Agent-Based Micro-Simulation of Business Establishments in ILUTE

JD Hunt

Third Oregon Symposium on
Integrated Land Use and Transport Models

Portland OR, USA
23-25 July 2002

Joint Program in
Transportation
University of Toronto

UNIVERSITY OF CALGARY

Outline

Describe Research Concerning Potential for Micro-simulation of Business Activity

- Introduction
- Approach
- Testbed Application
- Conclusions

Introduction

Context

- PhD Research at University of Calgary
  - student: JAS Khan
  - supervisor: JD Hunt
  - support: JE Abraham, as PDF

- ILUTE project funds
  - less concern about short-term practical relevance
  - more concern about longer-term possibilities for practice
  - less focus on calibration, more on behaviour and potentials

Introduction
Terms

- Business Establishment (BE)
  portion of a firm conducting activities at a single physical location

- Firmography:
  demography for BEs, covering:
  - births
  - deaths
  - locations/relocation/migration
  - growth

Approach
Behavior Represented

- Includes behavior of and interactions among:
  - BEs
  - land development
- Part of larger simulation system as in TLUMIP2
- Draws on:
  - same model of firm behavior implied in PECAS, but at agent rather than aggregate level
  - same sort of treatment as used for households in HA
  - land development for relevant commercial space types as in LD

Approach
Simulation Methods

- Monte Carlo Technique:
  - selecting changes in states from sampling distributions based on probabilistic choice models and sampling distributions
- Each BE considered once per year
- Floorspace development changes considered once per year
- Prices updated each 6 months

Approach
BE Representation

- BE properties:
  - consumption behavior (production function), what is used per unit of output:
    - commodities
    - labour
    - floorspace
  - production behaviour, what is produced
  - age (number of years BE active)
  - geographical location - cell where located

Approach
BE Dynamic Behavior

- Each year BE makes decision to
  - ‘stay’, in same floorspace area in same cell
  - ‘relocate’ to some other floorspace area in another cell
  - ‘leave’, the model area (emigrating or folding up) :

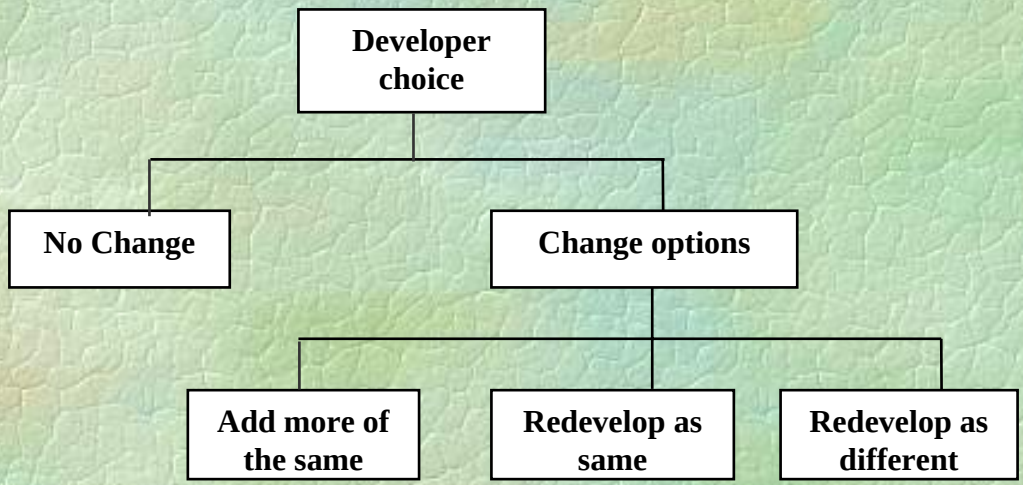
- Using a nested logit model
  - at top level of PECAS hierarchy of models
  - with composite utilities from PECAS hierarchy feeding up

- Price changes at each exchange zone every 6 months

$$Price_t = Price_{t-1} - Price_b(z_1 / z_2 - eqvr.)\theta_2$$

Approach
LD Dynamic Behavior

- Floorspace changes each year



- Similar to LD

Testbed Application
Hypothetical Case

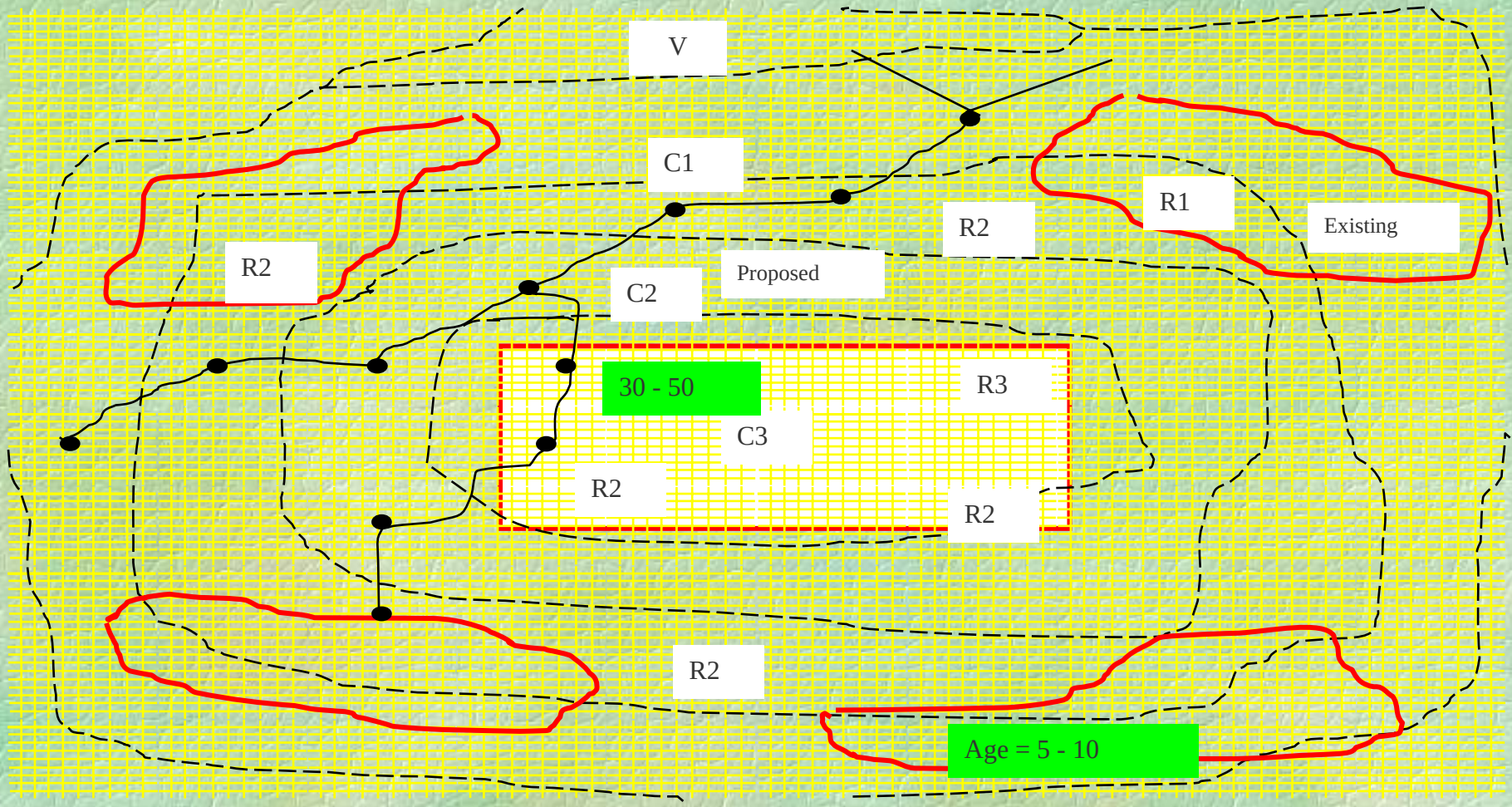
- test geography
  - 9 x 9= 81 zones, each with 100 cells
  - each cell 1 acre

- mix of sizes and types of establishments
  - start with 1,400 BEs
  - 3 commodities

- mix of initial floorspace types and quantities in each cell
  - 3 space types, range of allowable FARs

- static external economic conditions

- runs for 100 years



Legend:

Commercial Space (F.A.R)
C1 = Low density = 1
C2 = Medium density = 2
C3 = High density = 15
V = Vacant

Residential Space (F.A.R)
R1 = Low density = 0.5
R2 = Medium density = 1
R3 = High density = 15

1-Acre = 43560 sq-feet

Testbed Application

Initial Floorspace

Taz	# of GridCells	Area/cell	Dev Type	Min Dev	Max Dev	Min Age	Max Age	Z scheme
203	6	43560	Vacant	21666.66667	21833.3333	10	15	R1
204	85	43560	Vacant	21666.66667	21833.3333	10	15	R1
204	15	43560	Vacant	0	0	0	0	R1
205	50	43560	Vacant	21666.66667	21833.3333	10	15	R1
205	50	43560	Vacant	0	0	0	0	R1
206	100	43560	Vacant	0	0	0	0	R1
207	100	43560	Vacant	0	0	0	0	C1ORR1
208	100	43560	Vacant	0	0	0	0	R1
209	100	43560	Vacant	0	0	0	0	C1ORR1
210	100	43560	Vacant	0	0	0	0	R1
301	100	43560	Vacant	0	0	0	0	R1
302	90	43560	Vacant	0	0	0	0	R1
302	10	43560	Vacant	21666.66667	21833.3333	10	15	R1
303	15	43560	Vacant	0	0	0	0	R1
303	85	43560	Residential	21666.66667	21833.3333	10	15	R1
303	100	43560	Vacant	0	0	0	0	R1
304	92	43560	Residential	21666.66667	21833.3333	10	15	R1
304	8	43560	Vacant	0	0	0	0	R1
305	95	43560	Vacant	0	0	0	0	R1
305	5	43560	Residential	21666.66667	21833.3333	10	15	R1
306	55	43560	Vacant	0	0	0	0	Vacant
306	45	43560	Vacant	0	0	0	0	C3ORR3
307	90	43560	Vacant	0	0	0	0	C1ORR1
307	10	43560	Vacant	0	0	0	0	C3ORR3
308	65	43560	Vacant	0	0	0	0	R1

Testbed Application

Zoning

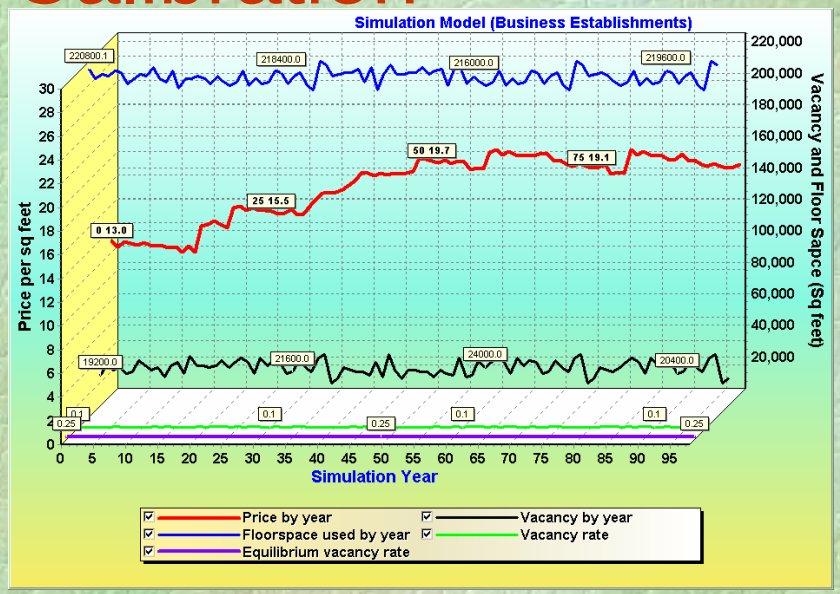
Zoning Scheme	Allowed Development Type	Maximum FAR
R1	Vacant	0
R1	Residential	0.5
R2	Vacant	0
R2	Residential	1
R3	Vacant	0
R3	Residential	15
C1	Vacant	0
C1	Commercial	1
C2	Vacant	0
C2	Commercial	2
C3	Vacant	0
C3	Commercial	15
C2ORR2	Vacant	0
C2ORR2	Commercial	2
C2ORR2	Residential	5
C1ORC2	Commercial	1.5
C1ORC2	Vacant	0
C3ORR3	Vacant	0
C3ORR3	Commercial	15
C3ORR3	Residential	15
C1ORR1	Vacant	0
C1ORR1	Commercial	1
C1ORR1	Residential	1
Vacant	Vacant	0

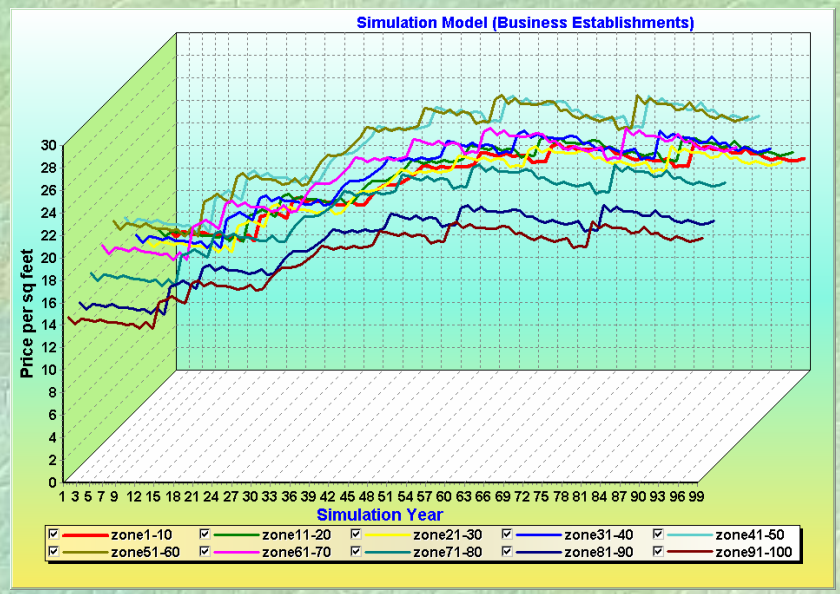
Testbed Application
Calibration

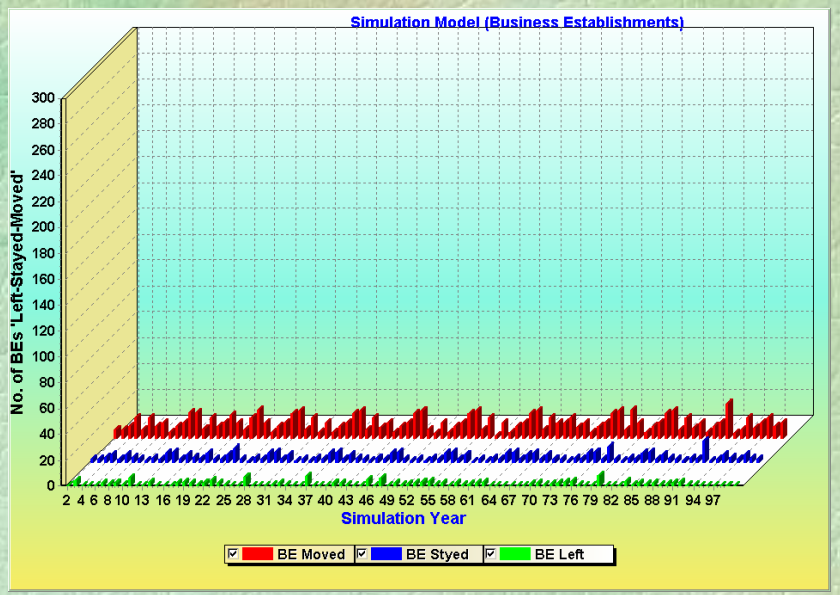
- adjust parameters until:
  - model stable
  - results not unreasonable
- work iteratively, parameter by parameter
- note emphasis on understanding and testing rather than practical results

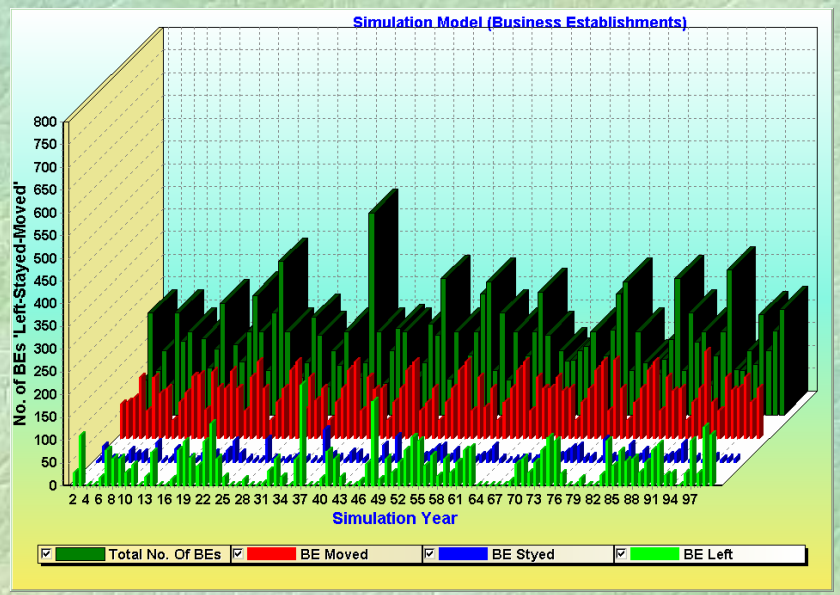
Testbed Application

Calibration





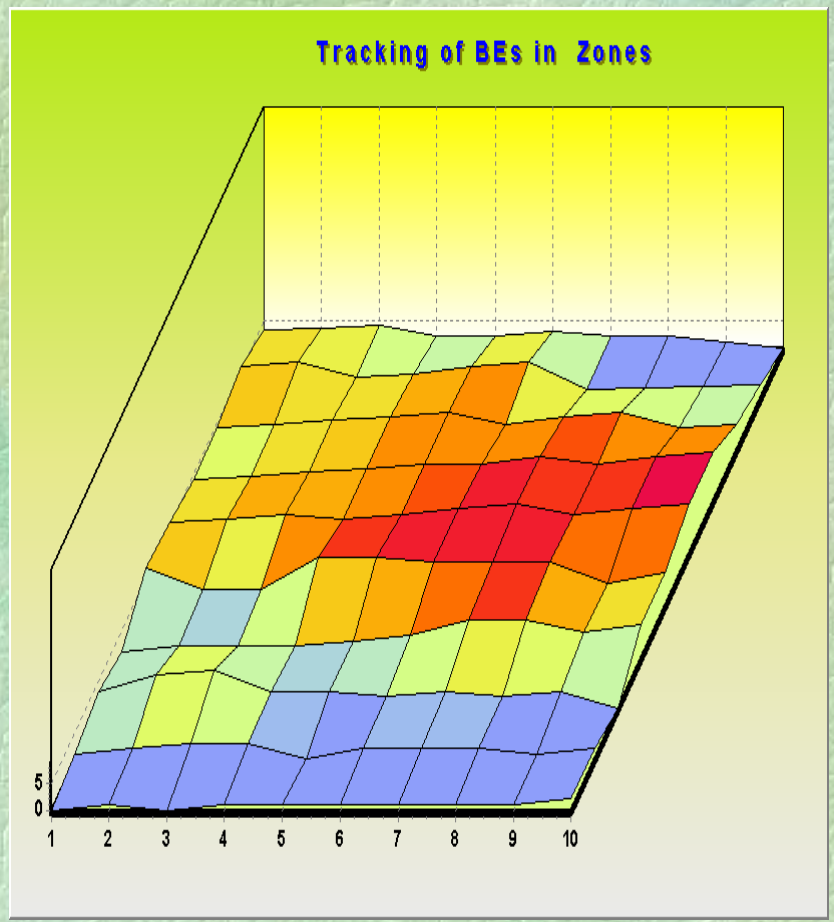




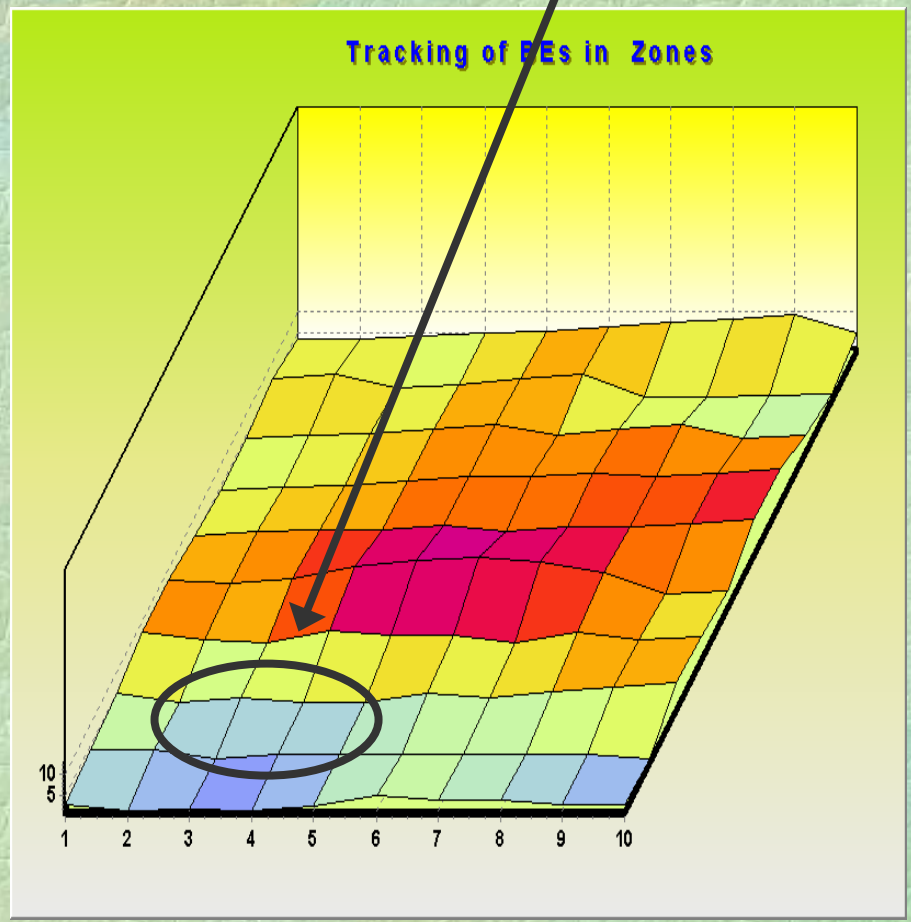
Testbed Application

Alternative Policy Test 1

Reference Case



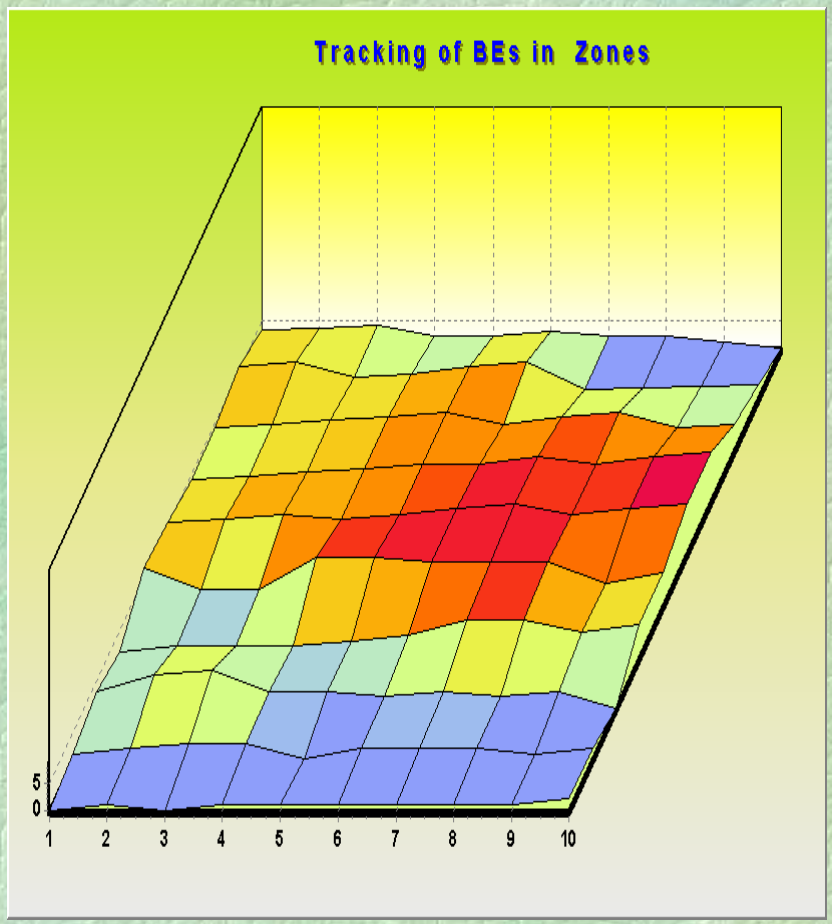
30% floorspace rent increase
zones 202, 203, 204



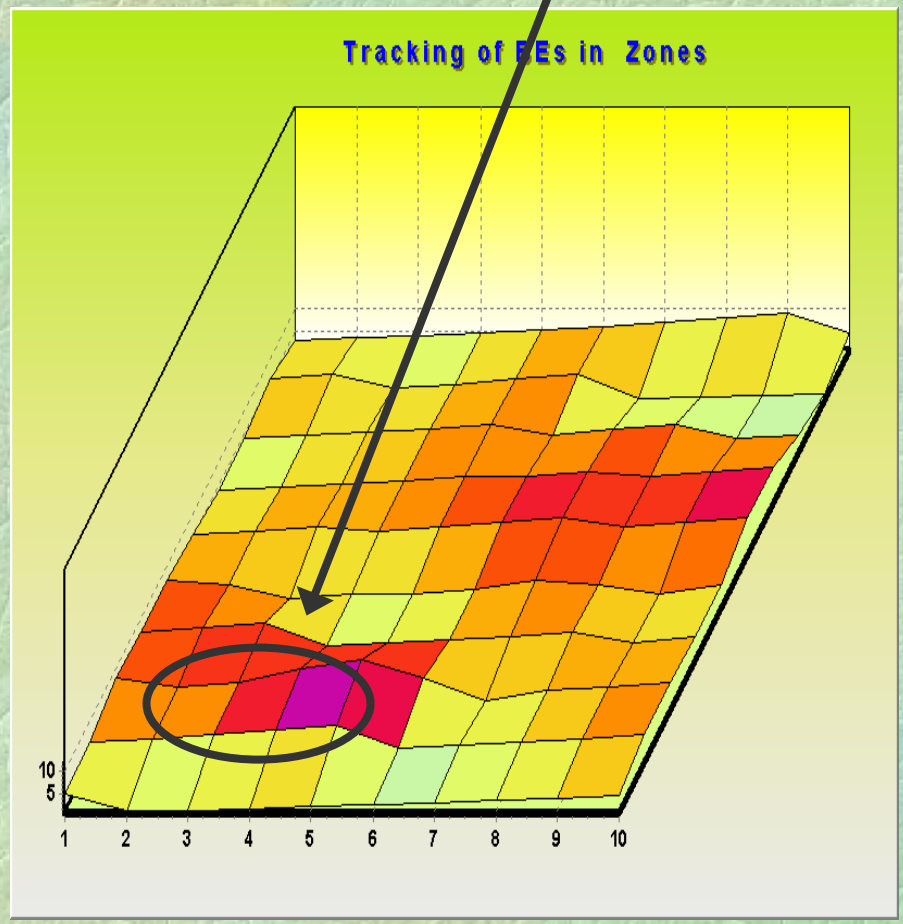
Testbed Application

Alternative Policy Test 2

Reference Case



30% floorspace rent subsidy
zones 202, 203, 204

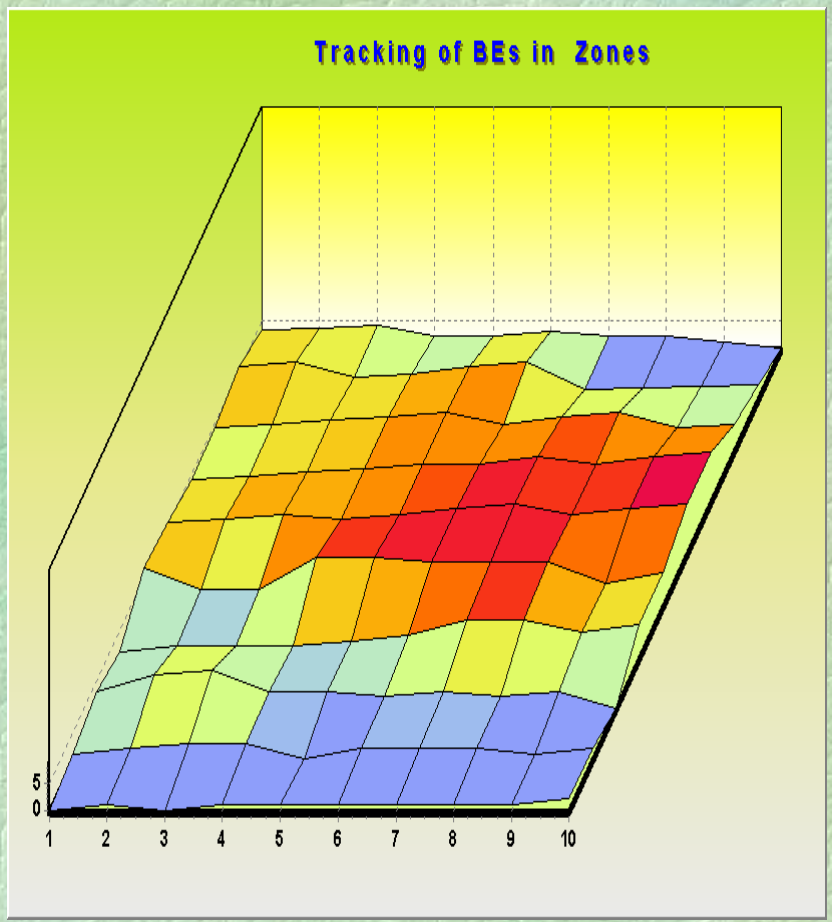


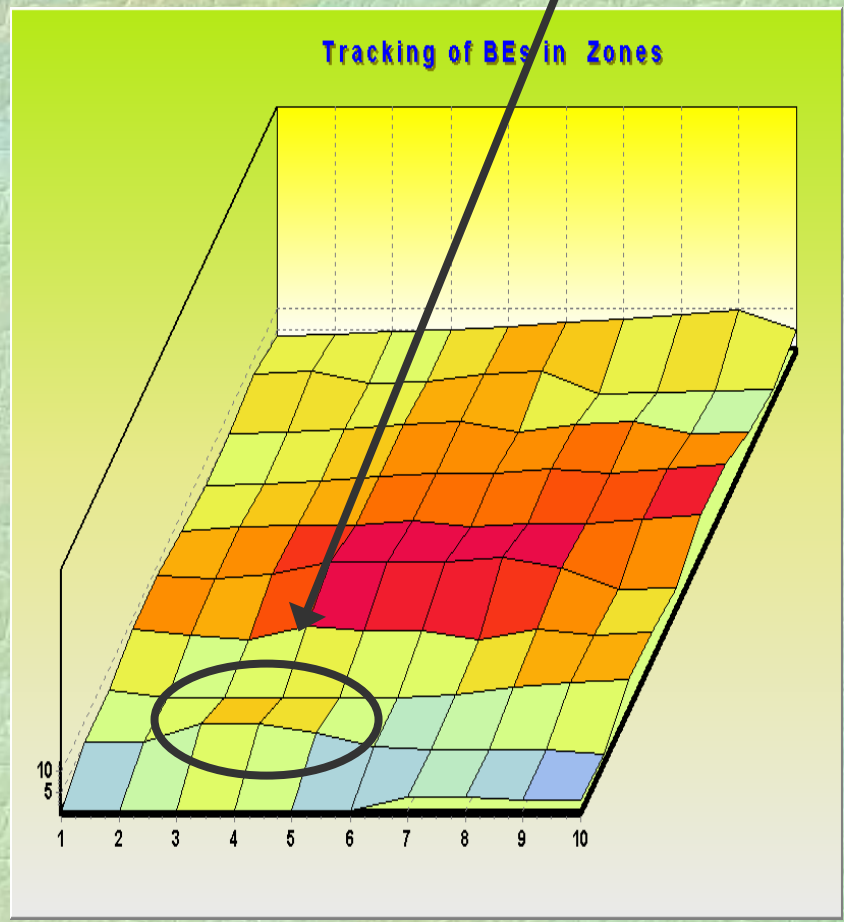
Testbed Application

Alternative Policy Test 3

Reference Case

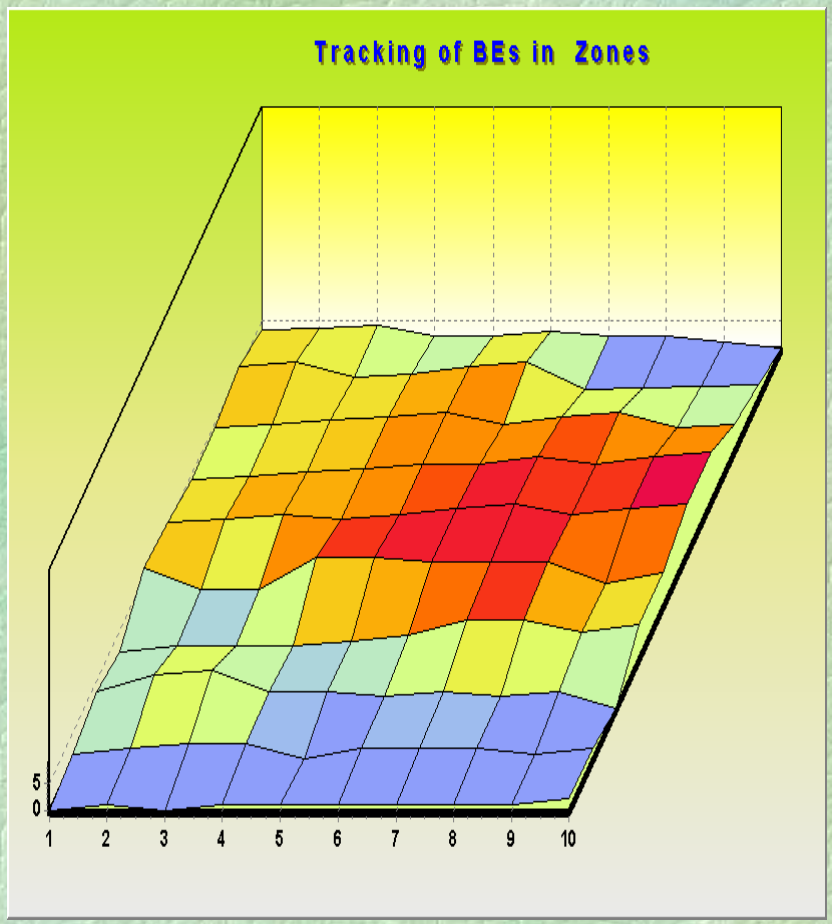
50% development cost subsidy
zones 202, 203, 204



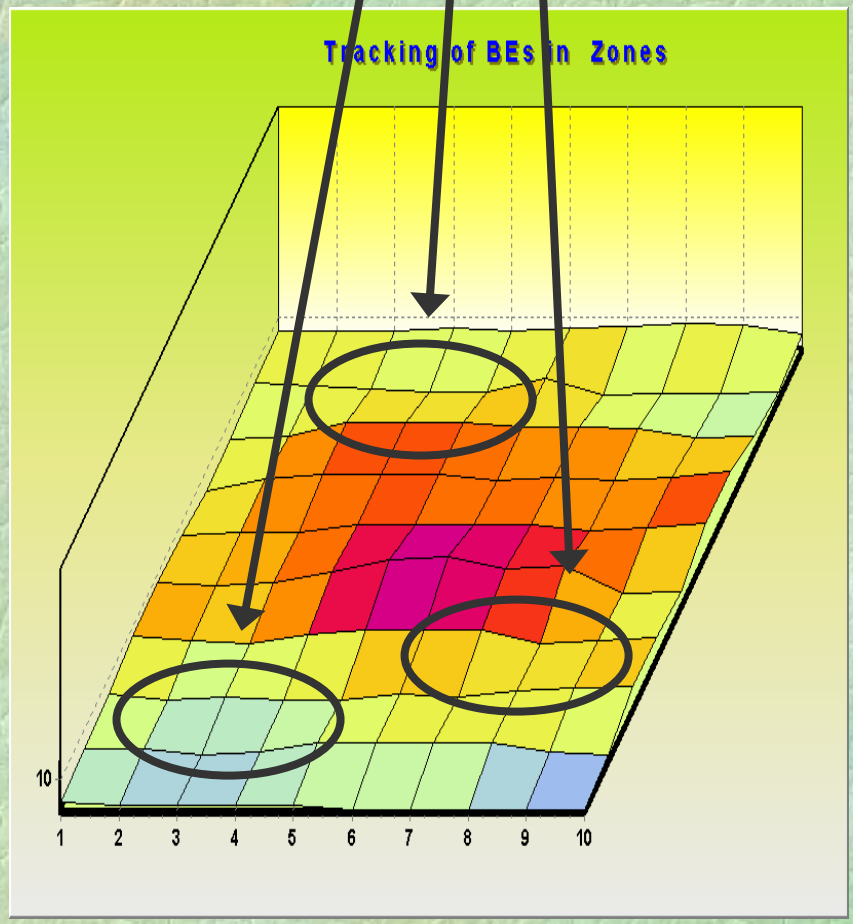


Testbed Application
Alternative Policy Test 4

Reference Case

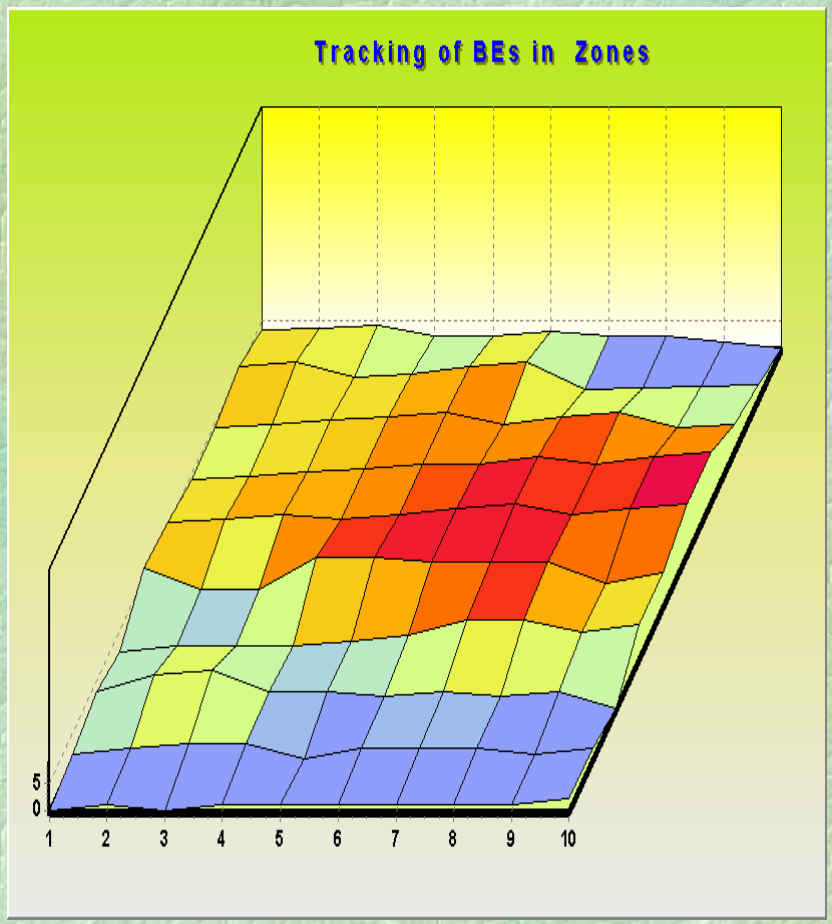


30% price increase
various zones

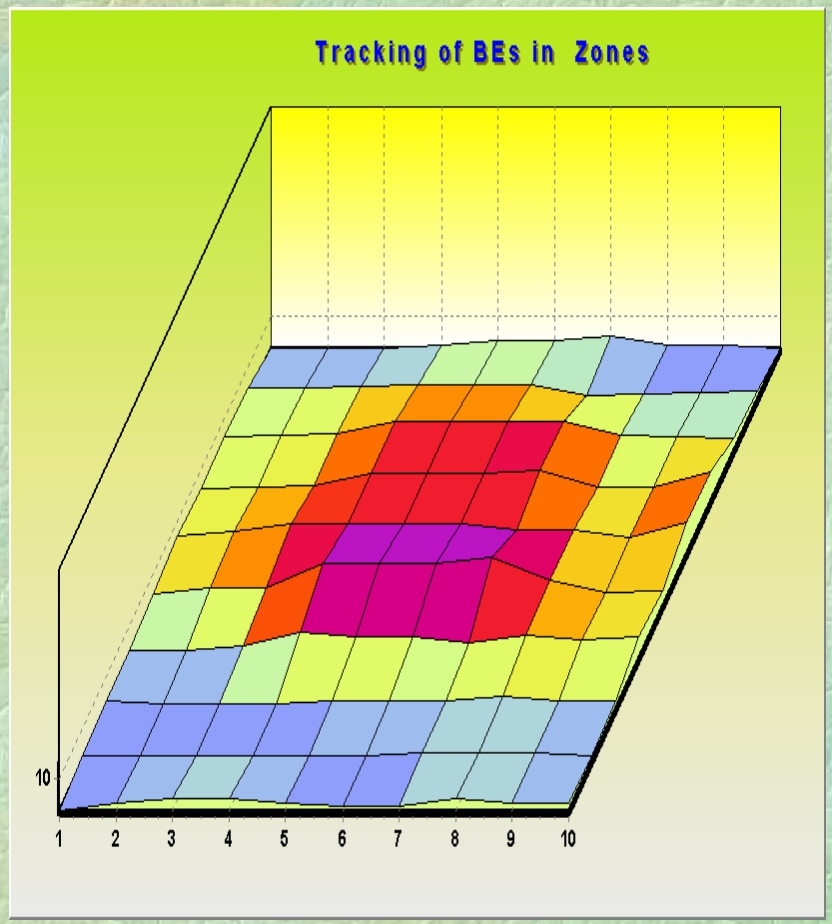


Testbed Application
Alternative Policy Test 5

Reference Case



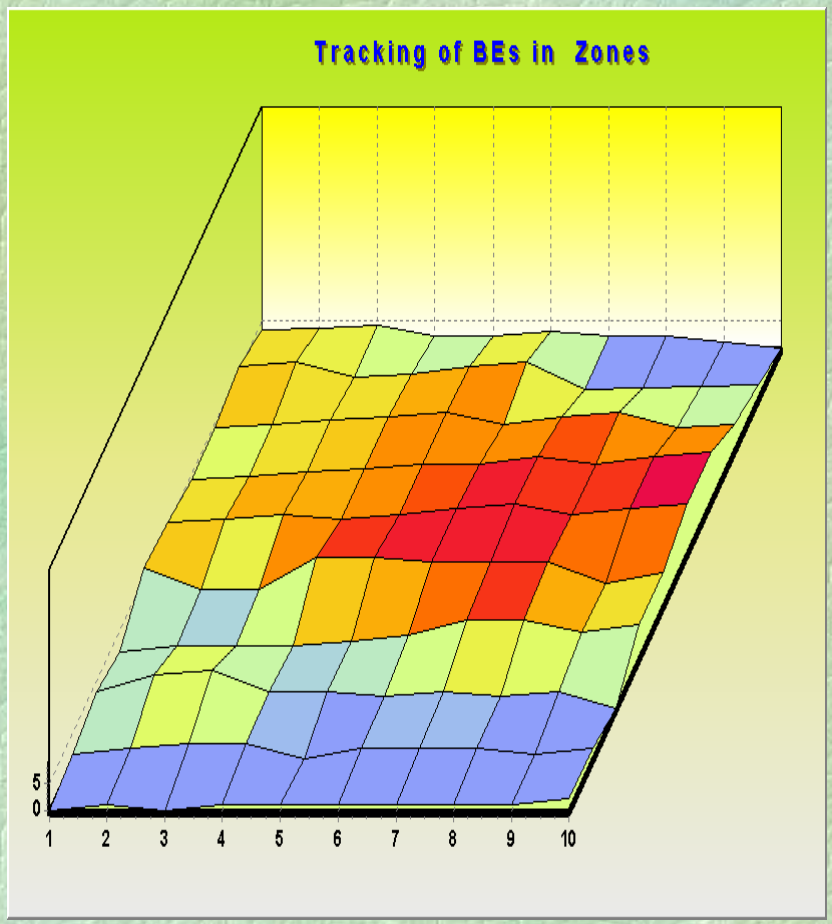
double travel
costs everywhere

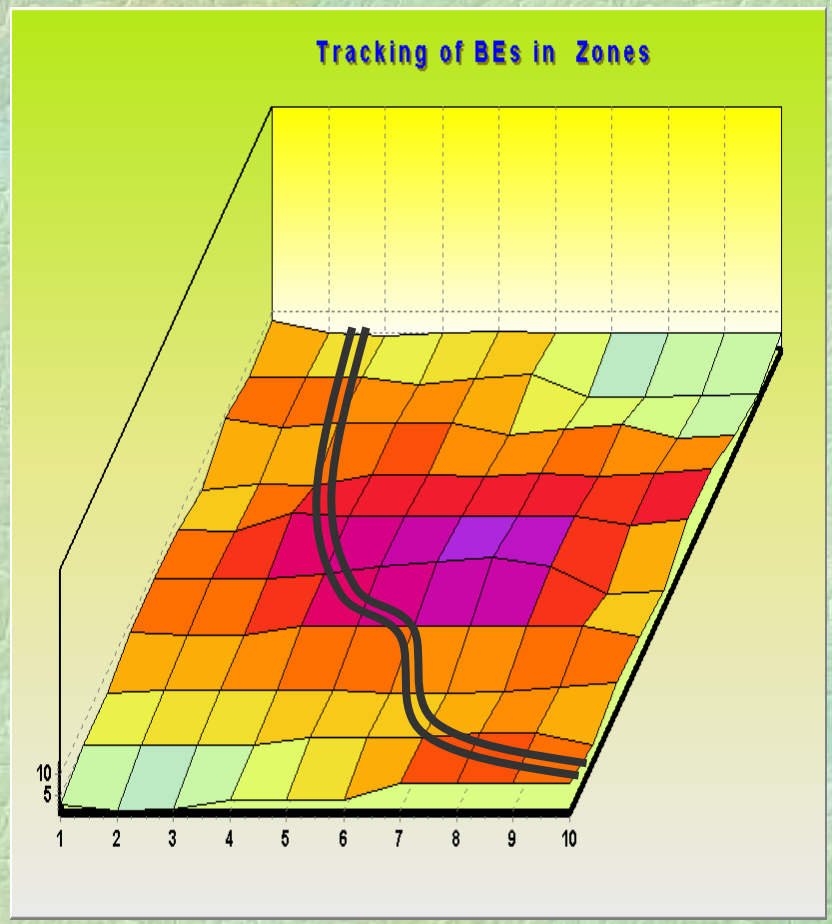


Testbed Application
Alternative Policy Test 6

Reference Case

new freeway; reduced travel times and costs



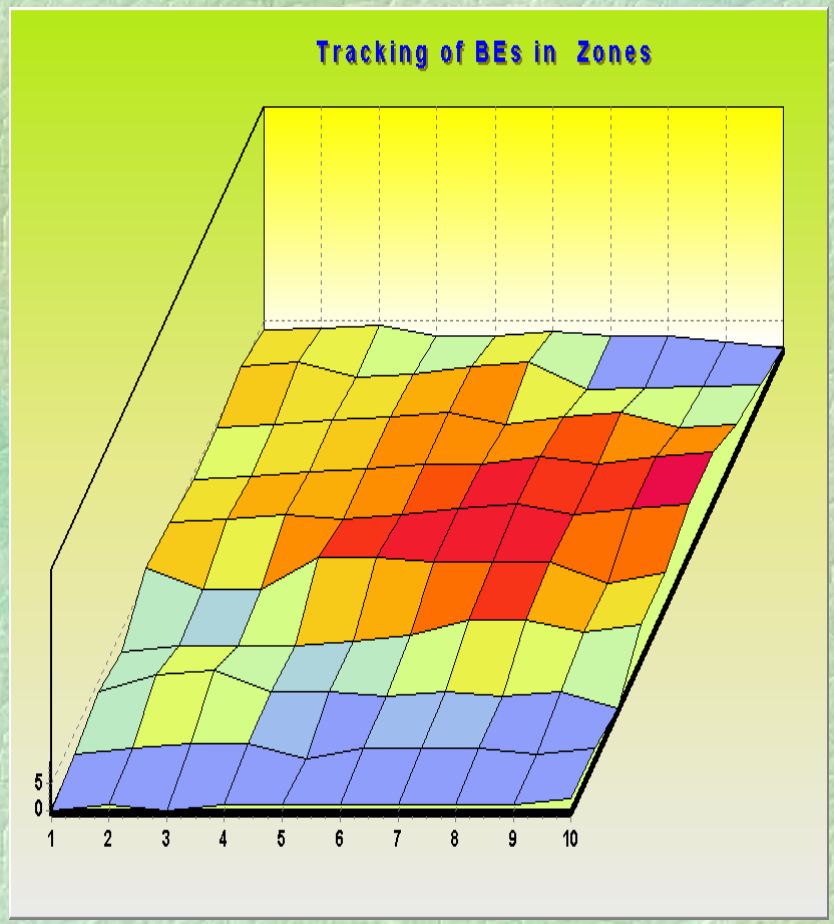


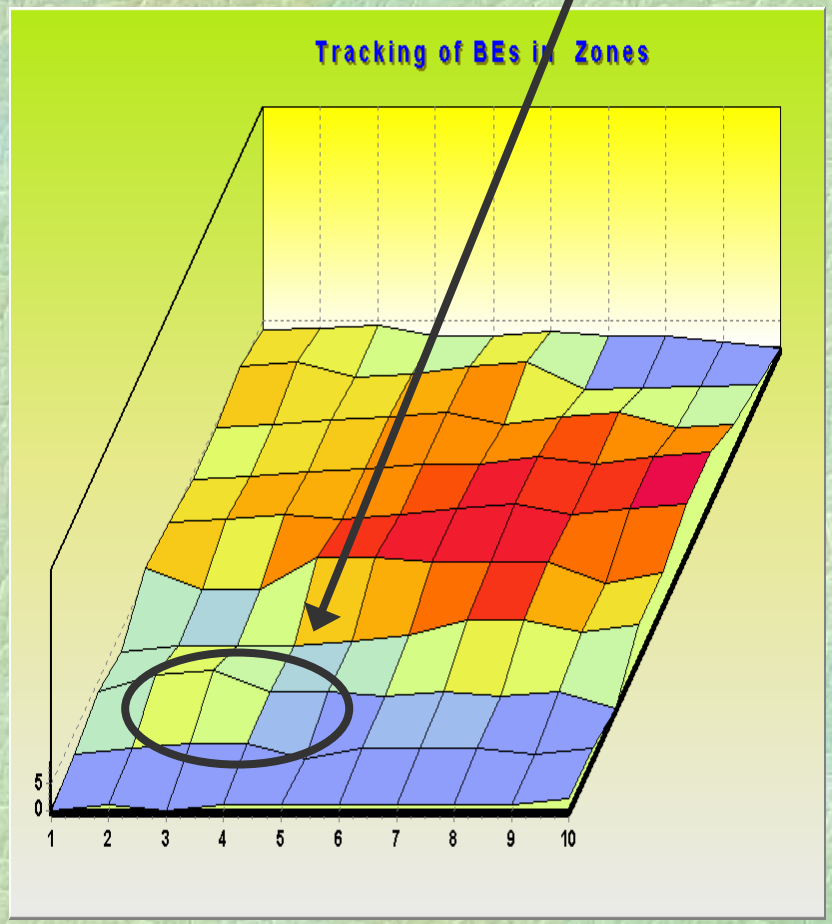
Testbed Application

Alternative Policy Test 7

Reference Case

increase allowable development all kinds zones 202, 203, 204

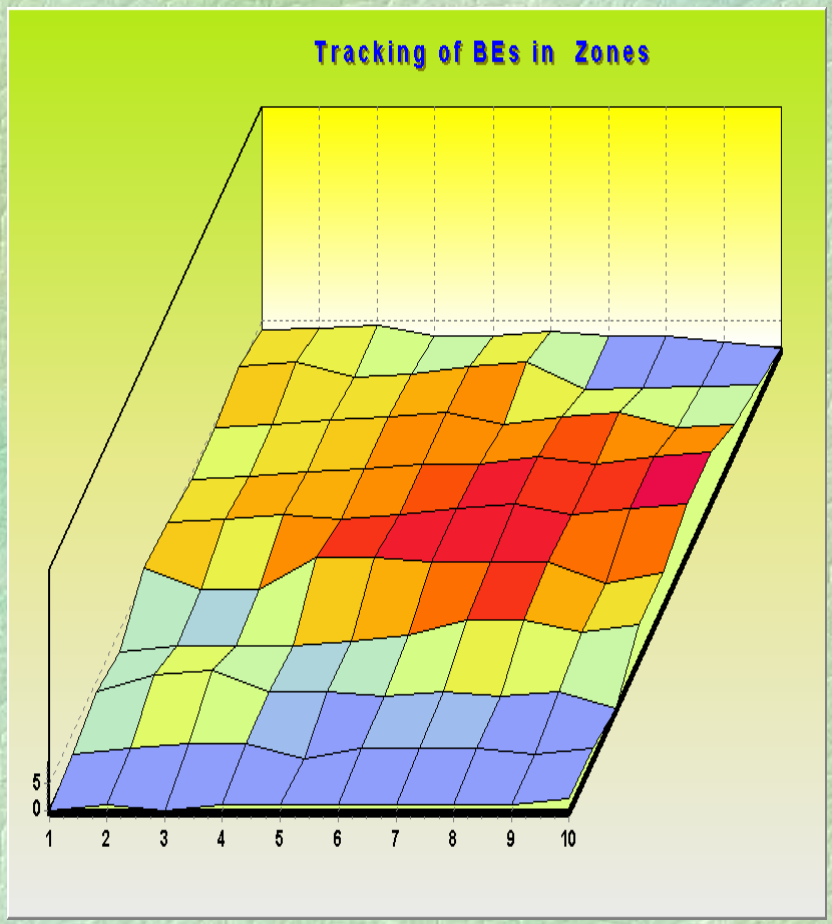


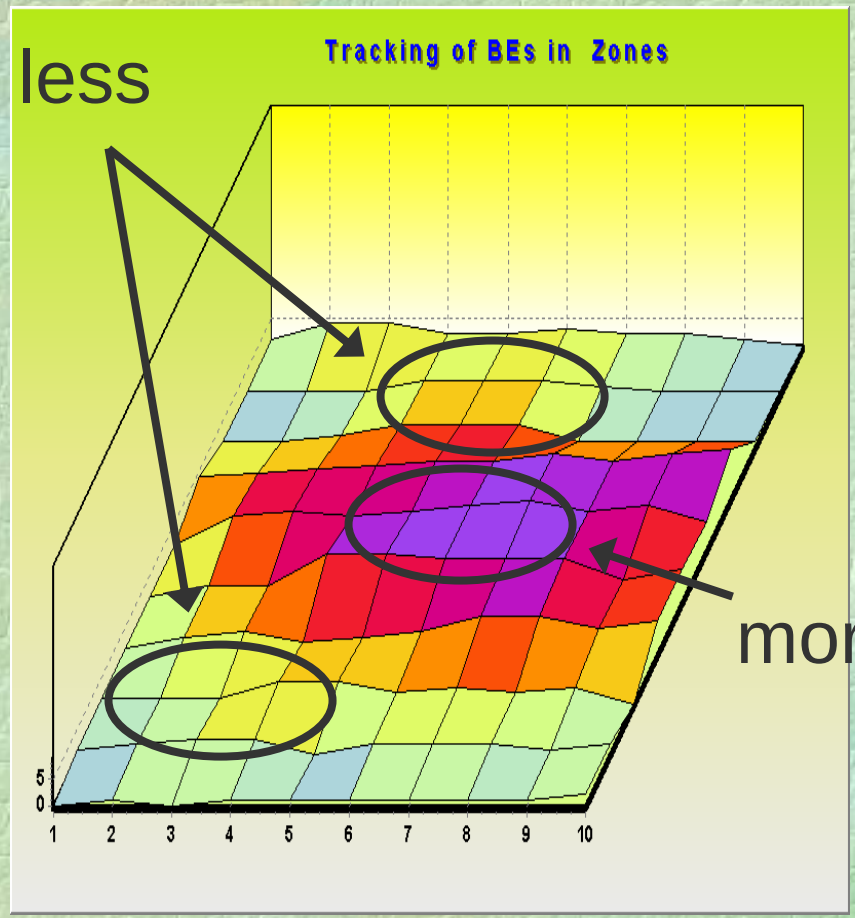


Testbed Application
Alternative Policy Test 8

Reference Case

changed allowable development for commercial, various zones





Conclusions

- Model and approach work:
  - reasonable aggregate behavior from disaggregate treatment
  - policy responses as expected
- Increased understanding of system:
  - link from individual BEs to aggregate patterns
  - new perceptions of
    - Von Thunen
    - Alonso
    - Christaller Central Place Theory
- Seems to offer interesting potential way ahead in practical modeling, but ...

Conclusions

- Run times an issue:
  - 10 hours for 100 years of hypothetical scenario
  - using 1GHz computer with 800 MB of RAM
- Range of BE sizes and types:
  - no growing and declining, just appearing and ‘leaving’
  - range of technologies, but simplified
- Reality much more complex, with many more commodity types, interactions and markets
- Substantial data issues also side-stepped here
- Gap to full-blown practical application
  - greater than with mirco-simulation of households
  - a ways into future . . . . more questions arising