Sociality, Rationality, and the Ecology of Choice

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Transportation – A technological behemoth bedeviled by human behavior

Human Behavior in Transportation Research Modeling

- Physical analogies such as the gravity model, fluid flow models, gas laws, and simple rules such as car following models.
- Economic demand and welfare analysis based on a theory of individual preference maximization (*economic rationality*)
- Behavioral models that go beyond individual rationality and account for errors in perceptions and decisions, and for sociality, the influence of others

Historical Examples: Models of Consumer Behavior in transportation

- Jules Dupuit (1844) "On the Measurement of the Utility of Public Works"
- Ernst Ravenstein (1885) and George Zipf (1946) "The P_1P_2/D Hypothesis: On the Intercity Movement of Persons"
- Tom Domencich and Dan McFadden (1972) "Urban Travel Demand: A Behavioral Analysis"

Domencich-McFadden: Random Utility Models of Discrete Choice

- Premise: Individuals obtain utility from activities that require travel, and make instrumental travel choices to maximize utility. Perceptions and expectations are objectively realistic and follow the laws of probability.
- Different people have different tastes ⟹ random utility
- With special assumptions on utility structure, get multinomial logit models for trip generation, route choice, peak/off-peak scheduling, and mode
- Can be fitted to data on individual choices, then aggregated to grain of policy

Important Features

- Subjective attributes of travel such as safety could matter, but objective travel times and costs were the core determinants of transportation choices
- Household and neighborhood interactions might influence behavior through constraints; such as car availability, but not through explicit models of family bargaining or collective choice
- These models have good predictive power and seem to be capturing fundamental regularities in human behavior

Nevertheless

- Humans are social animals who depend on others for facts, and for approval
- Market interactions over prices and congestion can be intense and up-close, but if they become personal, then one has to take it outside (of classical economics)

Market Interaction


TRUNG NGUYEN


TARGET

How does Sociality Influence Transportation Choices?

- Dugundji & Walker (2005) enter neighborhood and social network effects in a mode choice model for Amsterdam
- Network effects may be due to (supply-side) constraints, information/perceptions, or preferences
  - Field effect for reference group
  - Unobserved group “panel” effect or Group fixed effect
- Both neighborhood and social network field effects are significant, panel effects do not add significant explanation
  - Neighborhood effects may be unobserved constraints
  - Social network effects may come from information or from conforming preferences
-

Sociality Influences Choice through --

- Constraints
- Perceptions
- Preferences
- Process
- Experienced and remembered satisfaction

Driving Choices

- Strategic route and schedule
- Free speed, minimum headways
- Lane selection
- Acceptable gaps for lane changes and merges
- Response to attempted lane changes by others

Car Follower Models

- $$dv(t+\tau)/dt = f(v(t), s(t), ds(t)/dt)$$

  ↘ ↗ ↗

  - τ = driver reaction time,
  - $v(t)$ = velocity of the subject car at time t,
  - $s(t)$ = spacing between the subject car and its lead car
  - $ds(t)/dt$ = relative velocity of the lead car
  - $h(t) = s(t)/v(t)$ = time headway
  - v_f = free speed with no congestion
  - $k_{max} = 1/s_{min}$ = maximum density

Gazis/GM Flow Rate vs. Density

- Gazis specification of car follower model

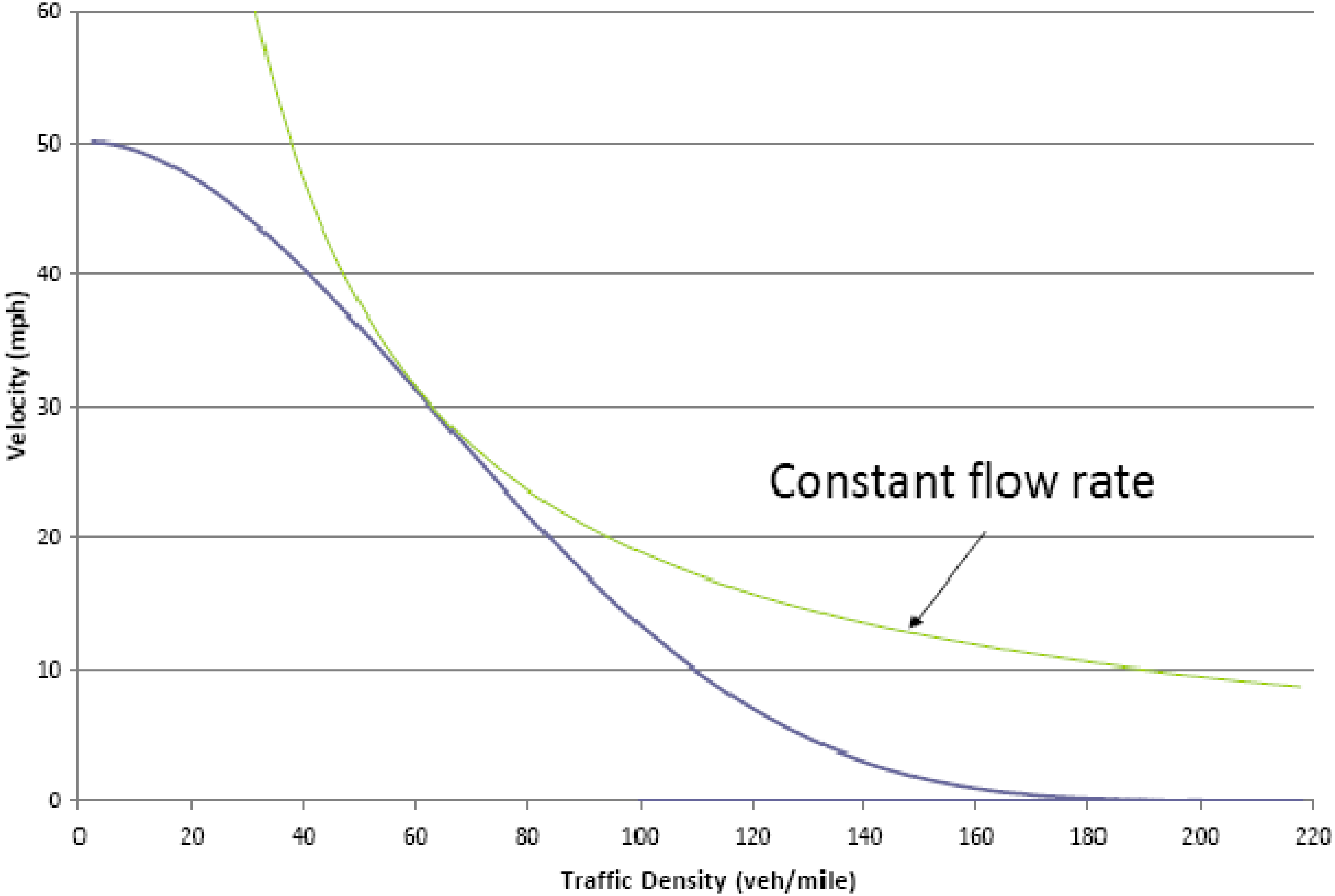
$$dv(t+\tau)/dt = \alpha v(t)^{\beta} s(t)^{-\gamma} ds(t)/dt \equiv \alpha h(t)^{-\beta} s(t)^{\beta-\gamma} ds(t)/dt$$

- Macroscopic steady state flow rate vs. density

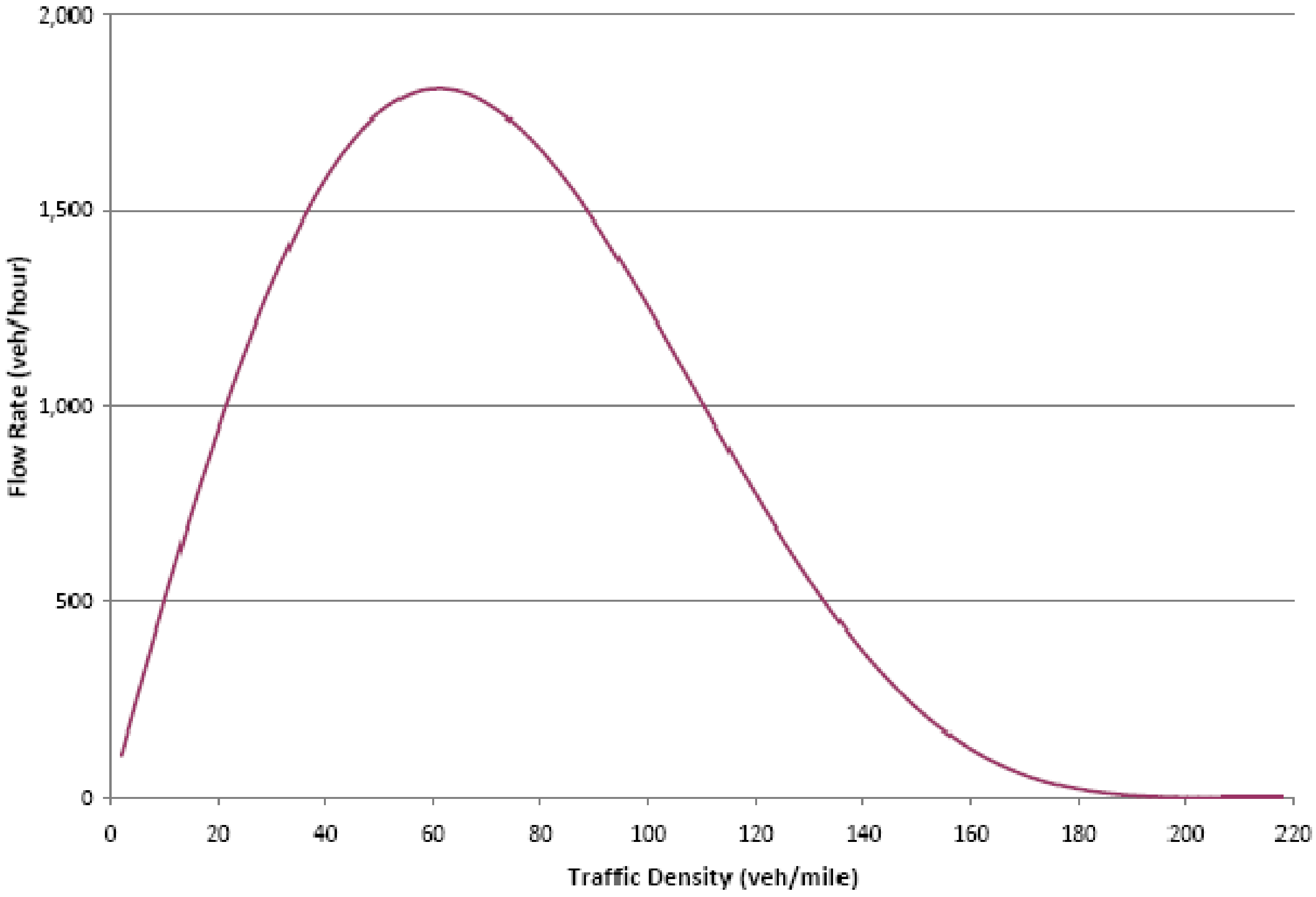
$$q(t) = v_f k(t)[1 - (k(t)/k_{max})^{\gamma-1}]^{1/(1-\beta)}$$

  – $k(t) = 1/s(t)$ = vehicle density
  – $q(t) = v(t) \cdot k(t)$ = flow rate

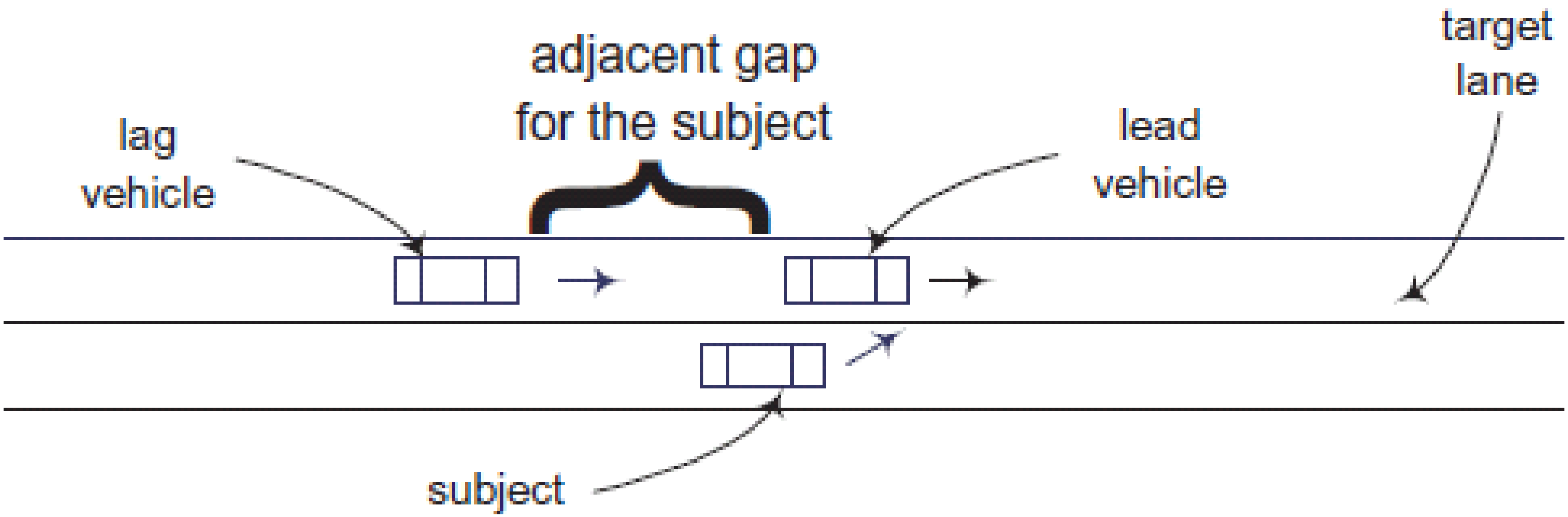
Gazis/GM Car Follower Model



Gazis/GM Density vs. Flow Rate

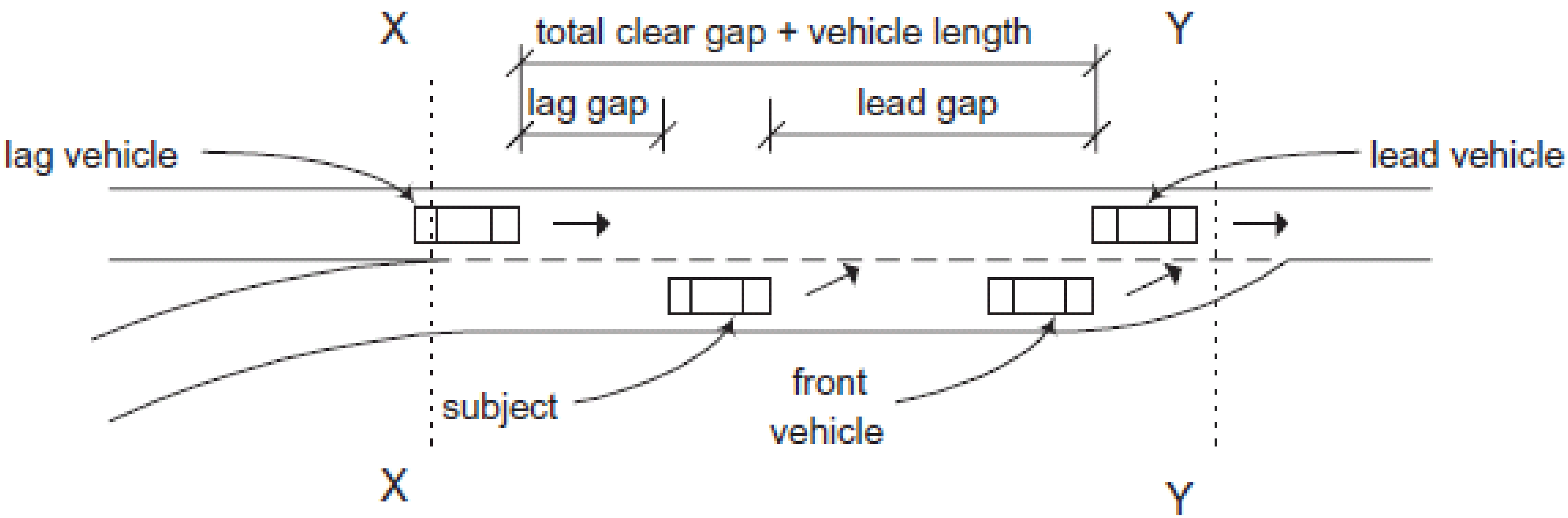


Acceptable Gap for Lane Change



Acceptable spacing is a function of adjacent gap headway and relative velocity of subject and lead vehicles, and expectations regarding lag vehicle behavior.

In merges and mandatory lane changes, merge point is a function of driver aggressiveness, target lane lead and lag headways, and expectations regarding front and lag vehicle behavior



Choice can be uncomfortable

"He who has choice has trouble."

Sociality and Rationality: Constraints

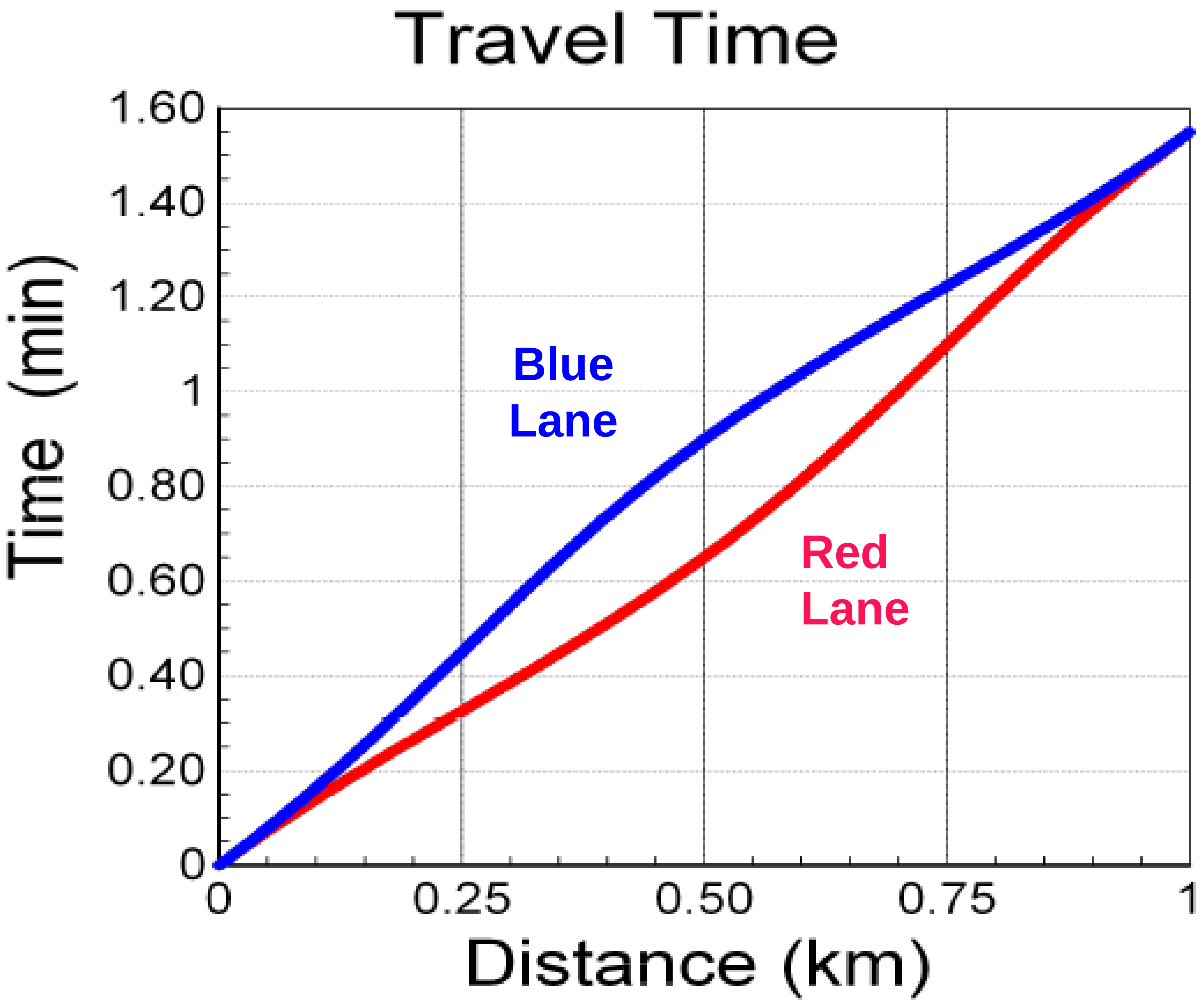
- Classical models of rationality are designed to handle constraints
- Primary focus: budget constraint operating through market prices
- Non-market externalities (e.g., congestion) can be accounted for in rational preferences
- Instrumental activities (e.g., travel) are part of household production of personal benefits
- Sociality may enter through constraints, but exposure to constraints may be voluntary (e.g., choosing to travel to the beach on a crowded weekend)

Sociality and Rationality: Perceptions

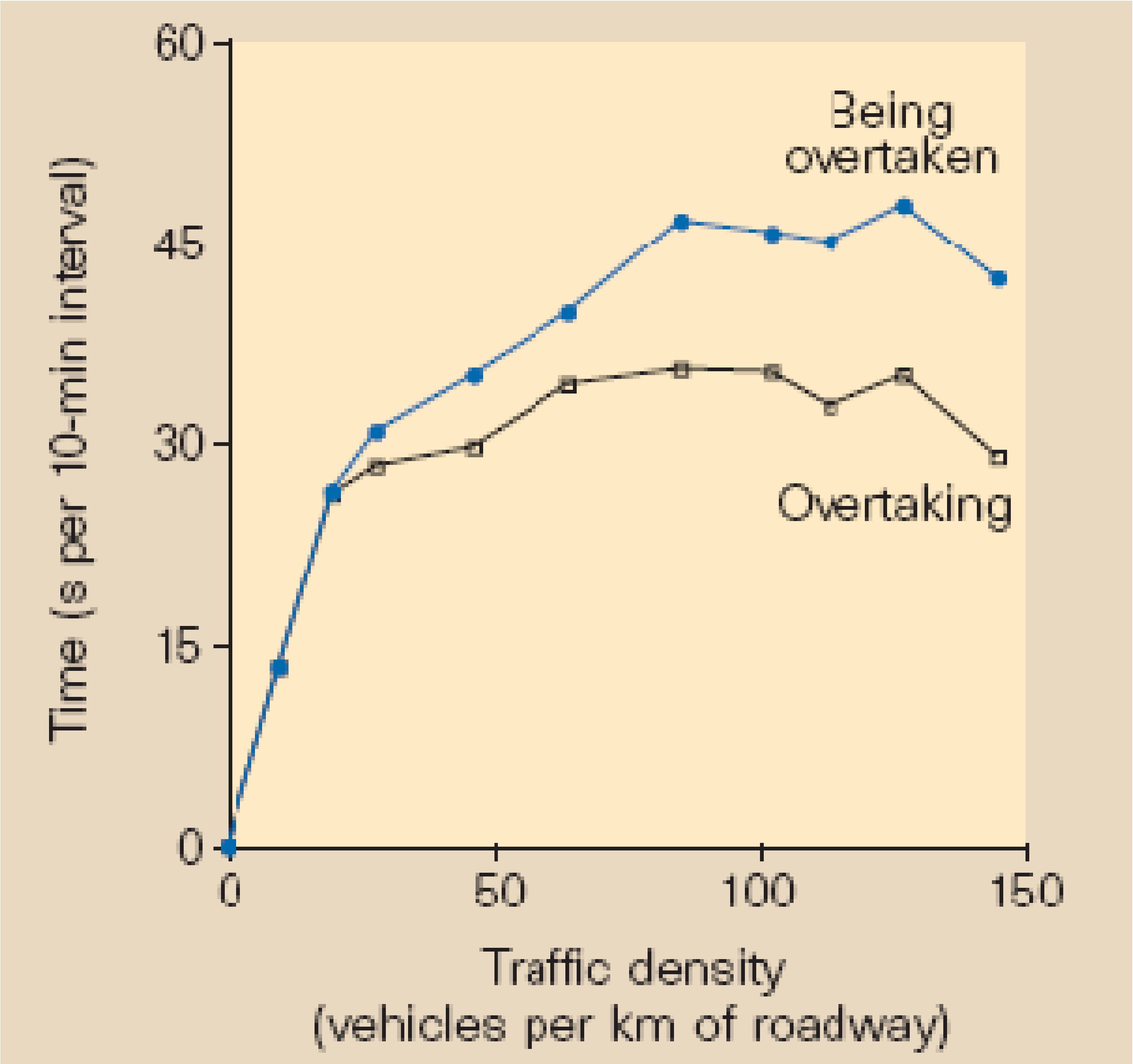
- Classical model: Consumers form and act on realistic, rational expectations based on sound statistical analysis of all available information
- Behavioral model: Memory is imperfect, and personal probabilities are systematically biased
  - First and last occurrences, coincidences are selectively remembered
  - Small probabilities are overestimated or ignored
  - Analogies and exemplars are used in place of calculated risks

Why am I so often stuck in the slower lane?

- Redelmeier and Tibshirani, *Nature*, 1999:
  - "We … videotaped traffic sequences by mounting a camera in a moving vehicle and filming the side-view perspective of the next lane on a congested road. When a section of videotape showing a slightly slower average speed in the next lane was screened to driving students (*n* = 4120), 70% stated that the next lane was moving faster and 65% said they would change lane if possible."
- What causes this common misperception?



Travel Time
Time (min)
1.60
1.40
1.20
1
0.80
0.60
0.40
0.20
0
0.25
0.50
0.75
1
Distance (km)
Blue Lane
Red Lane



60
45
30
15
0
0
50
100
150
Time (s per 10-min interval)
Traffic density
(vehicles per km of roadway)
Being overtaken
Overtaking

Psychophysical effects

- An overtaken vehicle is quickly out of sight (and out of mind), and an overtaking vehicle is a visible source of irritation until it disappears ahead
- Losses from the "status quo" outweigh gains, and are more memorable
- Slowly moving drivers may be more attentive to adjacent lane activity
- Humans (and other animals) are more stressed by objects moving toward them in their visual periphery than objects moving away from them in their central vision

Social Networks and Information

- People make interpersonal comparisons, judging the desirability of options from the apparent satisfaction and advice of others.
- While personal experience is the proximate determinant of the utility of familiar objects, our primary sources of information on novel objects come from others, through observation and advice.

Sociality and Rationality: Preferences

- Classical model: Consumers have utility based on their individualistic outcomes, and are indifferent to the welfare of others
- Behavioral model: Consumers have individualistic utility, but also have personal welfare functions that depend on
  - (Indicators for) the utility of others
  - Comparisons with outcomes of others
  - Approval by others
  - Accountability and sanctions

Pleasure, Pain, Habituation

- Humans (and other animals) are on a *hedonic treadmill*, quickly habituating to homeostasis, and experiencing pleasure from gains and pain from losses *relative* to their status quo reference point.
- Humans also seem to be on a *relative treadmill*, racing to "keep up with the Jones"
  - Positional goods that mark a consumer's relative status command premium prices
  - Positional goods that give an apparent advantage to some consumers are unpopular with the remainder (e.g., HOV and toll lanes)

Trust Game

- One-shot game, two anonymous players, no communication allowed
  - Experimenter gives 100 MU to Player 1 (Investor)
  - Player 1 invests $0 \leq x \leq 100$ with Player 2 (Trustee)
  - The experimenter triples the investment so that Trustee receives $3x$
  - Trustee gives $0 \leq y \leq 3x$ back to Investor, keeps $3x - y$
- Rational play for individualistic players: Trustee returns $y = 0$, therefore Investor invests $x = 0$

Experimental Trust Game Results

Berg-Dickhaut-McCabe, *Games and Economic Behavior*, 1995

- Results when players know the social history of trust game play:
- Average investment by Investor:

  x = 53.6 MU, or 56.1% of endowment
- Average return by Trustee:

  y = 64.6 MU, or 40.2% of augmented investment

What are Investors Thinking?

- Suppose investors believe that all players have CARA utility functions, $u(c) = -\exp(-c)$, and that trustees are of three possible types:
  - Selfish /Rational: Trustee will return nothing
  - Altruistic: Trustee altruistically maximizes the sum of the two players' utilities
  - Reciprocal: the Trustee will return the investment and half of the extra income the investment generates, or 2x
- The Investor maximizes $-\exp(-1+x-y) - \lambda \cdot \exp(y-3x)$
  - If $\lambda > 0$, then the Investor is somewhat altruistic

The McCabe data is explained by

- The Investor believes that the probabilities of trustees of different types are
  - Selfish 30.0%
  - Altruistic 21.7%
  - Reciprocal 48.3%
- The Investor is altruistic to the degree $\lambda = 0.1$
- A model with altruism and reciprocity is under-determined from this experiment, and the types and probabilities above are not unique

Sociality and Rationality: Process

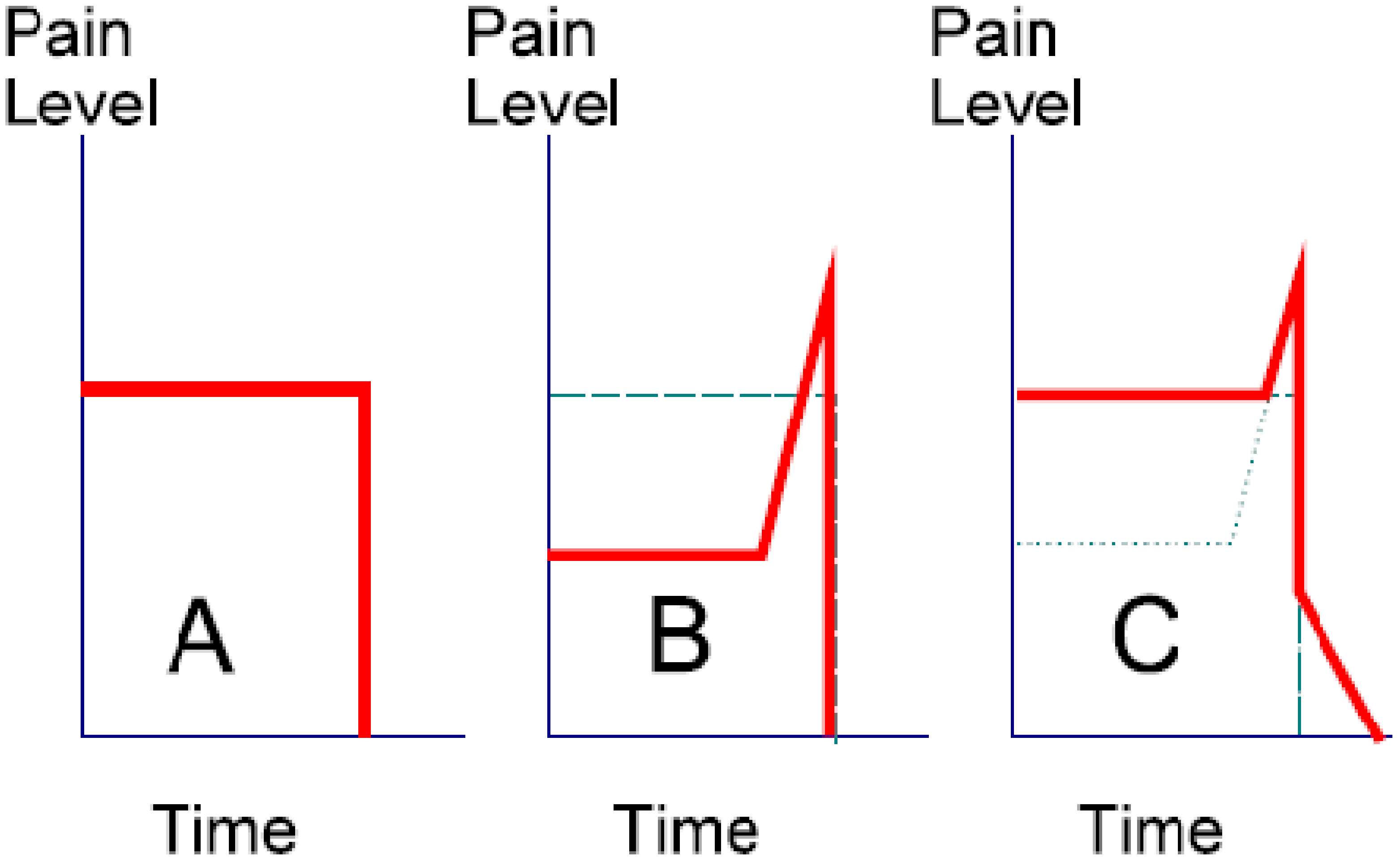
- Rationality – maximization of individualistic utility subject to applicable constraints
- Sociality – use analogies, exemplars, and heuristics influenced by information and approval of social network
- Consumers seem to be close to rationality when stakes are high, but show influence of sociality when stakes are modest and alternatives are unfamiliar

The Pellaton – voluntary affiliation with a social decision-making unit

- Affiliation with social networks, limiting choice by accountability to network norms, can be an efficient decision-making strategy
- Competitors in bicycle racing form a pellaton that provides an energy-saving, choice-limiting environment

Sociality and Rationality: Experience and Memory Satisfaction

- Humans are inconsistent in the ways that they integrate past experience
- A choice episode may “remember” differently than it was experienced at the time
- Future choices may be affected by remembered experience



Which procedure will you choose for your next medical exam?

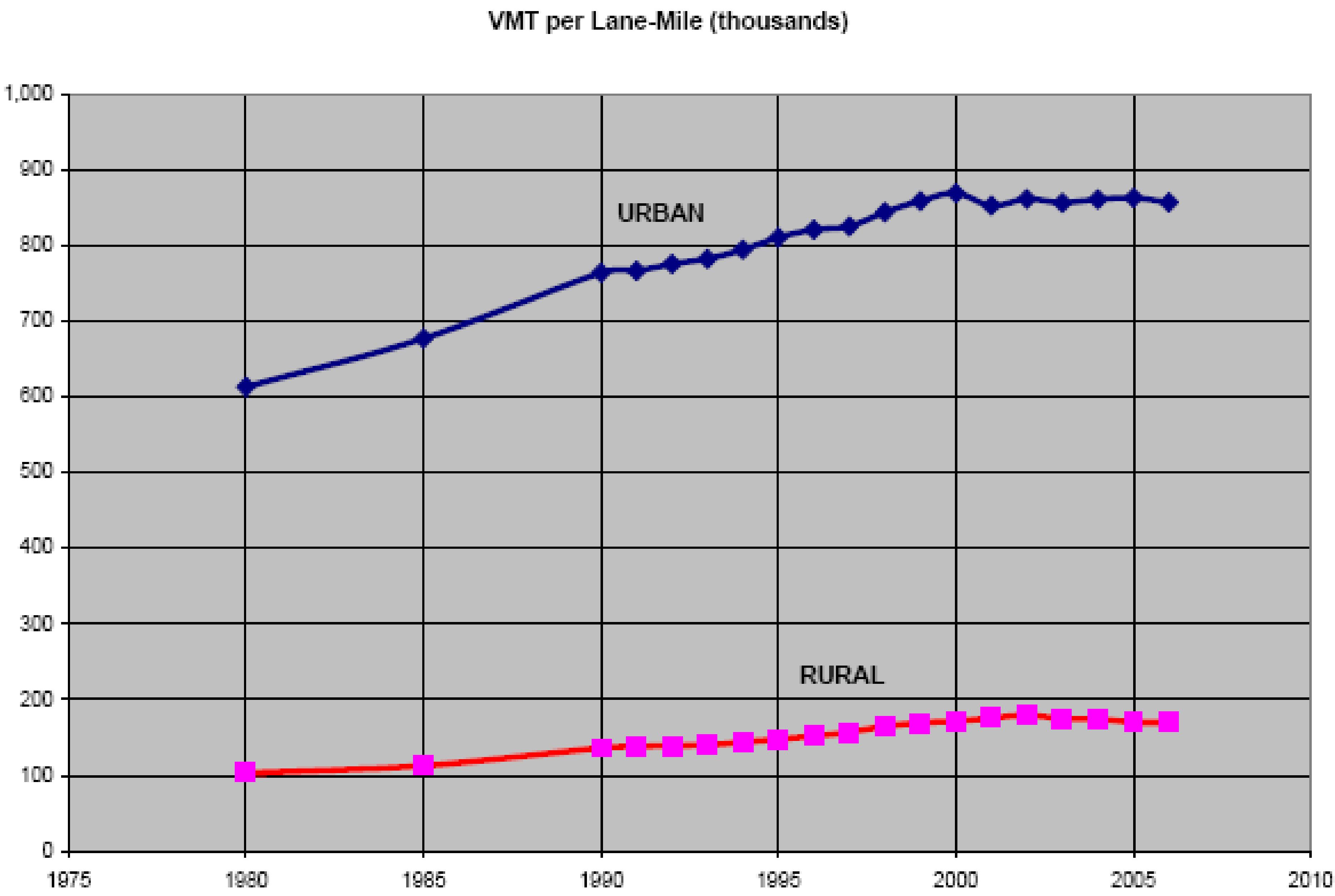
Putting Sociality in Travel Demand Models

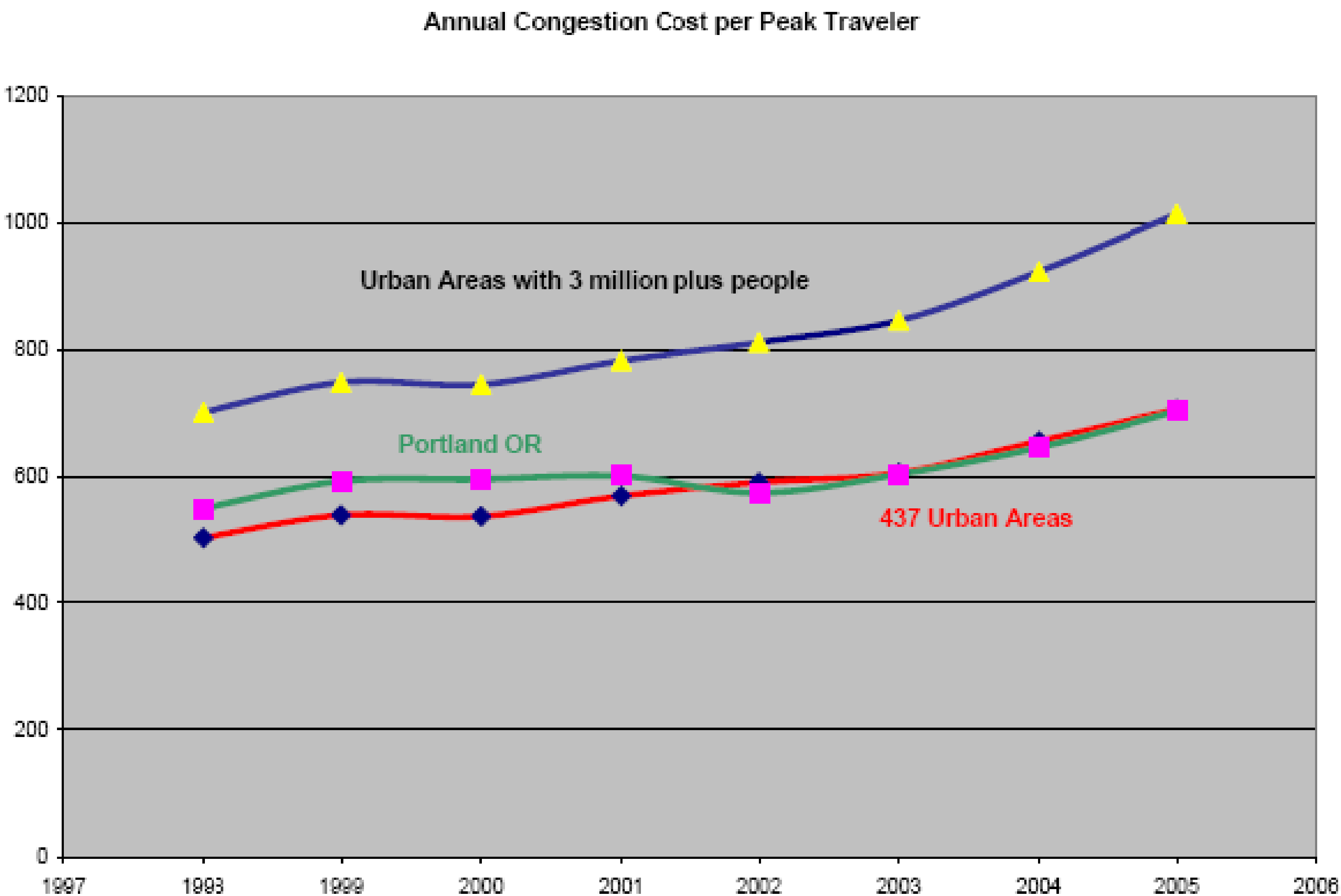
- Allow for distortions in subjective perceptions, for example in the perception of lane speeds
- Measure social network effects on beliefs
- Include field effects in choice models
- Take altruistic and reciprocal behavior into account in land changing/acceptable gap models
- Allow travel times and costs to enter in terms of worst and last experience rather than total integrated time and cost

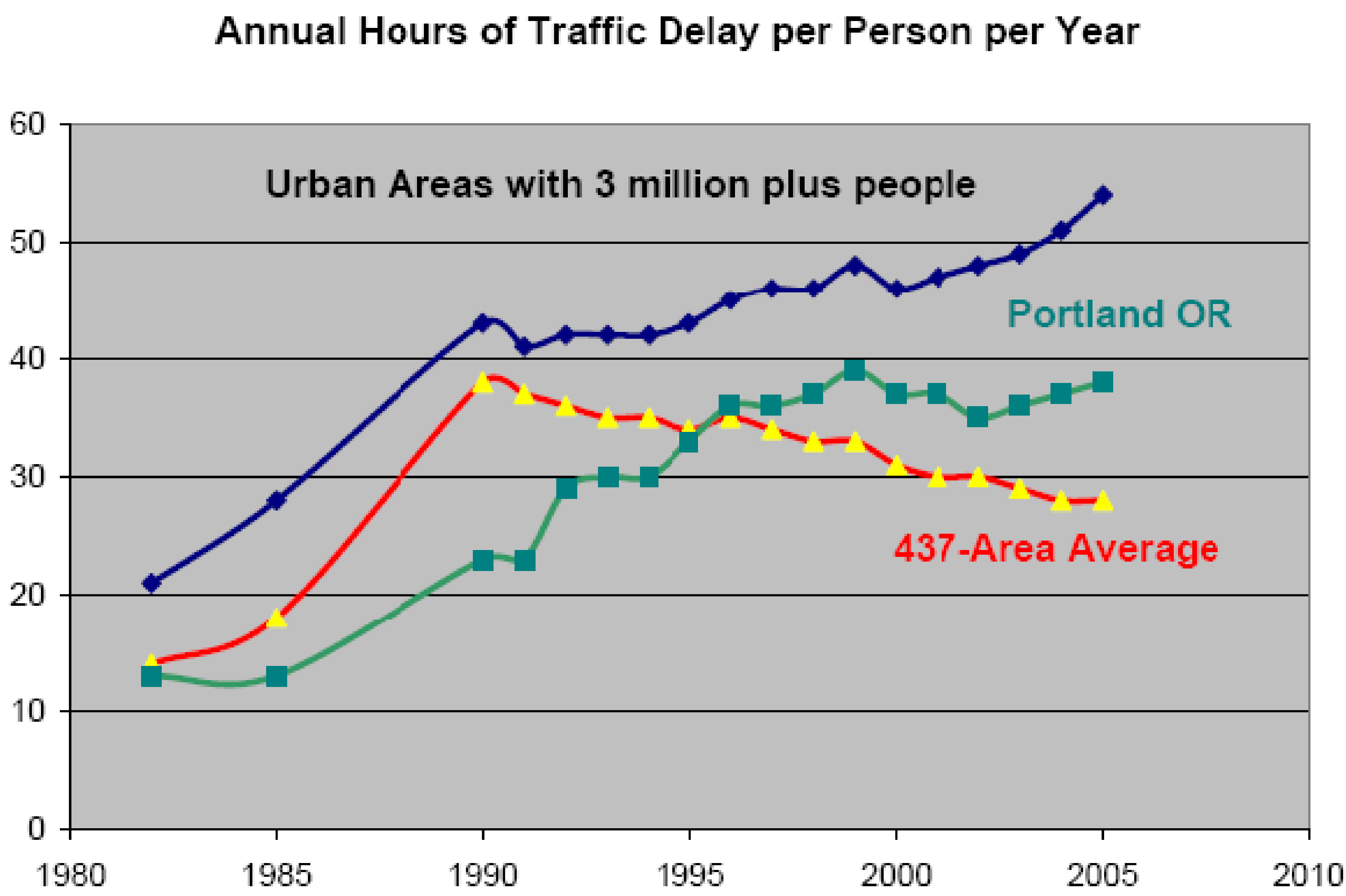
Summary

- Economic and Behavioral Science provides insights and models that are useful at many points of human interaction in transportation systems
- Current transportation demand models can in some circumstances be improved by taking into account features of rationality and sociality
- Transportation research can benefit from close and continuing connections to economic and behavioral science


THE ROAD TO RECOVERY
ATM
Ford
MATSON


VMT per Lane-Mile (thousands)
URBAN
RURAL
1,000
900
800
700
600
500
400
300
200
100
0
1975
1980
1985
1990
1995
2000
2005
2010


Annual Congestion Cost per Peak Traveler
Urban Areas with 3 million plus people
Portland OR
437 Urban Areas
1200
1000
800
600
400
200
0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006


Annual Hours of Traffic Delay per Person per Year
Urban Areas with 3 million plus people
Portland OR
437-Area Average
60
50
40
30
20
10
0
1980
1985
1990
1995
2000
2005
2010