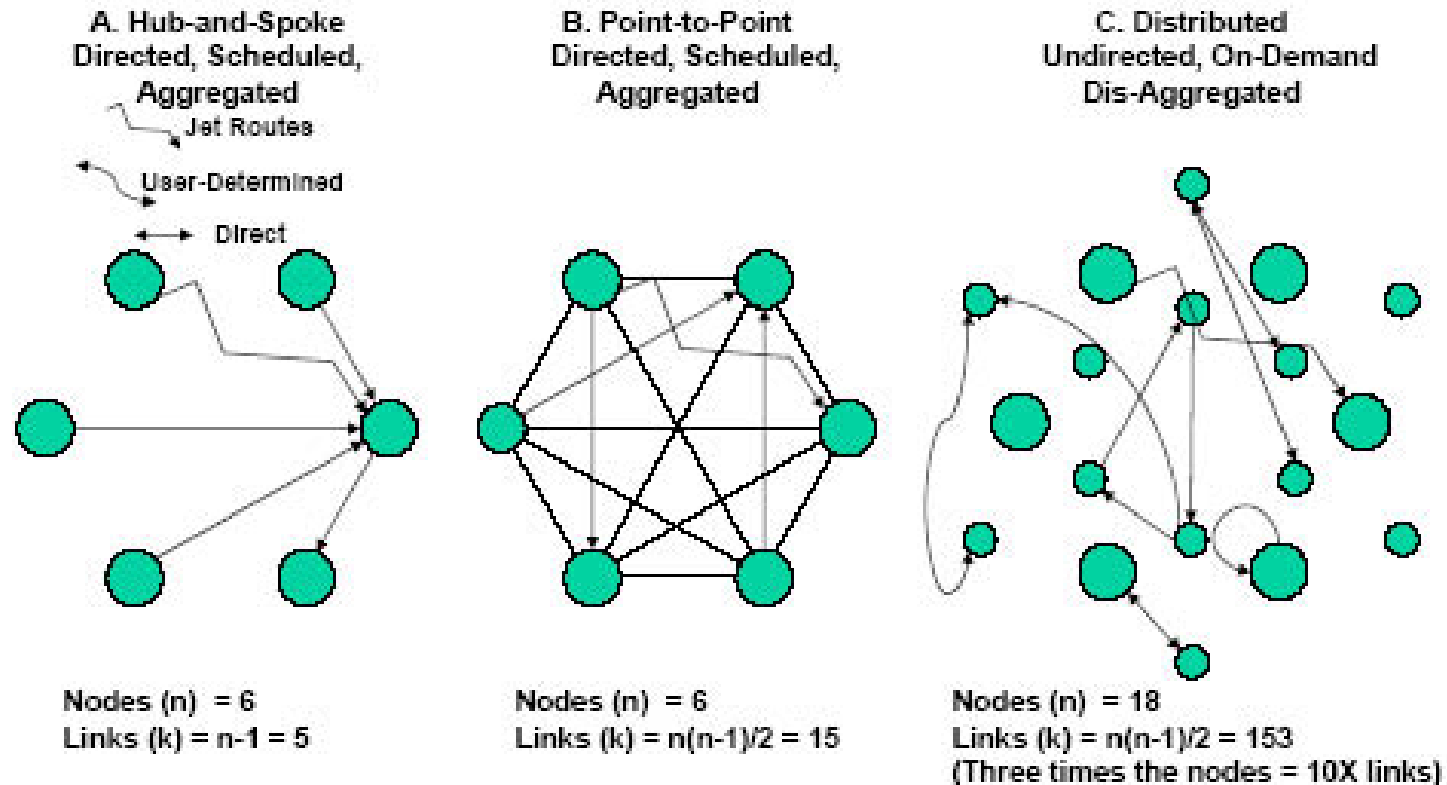
- Public transport and land use integration is key
- Recognizing the trip-chaining aspect of activity fulfillment can help shape land use/transport policy
- Designated bus ways/bus rapid transit is key (to be time competitive)
- Safe, clean, and secure are critical characteristics

# **5. Sensible coordination of land use and transport policy**

Debates rage on regarding the exact nature of the relationship between land use and transport

One thing is clear, they are mutually endogenous (co-dependent)

# Edge cities, suburban centers, urban growth boundaries, smart growth, urban in-fill, etc.



# Land use, density, and transit oriented development

“A new transit-oriented development could make jobs or non-work activities accessible via rail or bus to more residences without increasing the time price of auto use. Such a change may increase alternative mode use only slightly, if at all. But if road design standards are relaxed, if network load density also increases, and in turn road speeds decrease, auto mileage may decline, particularly if transit and walking options are available. Policies aimed solely to make things better for walkers may not reduce driving.”

(Chatman, TRA 2008)

# Land use characteristics

“Network load density, activity density, built form density, and pedestrian/transit-oriented design are not always highly correlated with each other in new development. Research failing to control for each may erroneously conclude that high-density developments will reduce auto use, when whether this will happen is clearly dependent on the particular details and context of development.”

(Chatman, TRA 2008)

# Things to consider.....

- Land use and transport planners need to be in the same room, often.
- Planners need to be made more aware of complexity of activity fulfillment and impediments to travel and mode choice
- Engineers need to pay more attention to non-auto modes
- More research is needed on identifying successful TOD

# 6. Harnessing technology

# Two sides of technology



# Technology has a MASSIVE role to play

- Improving safety and security
- Improving network efficiency (loads of applications)
- Replacing trips (video conferencing, telework)
- Improving efficiency of motors
- Pre-crash avoidance
- Traffic management applications

# 7. Effective management of transport demand

Federal, state, and local  
governments can  
influence travel demand  
through a variety of policy tools

# Transportation Demand Strategies

Trip Purpose	Site	Subarea/Corridor	Regional
Work	Carpools Vanpools Public/private transit Bicycling/walking Alternative work hours Site telecommuting Parking policies	Subarea rideshare Corridor HOV Parking policies Transit subsidies Subarea telecommute	Area-wide rideshare Transit service HOV lanes Area-wide pricing Area-wide telecommute Trip reduction ordinances Area-wide traveler information system
Shop	Shuttles Transit subsidies Pedestrian access Bicycle access Urban design Tele-shopping	Shuttles Park-and-ride Transit services	Tele-shopping Transit subsidies Area-wide transit services Area-wide traveler information system
Tourist	Shuttles Parking policies Transit services	Park-and-ride lots Parking management Shuttles Transit services Bicycle/pedestrian amenities	Regional transit services Marketing Park-and-ride lots Area-wide traveler information system

## Example Delivery Mechanisms for TDM Programs

Site	Subarea/Corridor	Regional
Employer trans. coordinators Personnel dept. Part time trans. manager Voluntary participation Negotiated traffic mitigation Site design	Transportation management associations Chambers of commerce Trans. management districts City or MPO coordinator	Trip reduction ordinances Adequate public facilities ordinances Growth management State, MPO, or transit agency coordination

Source: (Meyer, Sivak and Berman 1994)

# TDM Strategies.....

The success of any TDM strategy critically depends on the size and strength of the political constituency who support its implementation.

The right mix of TDM strategies at employment sites can reduce vehicle trips by 30% to 40%.

Some level of incentive or disincentive must be present in order to change travel behavior.

(Source: Meyer, TGA 1999)

# Estimated travel impacts of TDM.....

TCM literature review: ranges of travel impact estimates

TCM	Percent reduction in daily VMT		Percent reduction in daily TRIPS	
	Minimum	Maximum	Minimum	Maximum
Employer trip reduction <sup>a</sup>	0.2	3.27	0.14	4.06
Area-wide ridesharing	0.1	2.0	0.46	1.06
Transit improvements <sup>b</sup>	0.13	2.57	0.58	2.46
HOV lanes	0.23	1.4	0.5	0.57
Park and ride lots	0.1	0.45	0	0
Bike and walk facilities	0.02	0.03	0.04	0.04
<i>Parking pricing <sup>c</sup></i>				
Work	0.52	4.01	0.39	4.02
Non-work	3.1	4.2	3.9	5.4
<i>Congestion pricing <sup>d</sup></i>				
Compressed work week	0.03	0.64	0.03	0.5
Telecommuting		3.4		2.8
Land use planning	0.05	5.4	0.05	5.4
Signal timing	(0.02)	0	(0.02)	0
Incident management	(0.08)	0	(0.07)	0
Smog/VMT tax	0.2	0.6	0.1	0.9

Numbers in parenthesis represent increases in VMT or trips.

<sup>a</sup> Maximum values assume a parking charge of \$3.00 per day in conjunction with employer transportation programs.

<sup>b</sup> Minimum values assume new and expanded bus service; maximum values assumes rail expansion and doubling of annual bus miles.

<sup>c</sup> Maximum parking pricing values for work trips assume a \$3.00 per day charge; for non-work trips the parking charge varies from \$0.60 to \$3.00 per day.

<sup>d</sup> The minimum values assume a congestion price of \$3.00 per trip at 30 regional subcenters; the maximum value assumes a \$0.15 per mile charge applied to all regional highways.

Source: Apogee Research (1997).

# Road Pricing: A particular promising TDM Strategy

“Regardless of what regime currently exists and what the future holds for existing funding sources, there is a growing recognition that we need to realign the revenue streams to better reflect the use of the road system.”

The basic ingredient to successful future adoption of area-wide TDM actions is to link it to broader goals that the public can support.

Hensher and Puckett (2006)

# **8. Developing Alternative Fuels and Renewable Energy**

Alternative fuels need to be developed, tested, and adopted, with fleet vehicles as particularly well suited early adopters

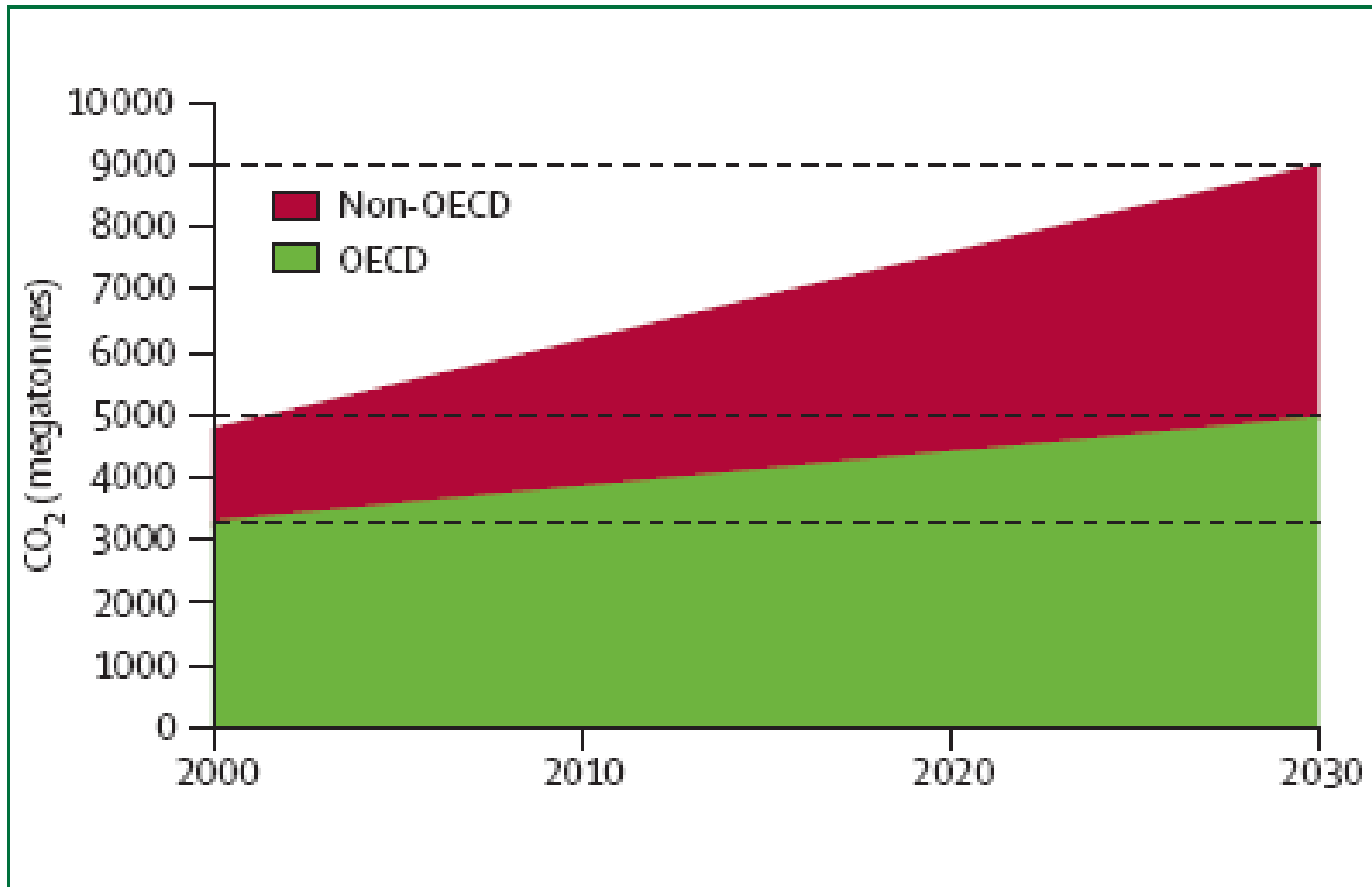


Figure 1: Projected growth in transport emissions of carbon dioxide to 2030<sup>1</sup>

Woodcock et al, 2007

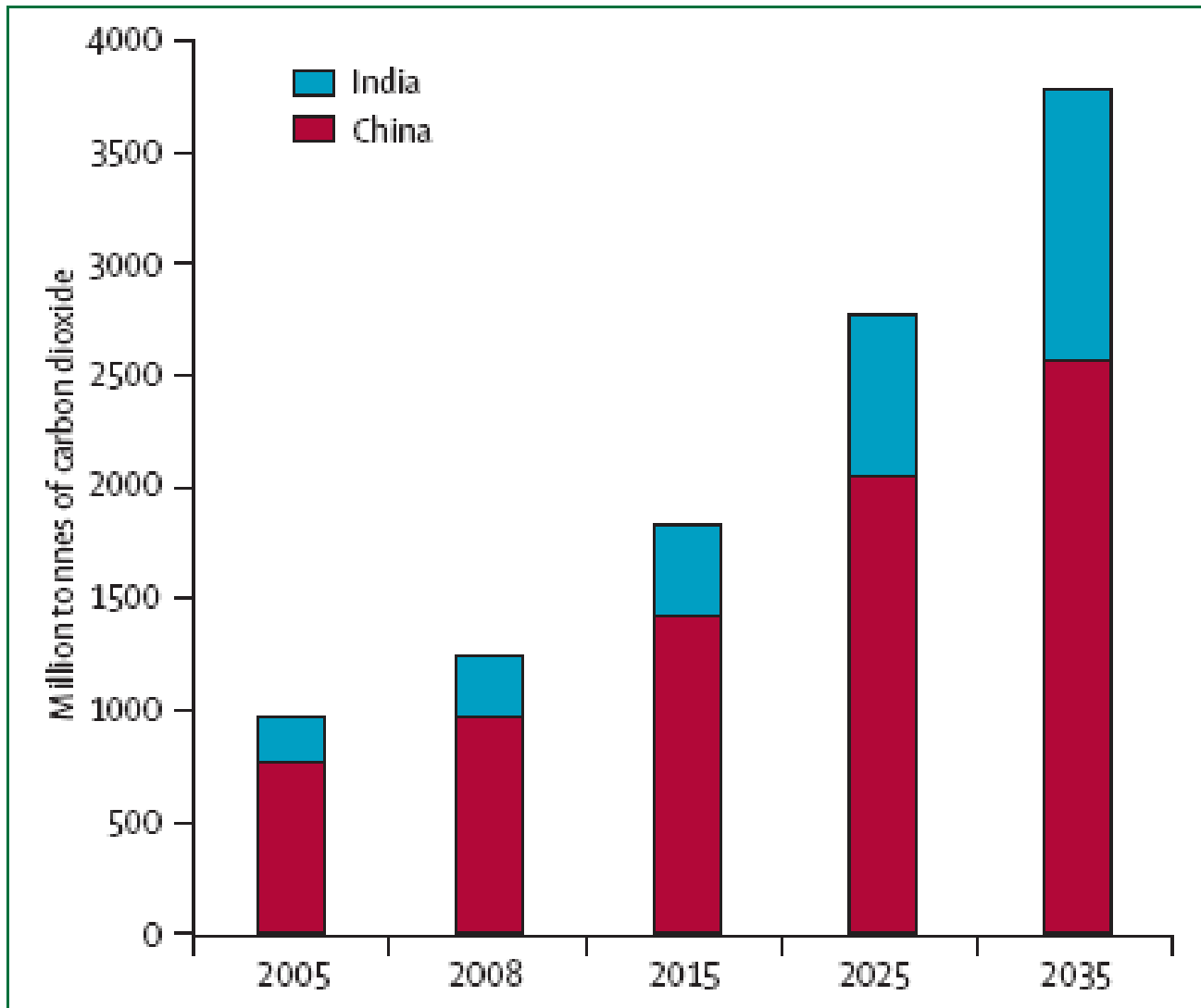


Figure 3: Total carbon dioxide emissions (well to exhaust) from on-road vehicles: India and China<sup>7</sup>

Woodcock et al, 2007

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# Things to consider.....

- 'Cradle to grave' analyses need to be carried out for all alternatives considered
- Impact to the energy grid is non-trivial for widespread electric vehicle use
- Fuel creation, storage, and distribution are critical issues moving forward
- Renewable energy sources (wind, solar, thermal, wave, etc.) will be key

# 9. Efficiency Improvements

# QUT SMART Transport Centre

- Real-time and predictable traveller information
- Intelligent transport systems for enhanced management of motorways and arterial roads
- Passenger transport information
- Large-scale hybrid simulation
- Sustainable traffic data management and provision



A way forward.....

# How transport decisions are made....



# Whether we like it or not.....

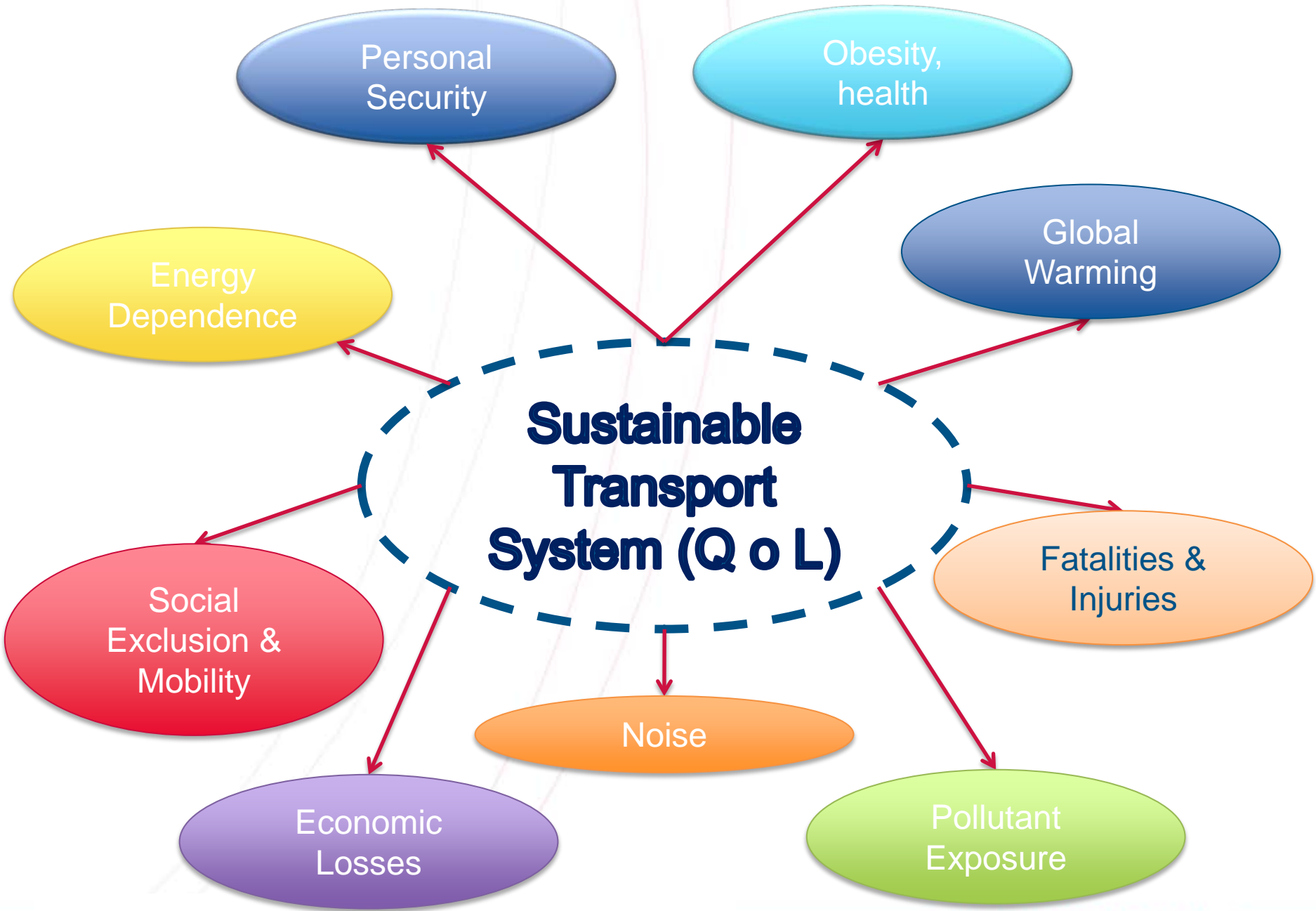
- A large proportion of major transport investment and policy decisions are informed by “models” of the transport system
- The models in use today were developed in the 60’s, and have been marginally improved ever since
- We know that outputs of these models are insensitive to some of the most important factors needed to shape a sustainable transport future.....

# Model insensitivities.....

- Ability to forecast penetration of products not in the marketplace
- Inter-relationships between household members in travel decisions
- Feedback of transport investment on residential location decisions
- Feedback of transport investment on commercial location decisions
- Supply-side variables in activity generation

# Model insensitivities (cntd.)

- Ability to predict mode shift for active transport modes as a function of mode-specific infrastructure
- Poor ability to capture peak spreading effects of TDM policies
- Poor information on land-use relationships with travel, health, etc.
- Inability to predict full range of metrics across spectrum of policy and investments options



# The way forward

- Time to consider supporting an Australian model development effort (multi-researcher, multi-institution)
- Research grade model with state of the practice methods (econometrics, revealed and state preference methods, new data collection support, etc.) for informing policy and transport investment decisions
- Models developed for all major metropolitan areas

And finally, back to more  
pressing matters....

## Question 5:



“Can you please send a list of all doctors in Australia who can dispense rattlesnake serum?”

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