Variability of Travel Times:
An Economic Perspective

Erik Verhoef
Dept. of Spatial Economics
VU University Amsterdam

Outline

1. Economic value of travel time variability
   - Measures of variability
   - Valuation studies
2. Economic policy implications of travel time variability
   - Why bother?
   - Pricing vs information provision
   - Industrial organization aspects

Economic perspective on variability

- Economic analysis of travel time variability will typically focus on social costs and benefits
- Implications for measurement
  - Not all variability corresponds to uncertainty
    - No-one expects a free passage of the Coen tunnel Mondays at 9:00
  - Relevant measure may depend on the question to be addressed
    - E.g.: capacity dimensioning: all variability may matter
    - E.g.: evaluating benefits of information: only variability on top of expected variation may matter
- Example study distinguishes between
  - "Rough information": travellers only know time of day
  - "Fine information": travellers know all relevant static info

Predicting variability (Peer et al., 2011)

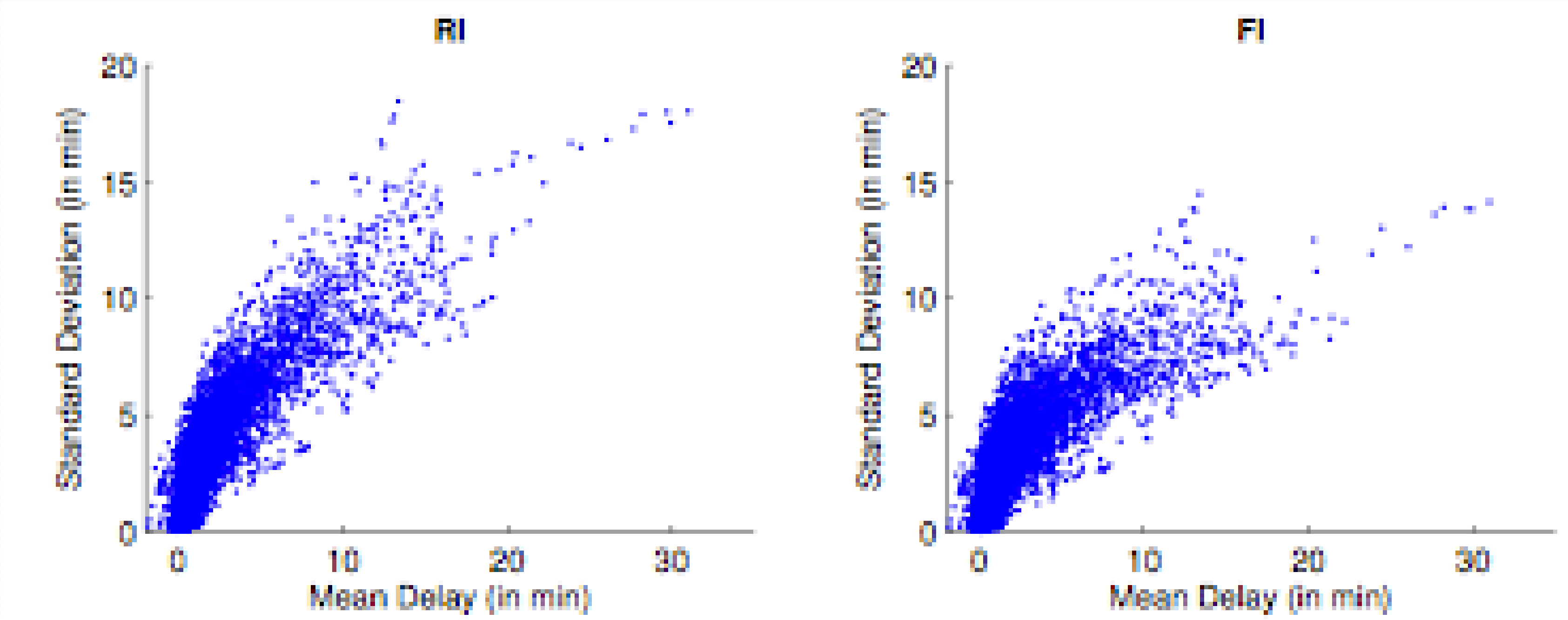
- Main question: can we predict variability of travel times from average travel times and congestion levels?
  - If so: useful for applied work
  - Test: 145 highway links
    all 255 working days in 2008

Static information explains substantial part of travel time variability

	Coefficent			Percentage of Coefficients significant at the		
VARIABLE	Median	10th Perc.	90th Perc.	1% level	5% level	10% level
Constant	6.44	2.46	13.99	94.91	96.19	96.71
Tuesday	-0.02	-1.85	1.65	28.83	39.18	46.47
Wednesday	-0.01	-1.81	2.08	31.52	43.63	51.37
Thursday	0.01	-1.43	1.59	24.82	34.69	42.78
Friday	-0.01	-1.41	1.76	23.98	34.53	41.89
July/August	-0.01	-0.96	0.96	8.53	15.06	19.84
December/January	-0.04	-0.81	0.99	5.83	11.92	16.41
maximum temp. < 5°	-0.04	-0.89	0.64	3.74	7.94	11.74
maximum temp. > 25°	-0.03	-0.84	1.06	4.45	8.49	12.55
duration rainfall > 5 h	0.01	-0.78	0.99	7.33	15.03	20.22
amount rainfall > 10mm	-0.03	-1.20	1.17	4.53	10.21	16.42
Network-wide Delays	0.61	0.04	5.21	54.80	66.73	72.34
R-Squared	0.12	0.03	0.34			

145 x 57 = 8265 regressions: for every link, and every quarter of an hour (6:00 – 20:15)

Standard deviations: FI < RI

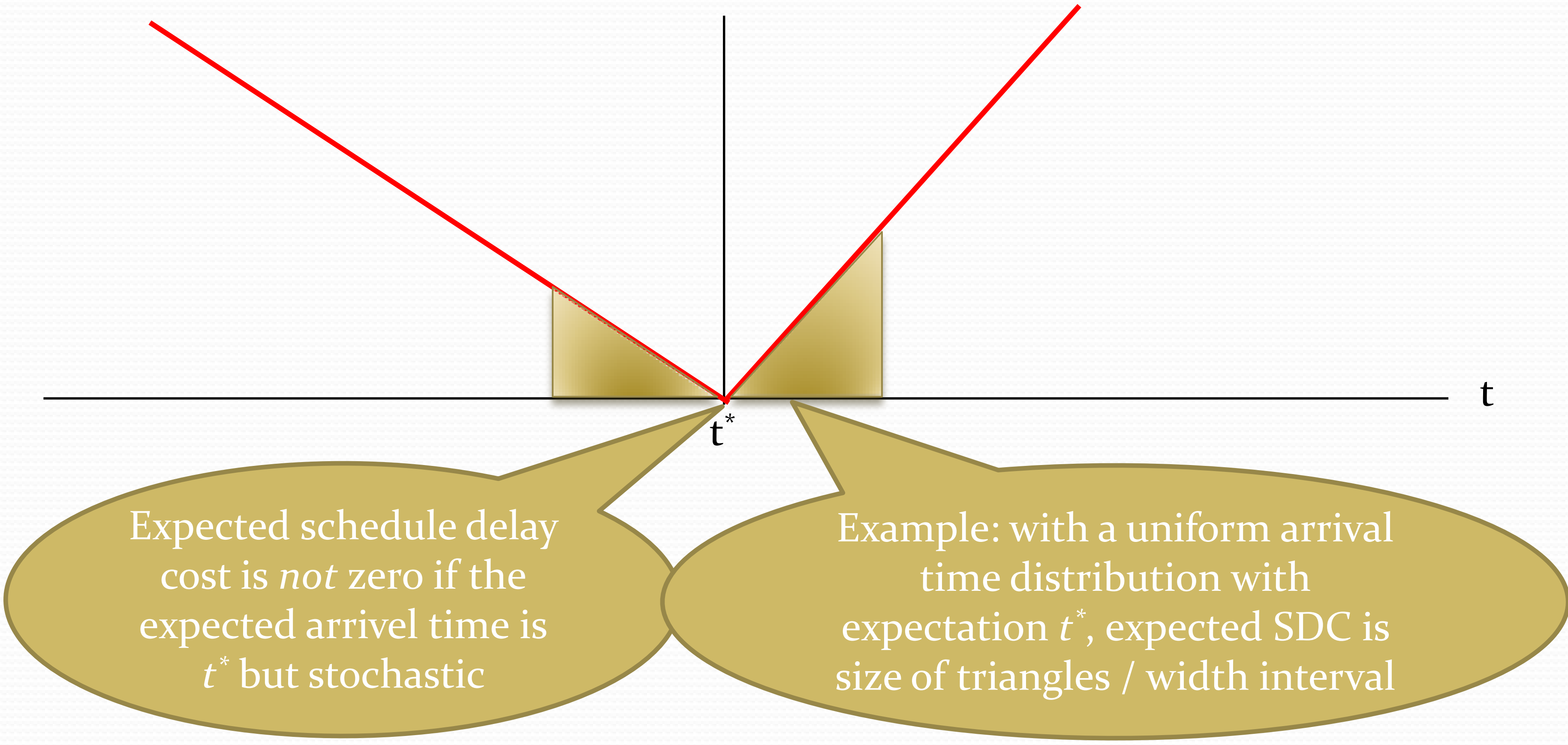


SD's: RI based on average for that link/quarter; FI for predicted value on basis of FI-model
Travellers who know and use FI, face considerable less variability
And: mean delay is indeed a reasonable predictor of SD

Valuing variability

- Unpredictable variability brings a disutility to travellers
- Putting a value to this is very useful for economic policy evaluations
  - How much to invest in measures to reduce it?
  - How much to charge for causing variability?
- Empirical literature is growing rapidly. Dimensions:
  - "Stated preference" versus "Revealed preference"
  - "Mean – dispersion" versus "Scheduling" models
  - All: closely related to valuation of travel time itself

Why scheduling relevant?



Results from meta-analysis (Tseng)

- Results expressed relative to Value of Time

	VOR ratio (RR)	VSDE ratio (SDER)	VSDL ratio (SDLR)
Mean	1.444	0.787	1.997
Median	1.409	0.744	1.311
Standard deviation	0.883	0.467	2.201
Minimum	0.100	0.166	0.164
Maximum	4.972	2.460	16.741
observations	84	84	83

Conditional means in meta study

Table 1 Conditional means for various categories of studies

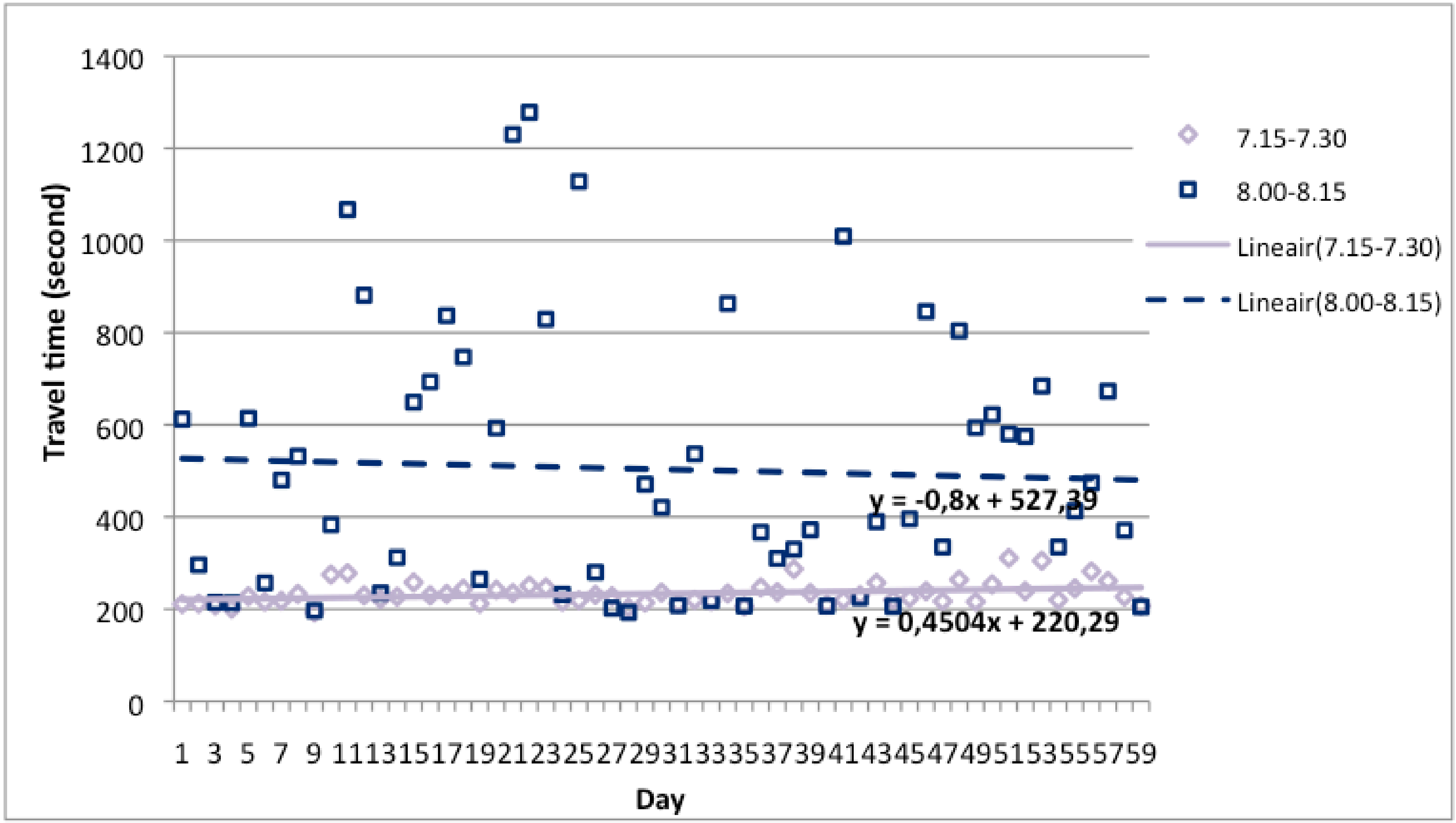
	VOR ratio (RR) (n=76)		VSDE ratio (SDER) (n=72)		VSDL ratio (SDLR) (n=70)	
Groups	n	Mean	n	Mean	n	Mean
Data Types						
Revealed preference	50	1.364	15	0.672	6	2.917*
Stated preference	34	1.561	69	0.811	67	1.777*
Choice types						
Between-mode choice	-	-	44	0.981**	45	2.104
Within-mode choice	-	-	40	0.572**	38	1.870
Mode specific estimate						
Private transport	-	-	62	0.841*	61	2.220
Public transport	-	-	22	0.634*	22	1.377
Trip type						
Fixed scheduled trips	77	1.427	50	0.780	48	2.723**
Others	7	1.630	34	0.796	35	1.001**
Unobserved Heterogeneity						
Not accounted for	67	1.379	30	0.616**	38	2.556**
Unobserved hetero.	17	1.700	44	0.942**	45	1.524**
Travel time measurements						
Uncongested travel time	79	1.457	74	0.833**	73	2.021
Congested travel time	5	1.234	10	0.438**	10	1.824
Reliability measurements						
Min-Max	17	2.297**	-	-	-	-
Others (standard deviation, percentile difference)	67	1.228**	-	-	-	-
Utility specification I						
No scheduling/reliability variable	63	1.598**	61	0.805	63	2.126
Including scheduling / reliability variable	22	0.983**	23	0.737	20	1.589

Note: The statistical test (t-test) is concerned with the comparison of means within each group. Significance is indicated by ** and *, referring to significance at the 5% and 10% level, respectively.

One other issue about valuation

- Most studies treat value of time gains as single-valued, independent of whether a gain is structural or incidental
- SpitsMijden experiment allowed us to distinguish the relative values
- Main idea: include in behavioural model a measure for *expected time gains* and one for *deviations from expectations*
  - The latter was given to participants through an information system on a smart-phone
- Setting: A12, morning peak, 108 with info and 232 without

Information *could* matter…



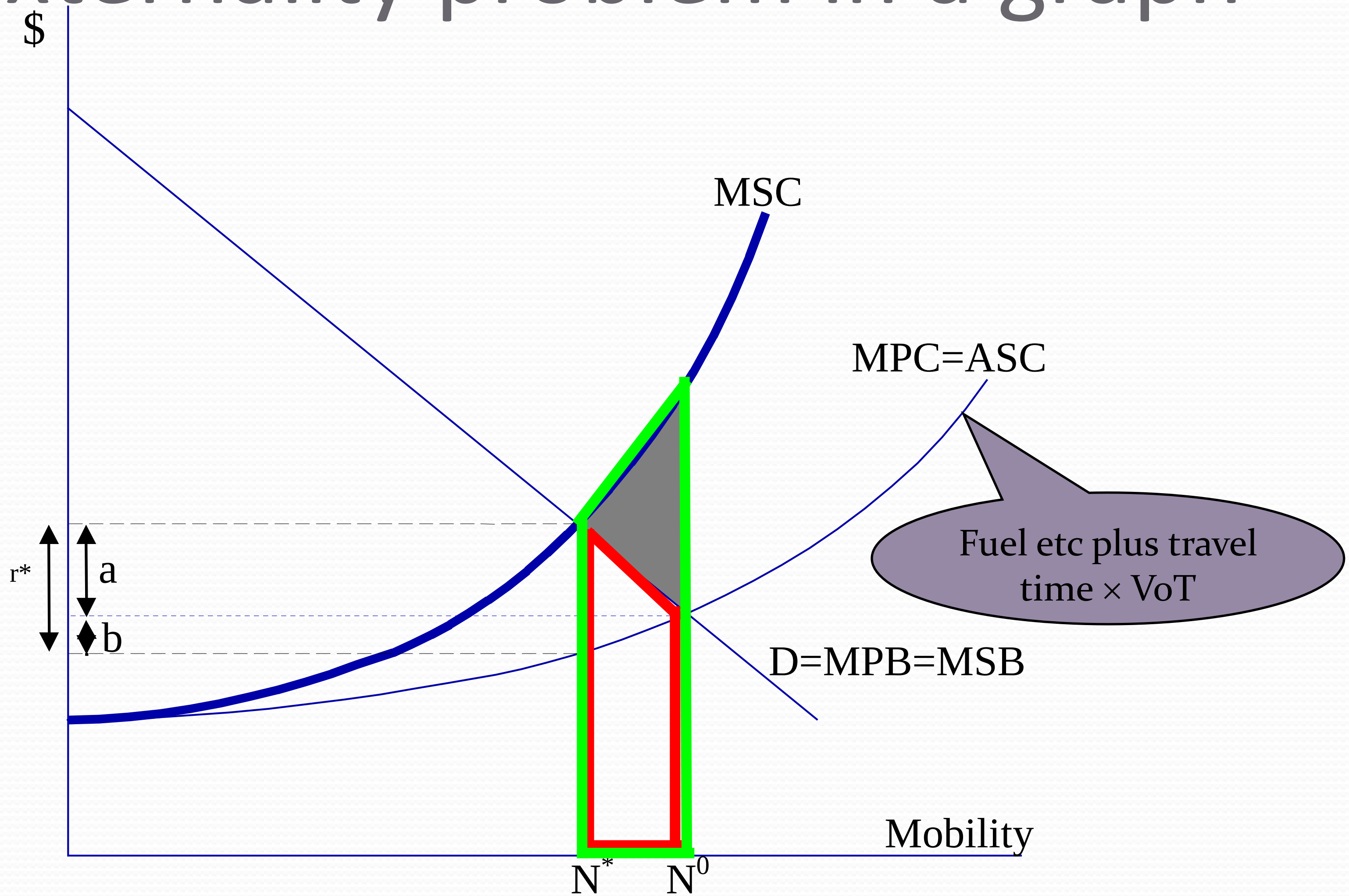
Resulting values

- Value of expected travel time: 14.5
- Value of deviations of travel time: 3.5
  - VSDE 6.5; VSDL 7
- Hence: estimates differ substantially
  - Limited possibilities to respond to last-minute information: schedule is largely fixed
  - Implies that to determine the value of information provision, one should be careful using conventional VoT estimates

Policy implications

- Uncertainty is a fact of life in many markets, but not necessarily a reason for government intervention
- Situation for traffic somewhat different, as traffic congestion entails an externality
  - Market fails to produce the efficient outcome
  - Excessive traffic, excessive congestion
  - Question: does stochasticity aggrevate or reduce that distortion
    - Hence: is removing stochasticity, e.g. through information provision, good or bad for social welfare?

The externality problem in a graph



Implication for information provision

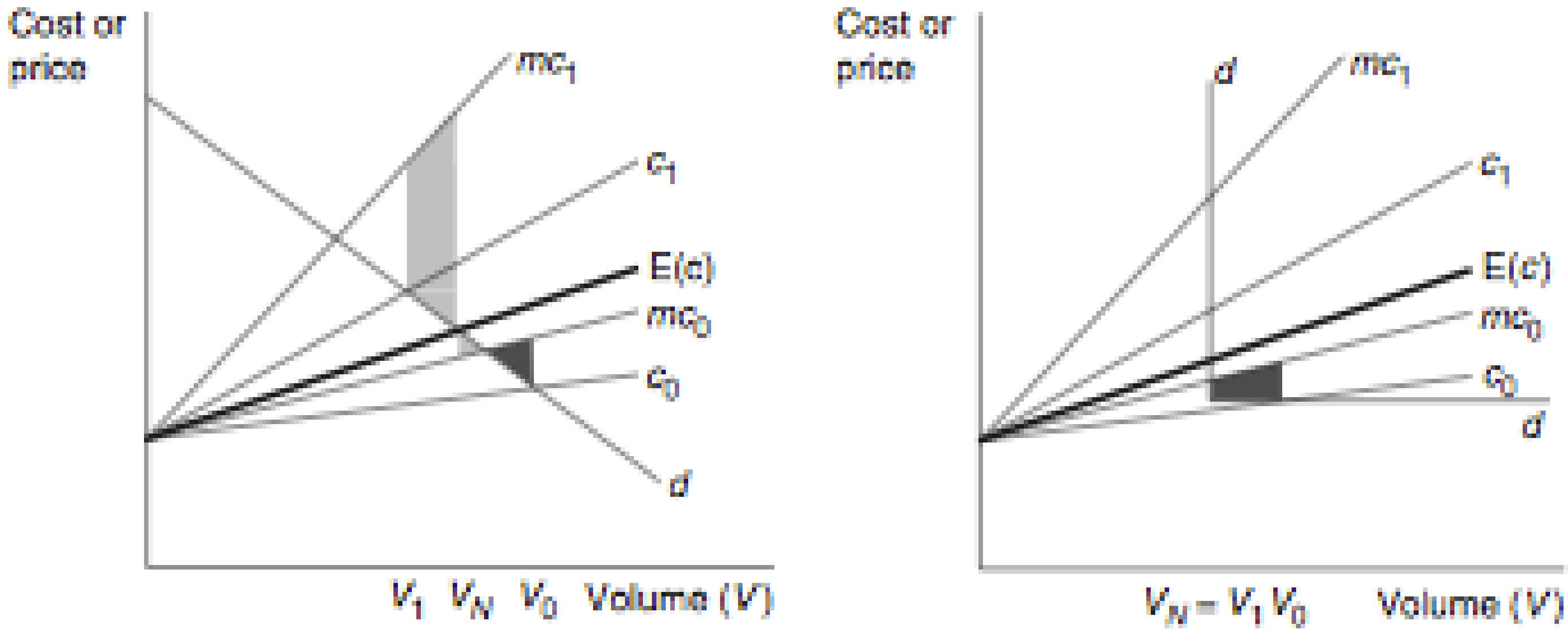
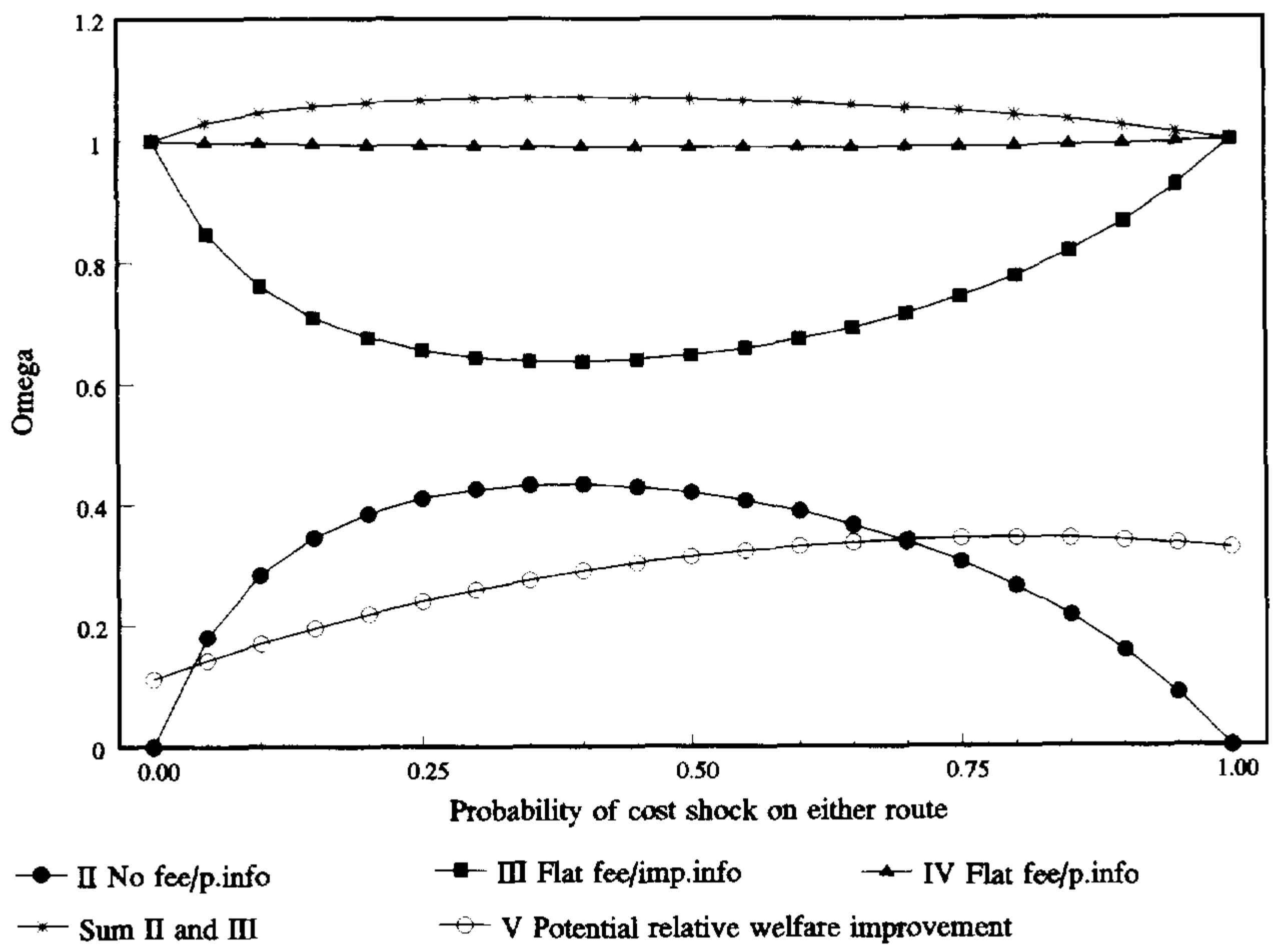


Figure 3.12 Stochastic road capacity and information provision: welfare gains (light shading) and welfare losses (dark shading).

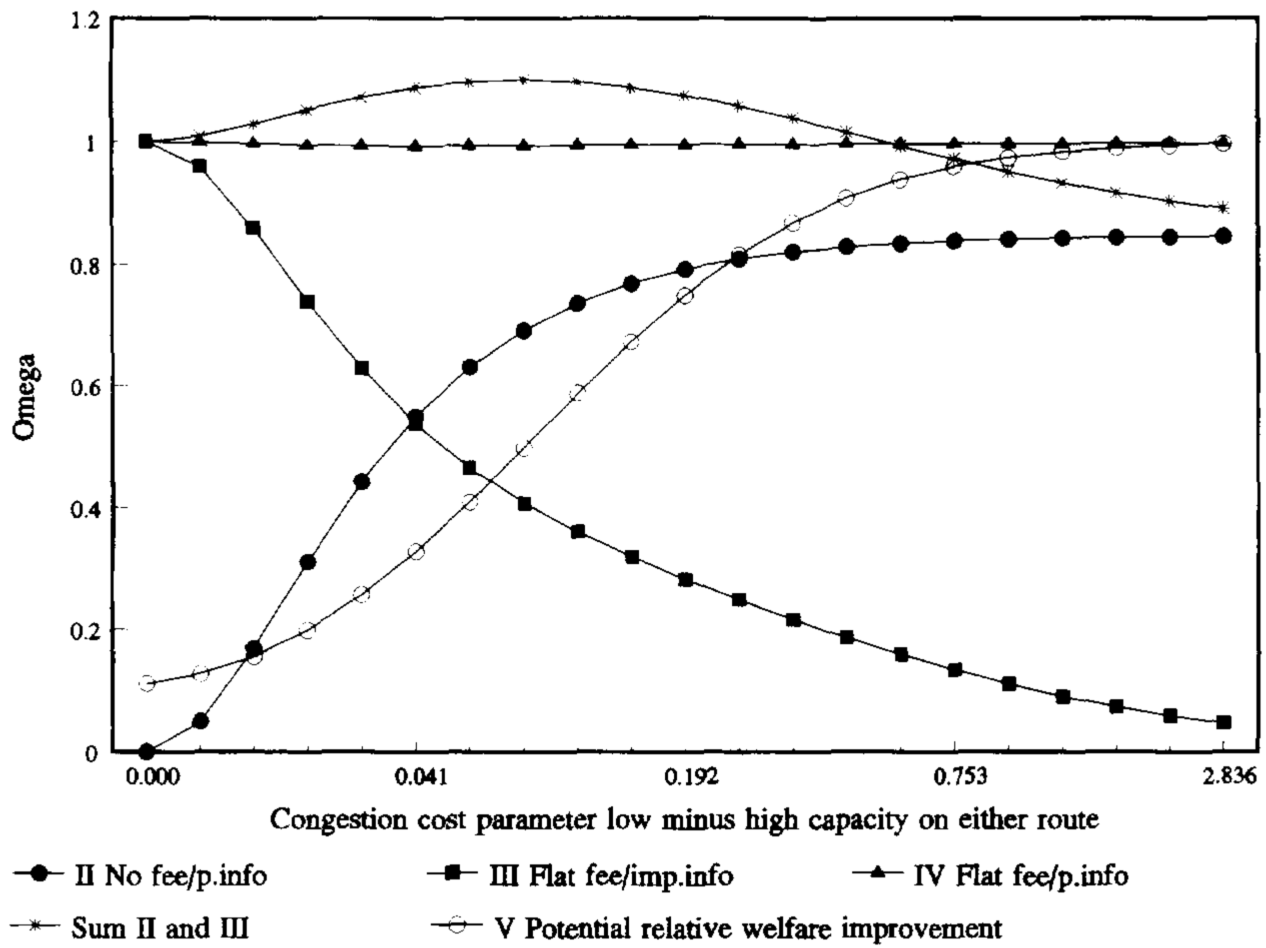
Information vs pricing

- Simplest possible set-up (VNR 1996)
  - Two congestible parallel routes
  - Stochastic coefficients in link cost functions
  - Linear demand and cost functions
  - Regimes
    - No tolling, imperfect information -> expected costs
    - No tolling, perfect information
    - Flat tolling, imperfect information
    - Flat tolling, perfect information
    - Fine tolling, perfect information
  - Question: how do they perform?

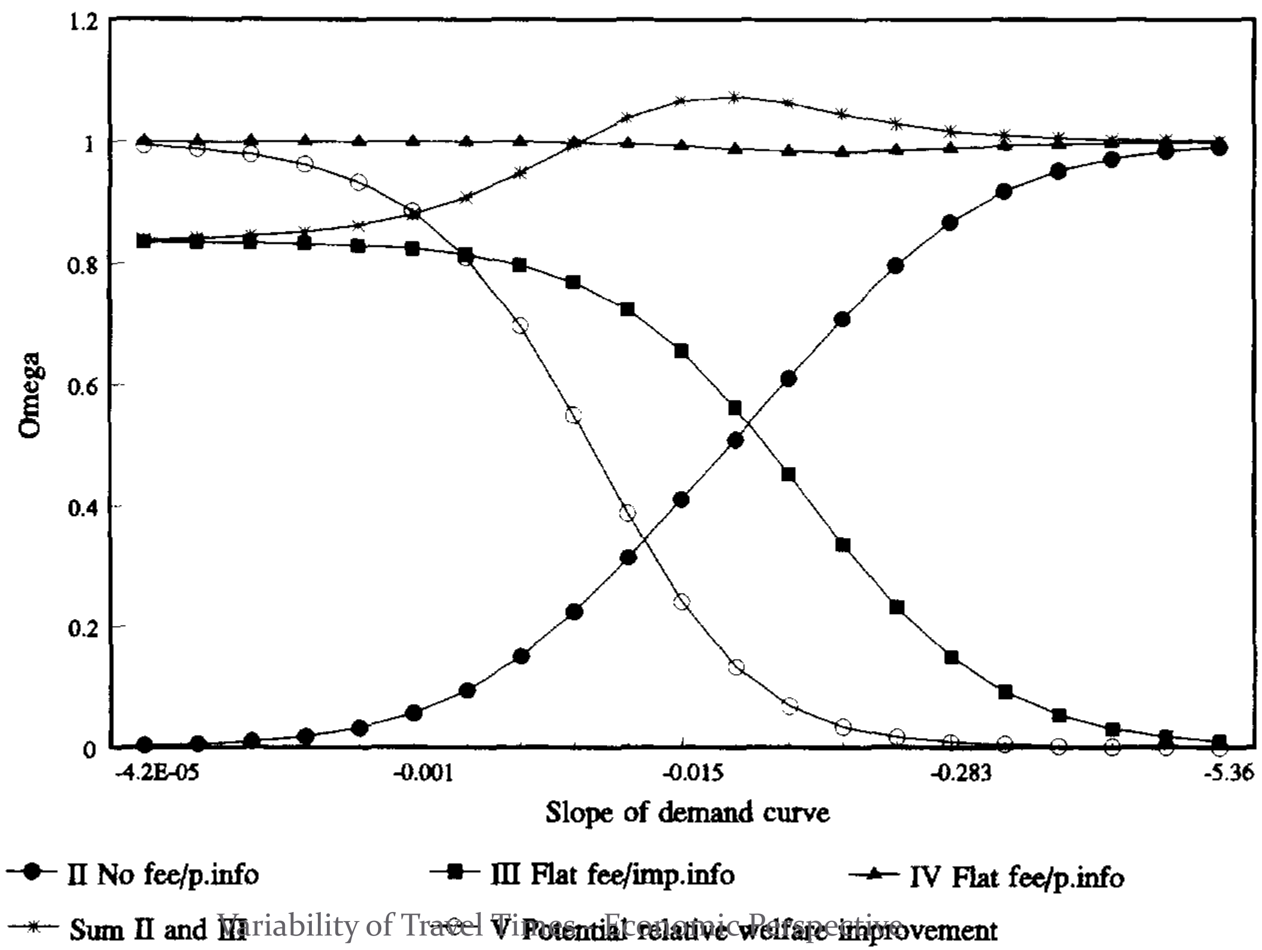
Varying probability of shocks



Varying size of shocks



Varying demand elasticity



Analysis suggests…

- Flat tolling and information provision are highly complementary
- Therefore
  - With perfect information in place, tolls can be based on expected congestion
  - Probably more acceptable
  - Not only technological complementarity of prcing and information, but also behavioural complementarity

A few words on market organization

- Emerging literature
  - Information provision by private or public operator(s)?
    - Monopoly power, economies of scale, different objectives…
  - Link with privatization of (toll) roads?
- We are only beginning to explore all this
- Provisional results
  - Complicated interactions: externalities on road markets, but also on information markets
    - Value of information declines as more people have it and respond to it
  - Private roads less attractive than private information
  - Possible issues around "double marginalization": it may be attractive to merge road and information operations

Conclusions

- Variability of travel times raises many economic issues
- Literature is rapidly developing
  - Measures for variability
  - Valuation of variability
  - Welfare effects of (measures to address) variability
  - Markets for information