STATEWIDE AND SUBSTATE LAND USE-TRANSPORT MODELING FRAMEWORK

Pat Costinett & Rick Donnelly
Parsons Brinckerhoff Quade & Douglas, Inc.
and
Carl Batten
EcoNorthwest

Statewide Analysis Issues

- Effect of land supply on land use and location decisions
- Effect of land supply on travel behavior
- Effect of highway capacity increases on travel behavior
- Effect of changes in the social and economic structure of the state
- Effect of rail investment on highway use

Substate Analysis Issues

- Effect of congestion on land use and locational decisions
- Effect of large commercial development at the periphery of the growth boundaries

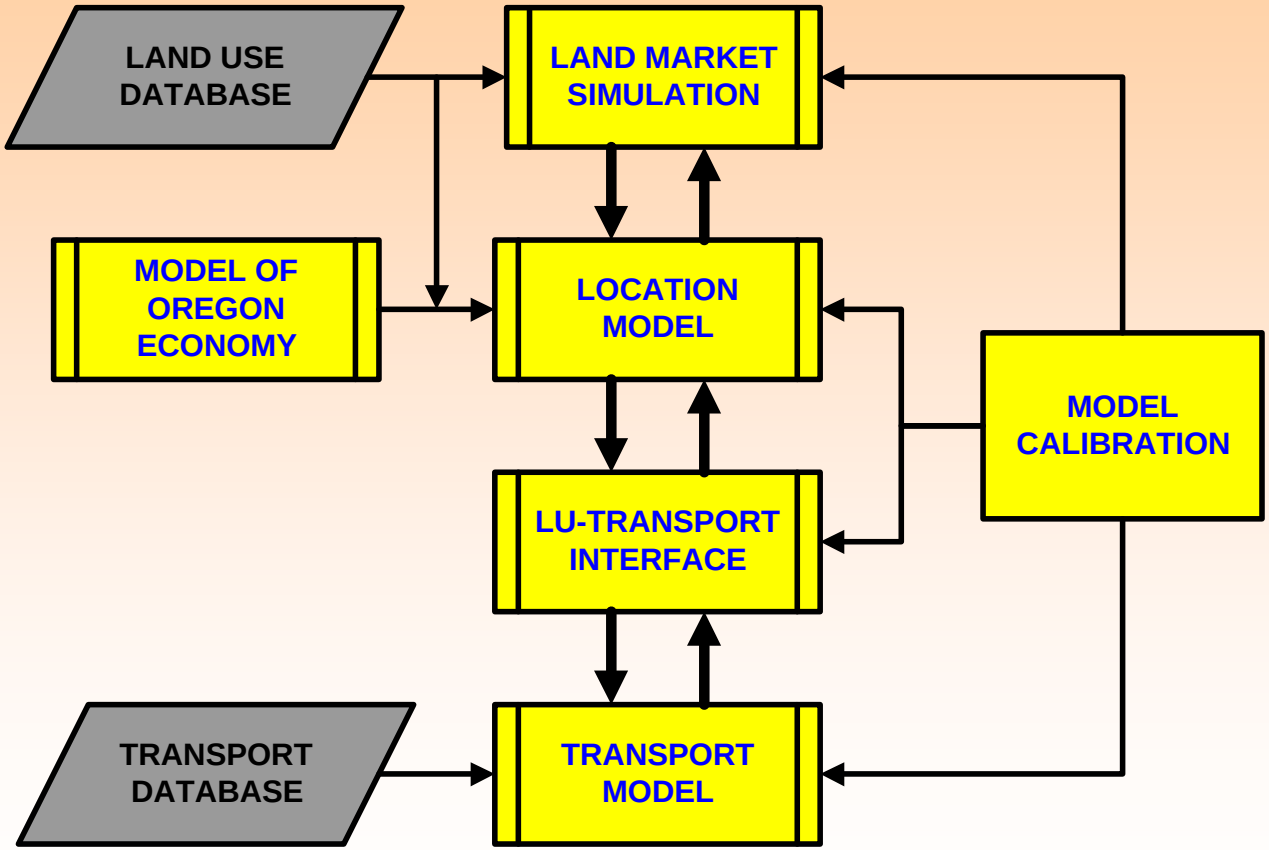
Local Analysis Issues

- Cumulative effects of retail location choice
- Effect of network connectivity on travel behavior
- Effect of parking supply on travel behavior
- Effect of urban form on mode choice

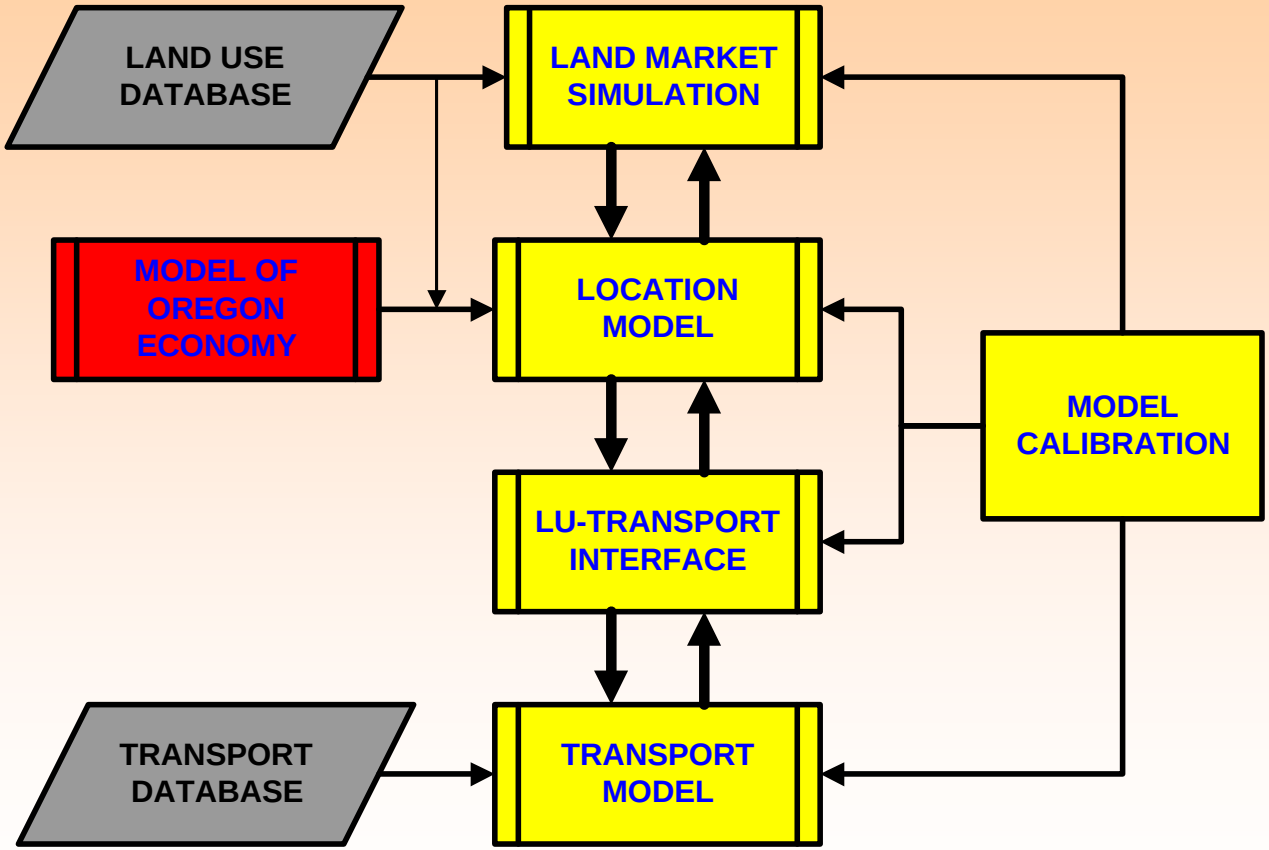
Use of TRANUS for Prototype

- Consistent theory and structure
- Integrated land use and transport modules
- Nested MNL structure
- Integrated time series framework
- Hierarchical scenario definition (trees)
- Umbrella user shell

OVERVIEW of STATEWIDE MODEL



OREGON ECONOMY



ECONOMIC MODEL

- Spatially Aggregate (Statewide)
- Specific to Oregon
- Annual Transactions in $Millions
- Retail & Imports “Un-margined”
- Based on IMPLAN Model (528 sectors)
- Aggregation to 28 Sectors to 12 Sectors
- Plus 3 Household & 4 Land Sectors

TRANUS SECTORS

#	SECTOR	DESCRIPTION
1	AGFF	Farms, Forests, Fisheries
2	CONS	Mines, Construction
3	OMFG	Food Processing, Non-metallic Minerals, Metals, Other
4	WOOD	Lumber & Wood, Pulp & Paper
5	PRNT	Printing & Publishing
6	TECH	Machinery & Equipment, High Tech, Transport Equipment
7	TCPU	Transport, Communications & Utilities
8	WLSE	Wholesale
9	RETL	Retail
10	FIRE	Finance, Insurance, & Real Estate
11	SERV	Lodging, Personal/Business/Health Services, Amusements, Organizations
12	GOVT	Education, Other Government

STATE I-O MATRIX

STATE OF OREGON ANNUAL TRANSACTIONS ($MILLIONS, RETAIL UNMARGINED)																	
	CONSUMERS																
PRODUCERS	AGFF	CONS	OMFG	WOOD	PRNT	TECH	TCPU	WLSE	RETL	FIRE	SERV	GOVT	HH_Lo	HH_Mid	HH_Hi	OTHFD	EXPORTS	TOTAL
AGFF	608	1	839	10	0	0	1	0	114	0	103	1				42	2,738	4,458
CONS	59	34	88	87	3	52	332	3	194	453	623	218				6,177	799	9,123
OMFG	90	162	568	187	20	116	31	1	1,229	7	162	12	1	2	1	146	8,349	11,085
WOOD	32	280	107	2,028	3	32	3	4	145	0	13	2				277	8,145	11,072
PRNT	1	4	106	46	24	49	18	6	113	37	103	10				31	733	1,281
TECH	43	105	52	71	7	957	53	1	356	7	268	7				1,190	5,052	8,169
TCPU	218	355	881	945	80	274	829	26	225	219	809	151	468	1,089	608	635	1,861	9,672
WLSE	103	267	292	308	24	262	68	6	26	8	187	12	197	543	320	303	1,387	4,312
RETL	3	218	7	11	2	7	14	2	10	16	90	2	1,697	4,251	2,522	94	635	9,582
FIRE	210	93	72	91	18	68	153	14	150	1,270	1,462	93	1,513	3,922	1,900	129	1,802	12,961
SERV	376	770	291	271	80	249	388	57	983	655	1,872	105	2,019	4,064	2,606	391	4,402	19,577
GOVT	20	11	51	106	3	26	54	2	25	22	146	18	202	564	344	5,899	81	7,575
EMPL COMP	378	2,483	2,229	2,753	412	2,499	3,046	2,690	3,863	1,983	6,830	6,401						35,567
OTHVA	1,004	1,194	1,244	1,230	193	892	2,967	1,438	966	7,056	3,031	214						21,428
IMPORTS	1,318	2,924	4,557	2,918	420	2,713	1,703	68	693	1,214	3,967	326						22,821
TOTAL	4,462	8,902	11,383	11,061	1,289	8,196	9,662	4,318	9,091	12,947	19,667	7,573	6,095	14,434	8,301	15,314	35,986	188,682

SOCIAL ACCOUNTING MATRIX

	CONSUMING SECTORS (n)																	
	Industries												Households					
PRODUCING SECTORS (m)	AGFF	CONS	OMFG	WOOD	PRNT	TECH	TCPU	WLSE	RETL	FIRE	SERV	GOVT	HH_Lo	HH_Mi	HH_Hi	OTHFD	Exports	TOTAL
Industries																		
AGFF	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
CONS	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
OMFG	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
WOOD	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
PRNT	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
TECH	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
TCPU	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
WLSE	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
RETL	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
FIRE	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
SERV	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
GOVT	a	a	a	a	a	a	a	a	a	a	a	a	p	p	p	o	x	T
Households																		
HH_Lo	l	l	l	l	l	l	l	l	l	l	l	l						T
HH_Mi	l	l	l	l	l	l	l	l	l	l	l	l						T
HH_Hi	l	l	l	l	l	l	l	l	l	l	l	l						T
Land																		
IND		e	e	e	e	e	e	e										
COM			e			e	e		e	e	e	e						
UrbRES													e	e	e			
RurRES													e	e	e			

SYMBOL	DESCRIPTION OF ECONOMIC FLOWS
a	Inter-Industry Transactions, dollar flows from consuming sectors to producing sectors.
	Includes imports produced by external zones and consumed by internal zones. Basis for
	Freight demand and NHB Passenger demand.
p	Personal Consumption, dollar flows from household sectors to industry sectors. Basis for
	HB, non-work passenger demand.
o	Other Final Demand components, government spending, inventory additions, capital formation.
	Treated as Exogenous Demand in TRANUS. Does not generate transport demand.
x	Exports, produced by internal zones, consumed by external zones. Basis for Freight demand
	and NHB Passenger demand.
l	Labor Compensation, dollar flows to household sectors for production of labor. Basis for
	Passenger Commute demand.
e	Land Demand functions. Land costs adds to production costs, produces no
	transport demand.
v	Other Value Added components, taxes, profits, no related transport demand.
T	Total Production and Total Consumption, Theoretically equal to one another for each Industry.

STATE OF OREGON ANNUAL TRANSACTIONS ($MILLIONS, RETAIL UNMARGINED)

	CONSUMERS											
PRODUCERS	AGFF	CONS	OMFG	WOOD-WLSE	RETL	FIRE	SERV	GOVT	HH_Lo	HH_Mid	HH_Hi	TOTAL
AGFF	608	1	839	12	114	0	103	1				4,458
CONS	59	34	88	477	194	453	623	218				9,123
OMFG	90	162	568	355	1,229	7	162	12	1	2	1	11,085
WOOD	32	280	107	2,071	145	0	13	2				11,072
PRNT	1	4	106	143	113	37	103	10				1,281
TECH	43	105	52	1,090	356	7	268	7				8,169
TCPU	218	355	881	2,154	225	219	809	151	468	1,089	608	9,672
WLSE	103	267	292	668	26	8	187	12	197	543	320	4,312
RETL	3	218	7	36	10	16	90	2	1,697	4,251	2,522	9,582
FIRE	210	93	72	344	150	1,270	1,462	93	1,513	3,922	1,900	12,961
SERV	376	770	291	1,044	983	655	1,872	105	2,019	4,064	2,606	19,577
GOVT	20	11	51	193	25	22	146	18	202	564	344	7,575
EMPL COMP	378	2,483	2,229	11,400	3,863	1,983	6,830	6,401				35,567
OTHVA	1,004	1,194	1,244	6,719	966	7,056	3,031	214				21,428
IMPORTS	1,318	2,924	4,557	7,822	693	1,214	3,967	326				22,821
TOTAL	4,462	8,902	11,383	11,061	9,091	12,947	19,667	7,573	6,095	14,434	8,301	188,682

FINAL TRANSACTIONS (IMPORTS AND RETAIL UNMARGINED)

	CONSUMERS											
PRODUCERS	AGFF	CONS	OMFG	WOOD-WLSE	RETL	FIRE	SERV	GOVT	HH_Lo	HH_Mid	HH_Hi	TOTAL
AGFF	781	1	1,374	212	106	0	84	1				4,458
CONS	99	315	901	1,396	55	448	486	274				9,123
OMFG	750	1,729	2,823	3,026	3,447	41	1,026	66	1	2	1	11,085
WOOD	61	453	227	2,516	272	11	108	10				11,072
PRNT	3	13	204	396	279	96	480	28				1,281
TECH	174	348	195	2,418	1,082	30	671	33				8,169
TCPU	307	398	833	2,529	165	312	1,089	231	468	1,089	608	9,672
WLSE	141	350	364	854	17	10	209	16	197	543	320	4,312
RETL	5	268	8	45	8	21	81	2	1,697	4,251	2,522	9,582
FIRE	348	141	94	562	123	1,894	1,612	168	1,513	3,922	1,900	12,961
SERV	525	1,024	415	1,607	765	921	2,501	148	2,019	4,064	2,606	19,577
GOVT	32	16	69	222	18	46	158	26	202	564	344	7,575
E-COMP, HH_Lo	55	164	145	534	495	108	529	417				2447
E-COMP, HH_Mi	173	1292	1131	5499	2020	718	2668	3067				16569
E-COMP, HH_Hi	150	1027	953	5368	1347	1158	3632	2917				16552
OTHVA	1,004	1,194	1,244	6,719	966	7,056	3,031	214				21,428
TOTAL	4,609	8,734	10,981	33,901	11,166	12,869	18,366	7,619	6,095	14,434	8,301	165,862

TECHNICAL COEFFICIENTS

If producing sectors are denoted by the subscript “m” and consuming sectors by the subscript “n”, then the coefficients are calculated as follows:

$$a_{mn} = I\text{-}O_{mn} / \sum_n I\text{-}O_{mn}$$

where: a_{mn} = amount of sector m required as input per unit of sector n production

$I\text{-}O_{mn}$ = dollar flow from sector m to sector n

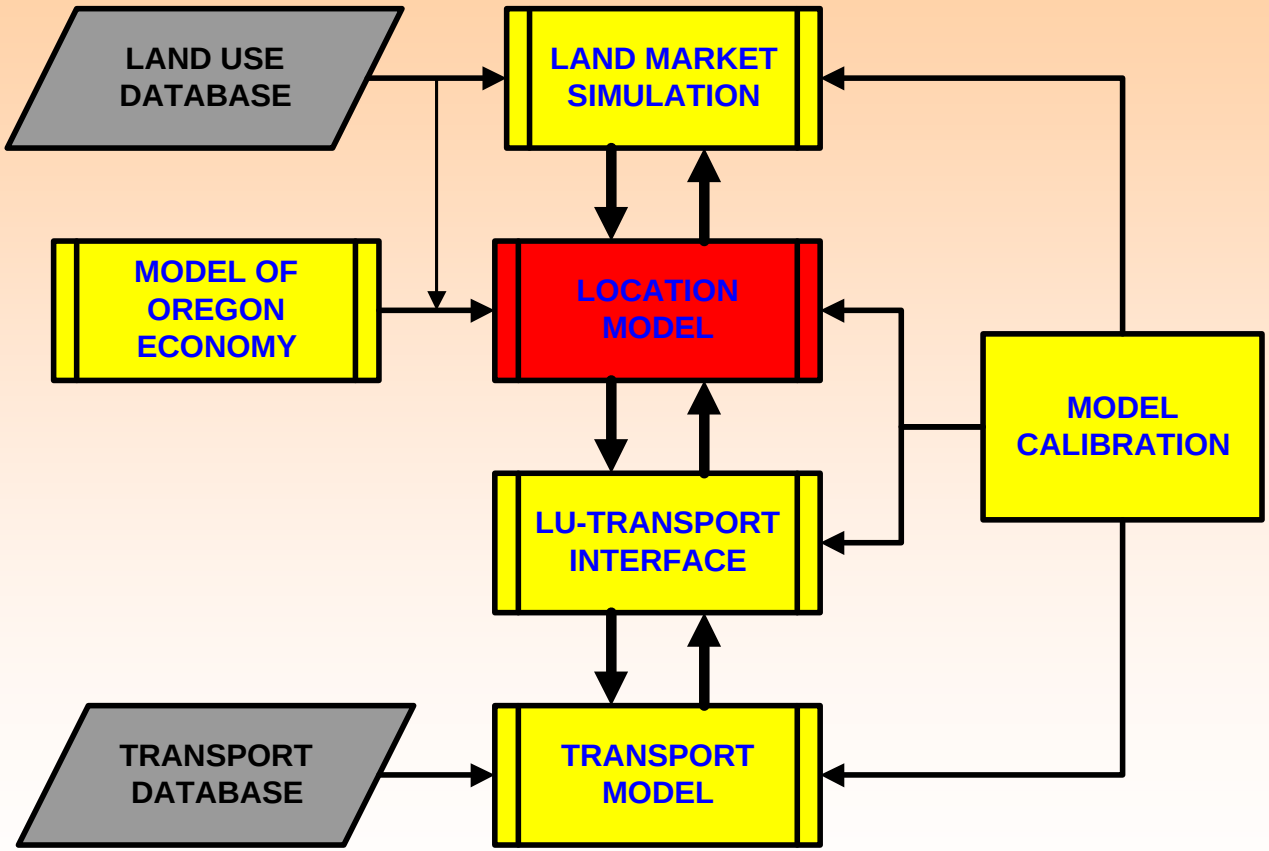
$\sum_n I\text{-}O_{mn}$ = total production for sector m

Although these coefficients may change over time due to technological or other changes, they are assumed to be fixed for the initial model implementation.

TRANUS DEMAND COEFFICIENTS

TECHNICAL COEFFICIENTS											
	CONSUMERS										
PRODUCERS	AGFF	CONS	OMFG	.....	RETL	FIRE	SERV	GOVT	HH_Lo	HH_Mi	HH_Hi
AGFF	0.175	0.000	0.124	.....	0.011	0.000	0.004	0.000			
CONS	0.022	0.035	0.082	.....	0.006	0.035	0.025	0.036			
OMFG	0.168	0.190	0.256	.....	0.360	0.003	0.052	0.009	0.000	0.000	0.000
WOOD	0.014	0.050	0.021	.....	0.028	0.001	0.005	0.001			
PRNT	0.001	0.001	0.018	.....	0.029	0.007	0.025	0.004			
TECH	0.039	0.038	0.018	.....	0.113	0.002	0.034	0.004			
TCPU	0.069	0.044	0.075	.....	0.017	0.024	0.056	0.030	0.191	0.066	0.037
WLSE	0.032	0.038	0.033	.....	0.002	0.001	0.011	0.002	0.080	0.033	0.019
RETL	0.001	0.029	0.001	.....	0.001	0.002	0.004	0.000	0.694	0.257	0.152
FIRE	0.078	0.015	0.009	.....	0.013	0.146	0.082	0.022	0.618	0.237	0.115
SERV	0.118	0.112	0.038	.....	0.080	0.071	0.128	0.020	0.825	0.245	0.157
GOVT	0.007	0.002	0.006	.....	0.002	0.004	0.008	0.003	0.082	0.034	0.021
ECOMP-Lo	0.012	0.018	0.013	.....	0.052	0.008	0.027	0.055	0.000	0.000	0.000
ECOMP-Mi	0.039	0.142	0.102	.....	0.211	0.055	0.136	0.405	0.000	0.000	0.000
ECOMP-Hi	0.034	0.113	0.086	.....	0.141	0.089	0.186	0.385	0.000	0.000	0.000
TOTAL	1.0	1.0	1.0	.....	1.2	1.0	0.9	1.0	2.5	0.9	0.5

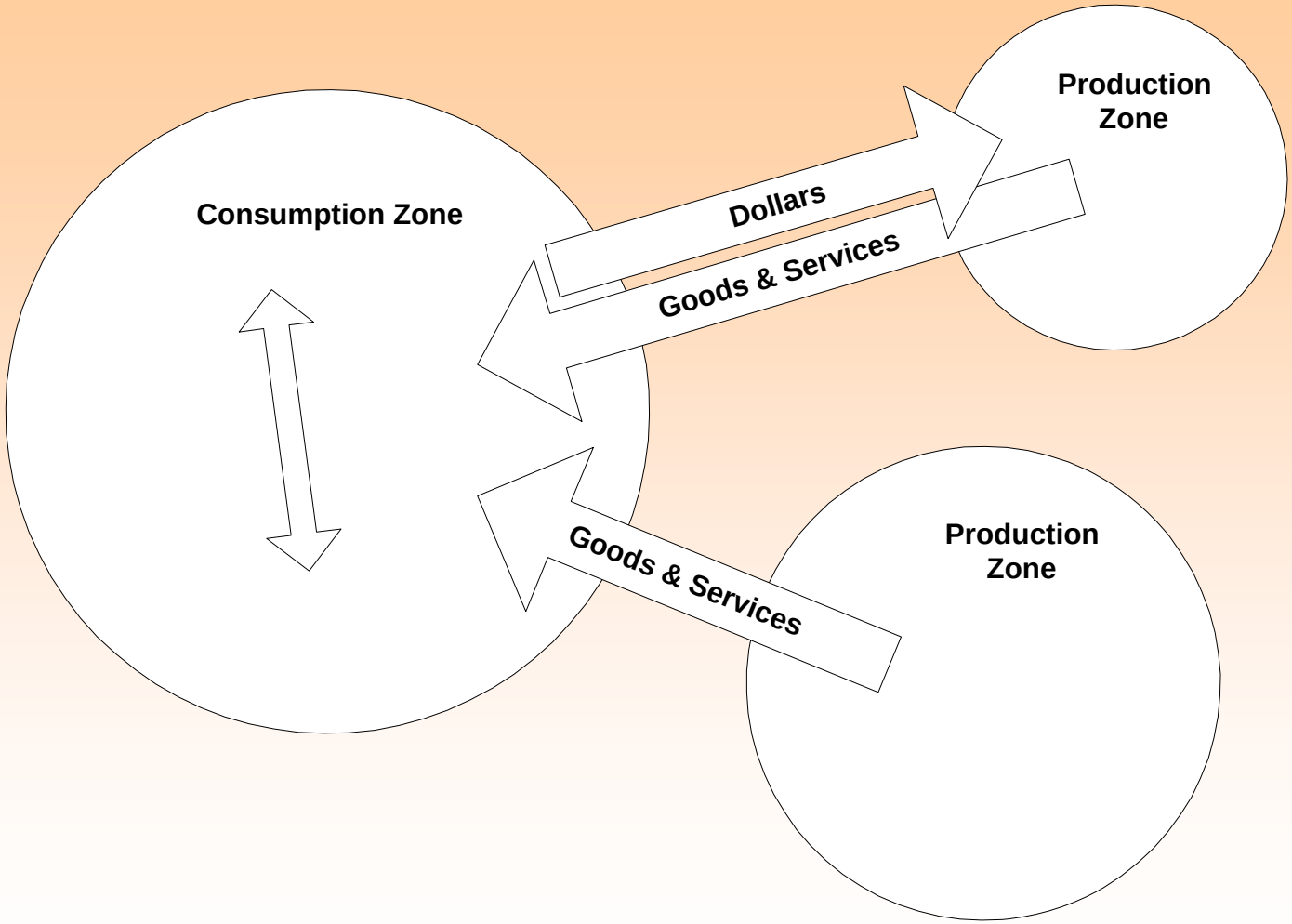
LOCATION MODEL



LOCATION MODEL

- Production & Consumption Relationships
- Generation of Induced Demand
- Location of Induced Production
  - Utility Function
  - Utility Scaling
  - MNL Distribution Function
- Equilibration of Demands & Prices

SPATIAL RELATIONSHIPS



Generation of Induced Demand

$$A_i^{mn} = min^{mn} + (max^{mn} - min^{mn}) * exp(-\delta^{mn} * C_i^n)$$

Where:

A_i^{mn} = production of **n** demanded per unit of **m** in zone **i**

min^{mn} = minimum **n** required per unit of **m**

max^{mn} = maximum **n** required per unit of **m**

δ^{mn} = elasticity of **m** with respect to cost of **n**

C_i^n = consumption cost or disutility for **n** in zone **i**

Location Utility Function

$$U_{ij}^{n} = \lambda^{n} * (p_j^{n} + h_j^{n}) + t_{ij}^{n}$$

Where:

U_{ij}^{n} = total disutility of sector **n** for production in **j** and consumption in **i**

p_j^{n} = price of sector **n** in production zone **j**

h_j^{n} = “shadow price” of **n** in zone **j**

t_{ij}^{n} = transport disutility between zones **i** and **j**

λ^{n} = price versus transport disutility scale for **n**

Location Utility Scaling

$$U_{ij}^{n} = U_{ij}^{n} / \min_j(U_{ij}^{n})$$

Where:

U_{ij}^{n} = scaled disutility for location of induced production

MNL Distribution Function

$$X_{ij}^{n} = D_i^{n} * [A_j^{n} * \exp(-\beta^{n} * U_{ij}^{n}) \,/\, \Sigma_j A_j^{n} * \exp(-\beta^{n} * U_{ij}^{n})]$$

Where:

X_{ij}^{n} = production of **n** in zone **j** induced by activity in zone **i**

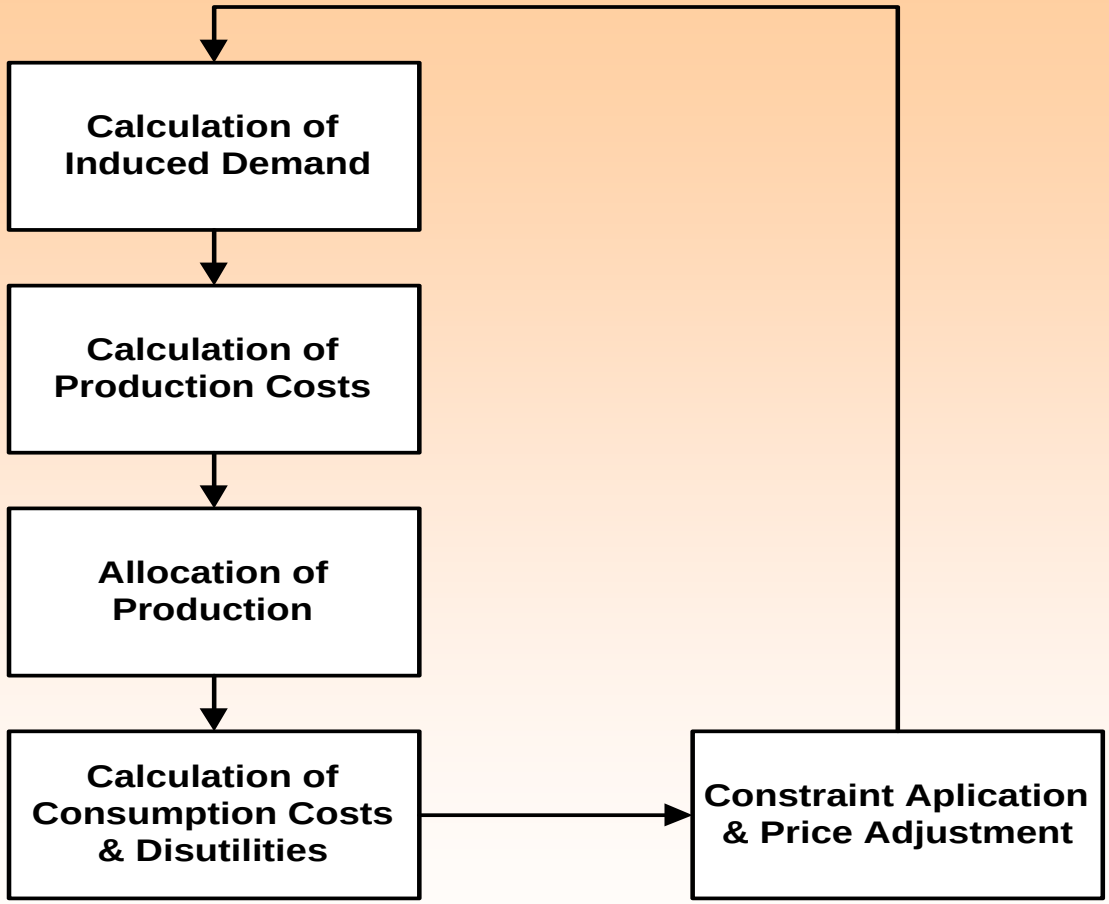
D_i^{n} = total demand for **n** in zone **i**

A_j^{n} = attractor term for the production of **n** in zone **j**

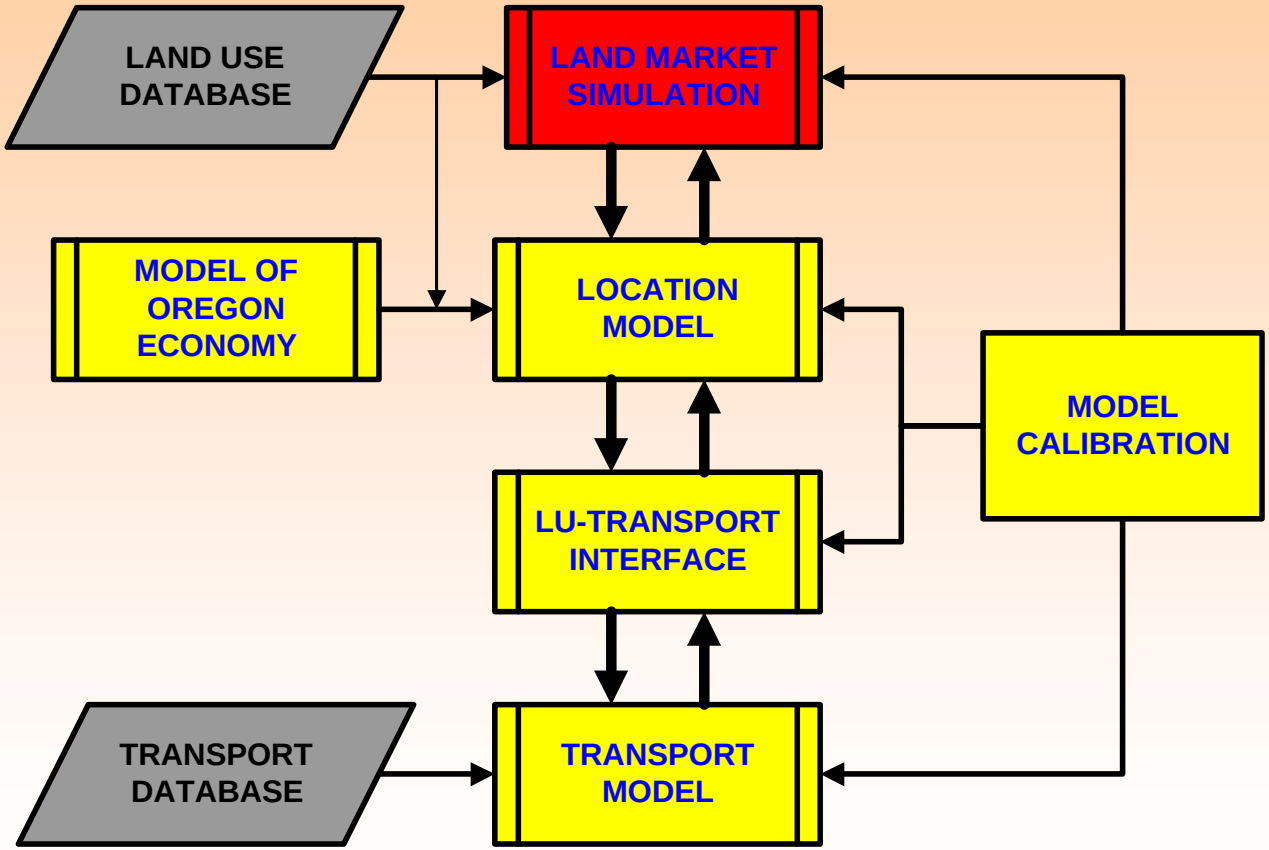
U_{ij}^{n} = scaled location disutility

β^{n} = dispersion parameter of the MNL model

Demand-Price Equilibration



LAND MARKET SIMULATION



Land Market Simulation

- Alternative Segmentation Schemes
- Demand Function Form
- Sample Consumption & Price Data
- Derived Functions

Options for Land Segmentation

OPTION 1	OPTION 2	OPTION 3	OPTION 4
Urban	Urban Industrial/ Commercial	Urban Industrial	Industrial
Rural Industrial	Urban Residential	Urban Commercial	Commercial
Rural Commercial	Rural Industrial/ Commercial	Urban SF Residential	SF Residential
Rural Residential	Rural Residential	Urban MF Residential	MF Residential
		Rural Industrial	
		Rural Commercial	
		Rural Residential	

Generation of Induced Demand

$$A_i^{mn} = min^{mn} + (max^{mn} - min^{mn}) * exp(-\delta^{mn} * C_i^n)$$

Where:

A_i^{mn} = production of **n** demanded per unit of **m** in zone **i**

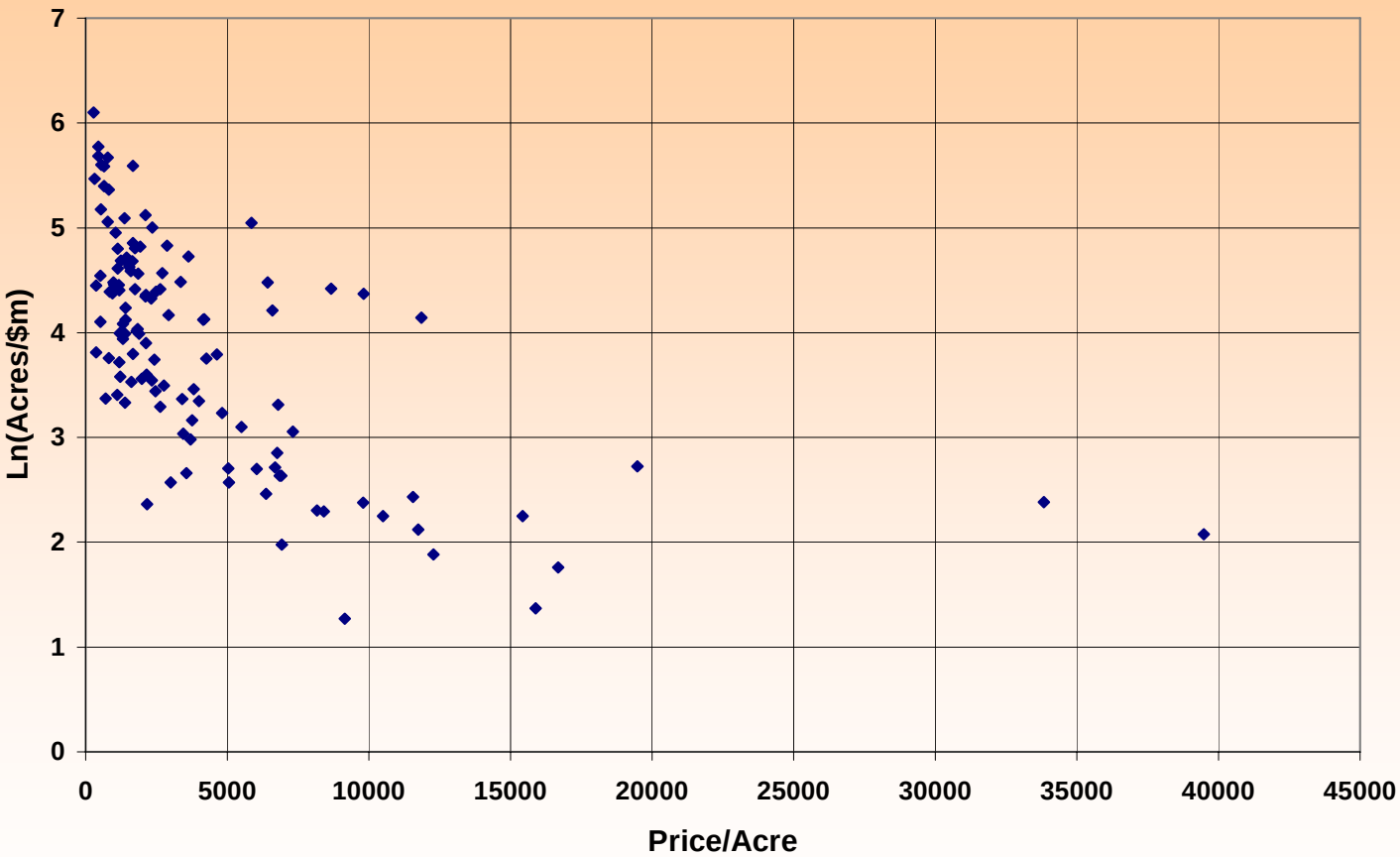
min^{mn} = minimum **n** required per unit of **m**

max^{mn} = maximum **n** required per unit of **m**

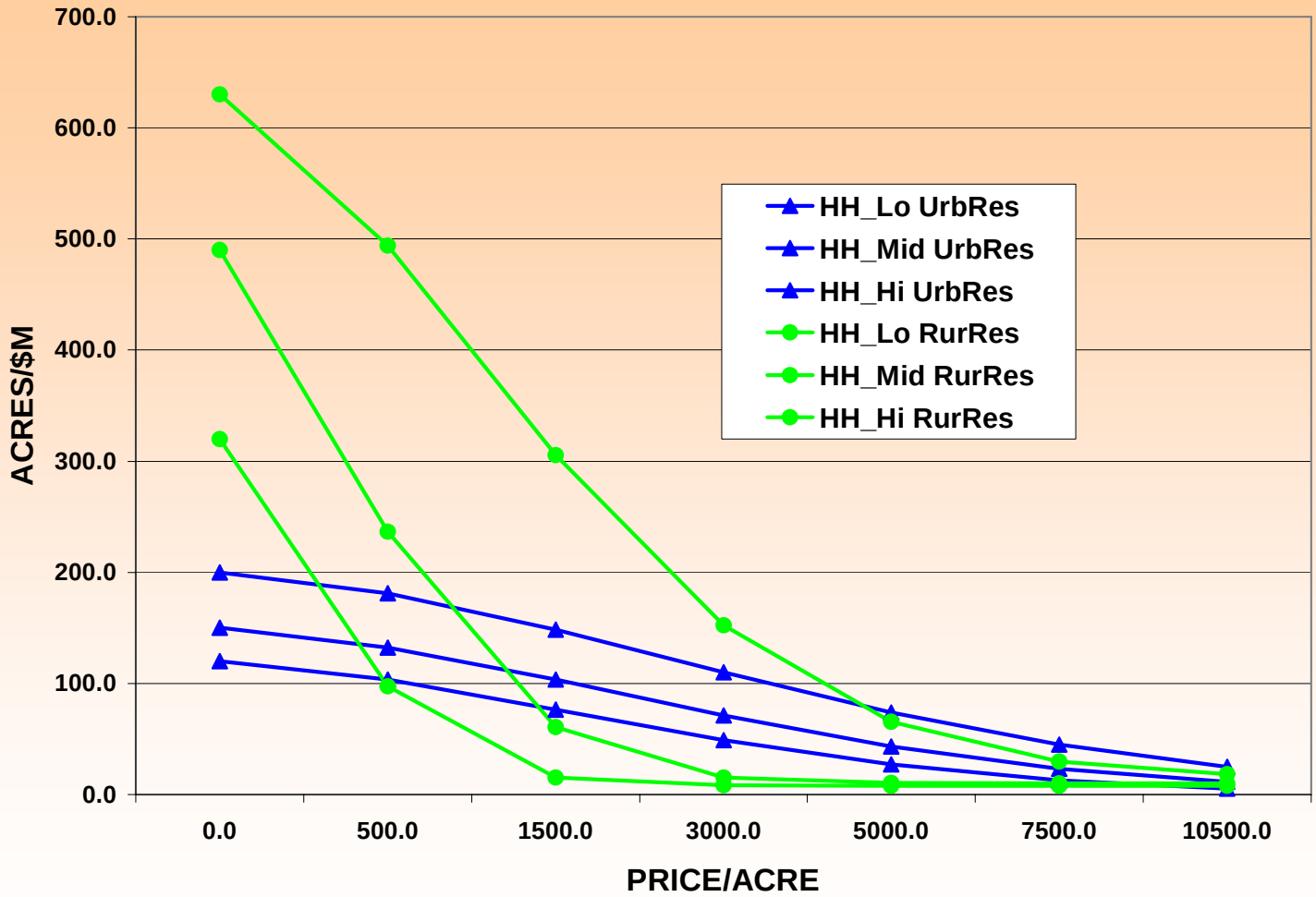
δ^{mn} = elasticity of **m** with respect to cost of **n**

C_i^n = consumption cost or disutility for **n** in zone **i**

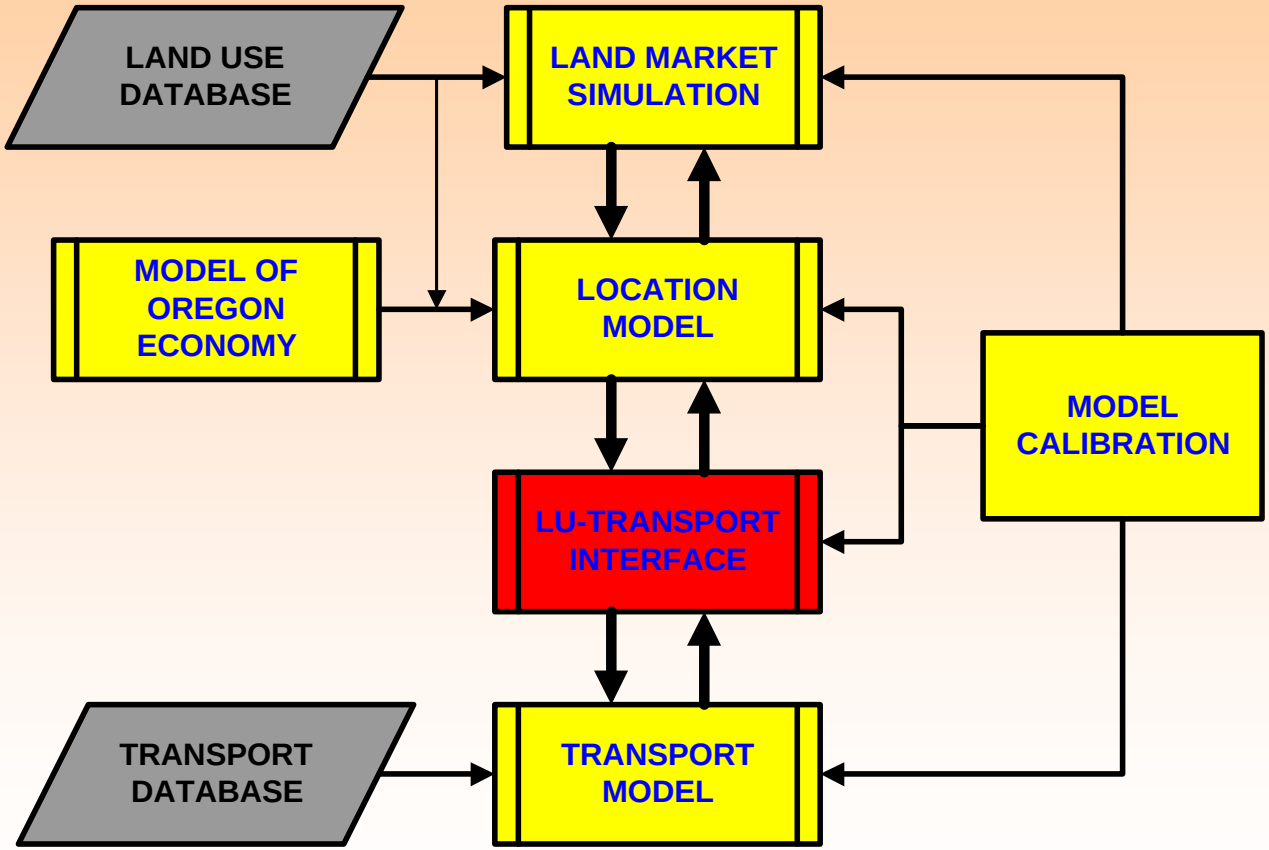
Sample Demand-Price Data



Residential Land Demand



LU-TRANSPORT INTERFACE



LU-Transport Interface

- Maps SE Sectors to Transport Categories
- Specifies Units Conversions
  - Dollars to Households for Passenger
  - Dollars to Tons for Freight
- Defines Directionality
  - Two-way for Passenger
  - One-way for Freight
- Defines Temporal Relationship

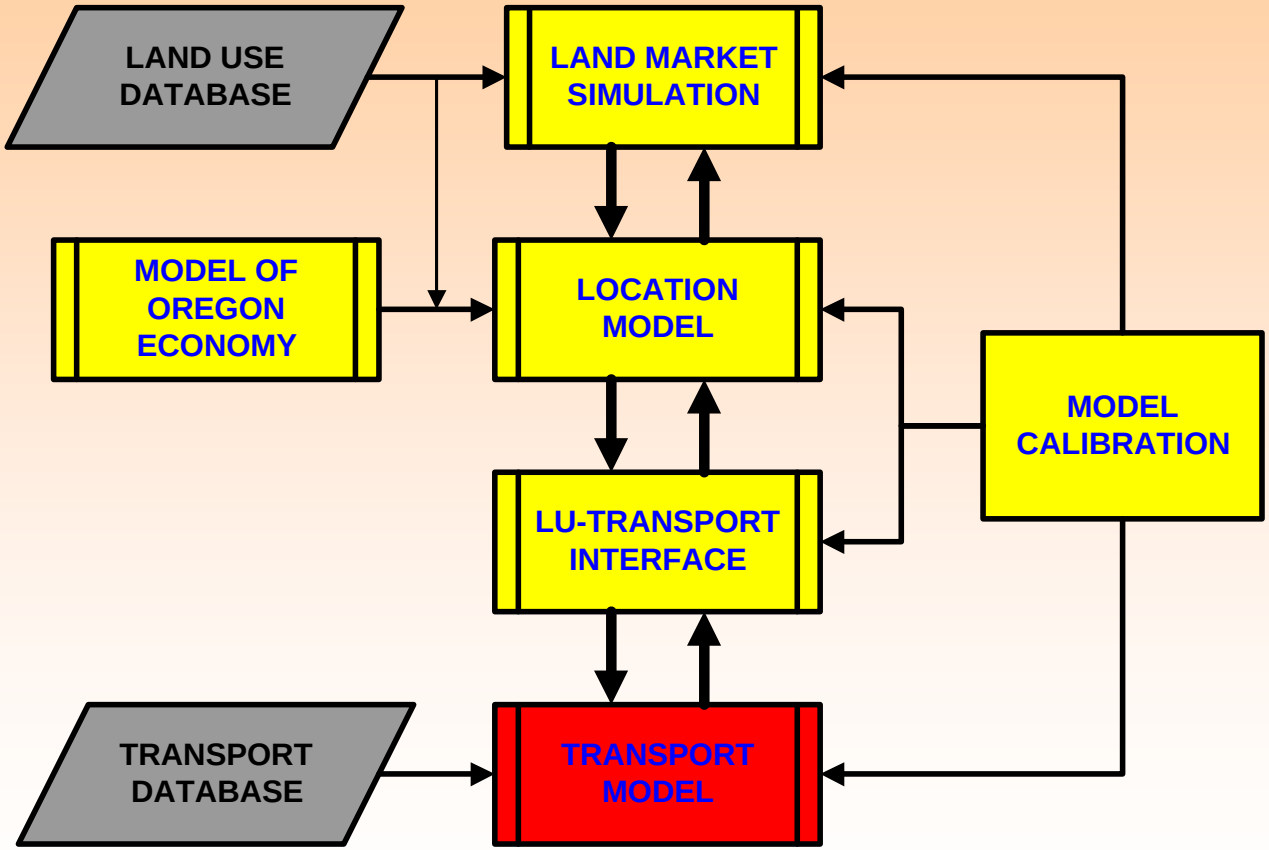
ECONOMIC FLOWS (Z-Z)

CONSUMING SECTORS	PRODUCING SECTORS (Note Re-Orientation)																	
	Industries												Households			Land		
	AGFF	CONS	OMFG	WOOD	PRNT	TECH	TCPU	WLSE	RETL	FIRE	SERV	GOVT	HH_Lo	HH_Mi	HH_Hi	IND	COM	UrbRES	RurRES
Industries																			
AGFF	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f				
CONS	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e			
OMFG	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e			
WOOD	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e			
PRNT	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e			
TECH	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e	e		
TCPU	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e	e		
WLSE	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e	e		
RETL	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e		
FIRE	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e		
SERV	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e		
GOVT	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e		
Households																			
HH_Lo	f	f	f	f	f	f	f	f	f	f	f	f						e	e
HH_Mi	f	f	f	f	f	f	f	f	f	f	f	f						e	e
HH_Hi	f	f	f	f	f	f	f	f	f	f	f	f						e	e

TRANSPORT FLOWS (Z-Z)

Transport Categories	Industries												Households				MODES	
	AGFF	CONS	OMFG	WOOD	PRNT	TECH	TCPU	WLSE	RETL	FIRE	SERV	GOVT	HHIncLo	HHIncMi	HHIncHi		Passeng	Freight
CmuteLo													1				1	
CmuteMid														2		→	1	
CmuteHi															3		1	
Recreation	4								4		4	4				→	1	
HBOther									5	5	5	5					1	
NHBOther									6	6	6	6				→	1	
NHBWork	7	7	7	7	7	7	7	7	7	7	7	7					1	
VisitorBus																→	1	
VisitorOth																	1	
Freight	8	8	8	8	8	8	8	8								→		2

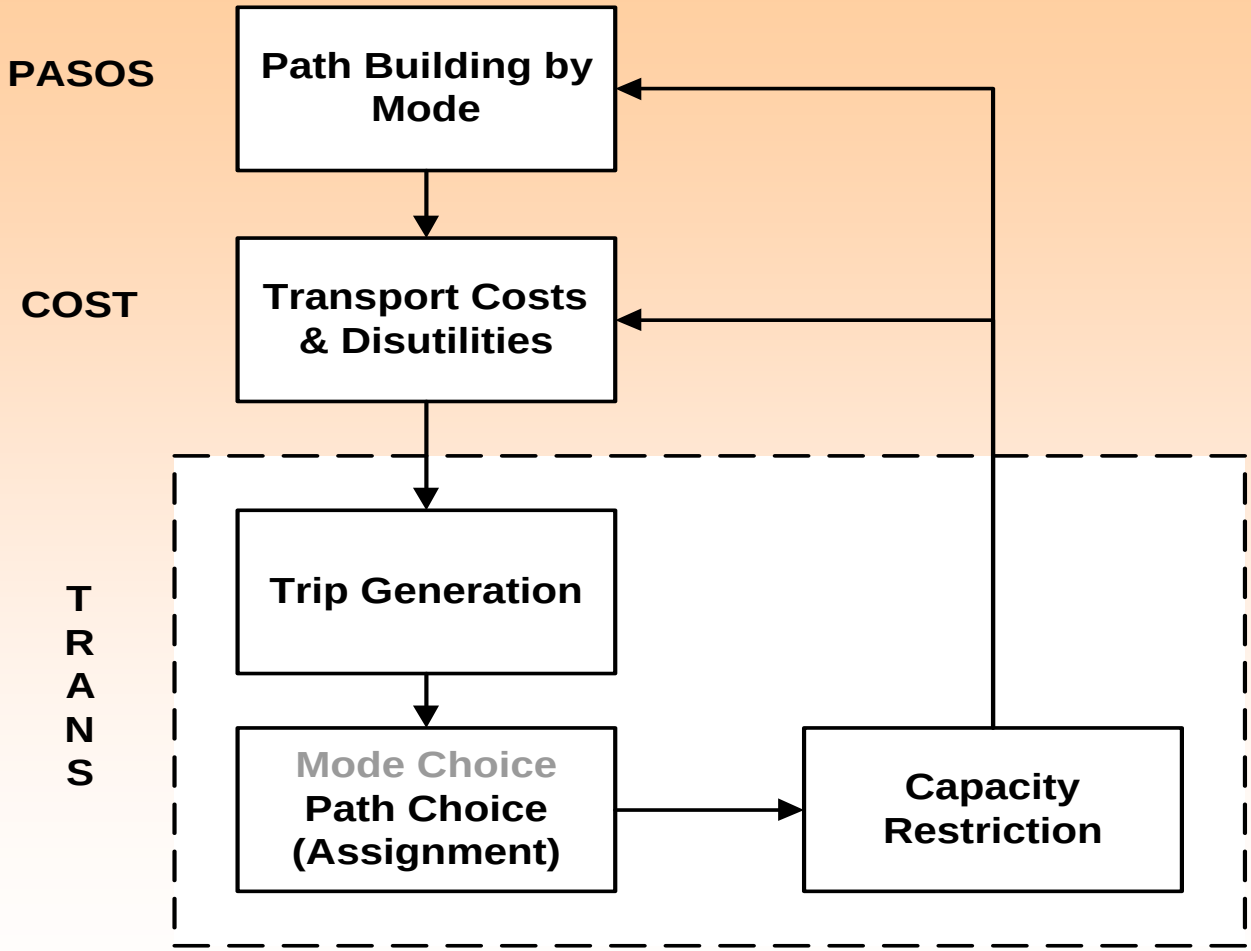
TRANSPORT MODEL



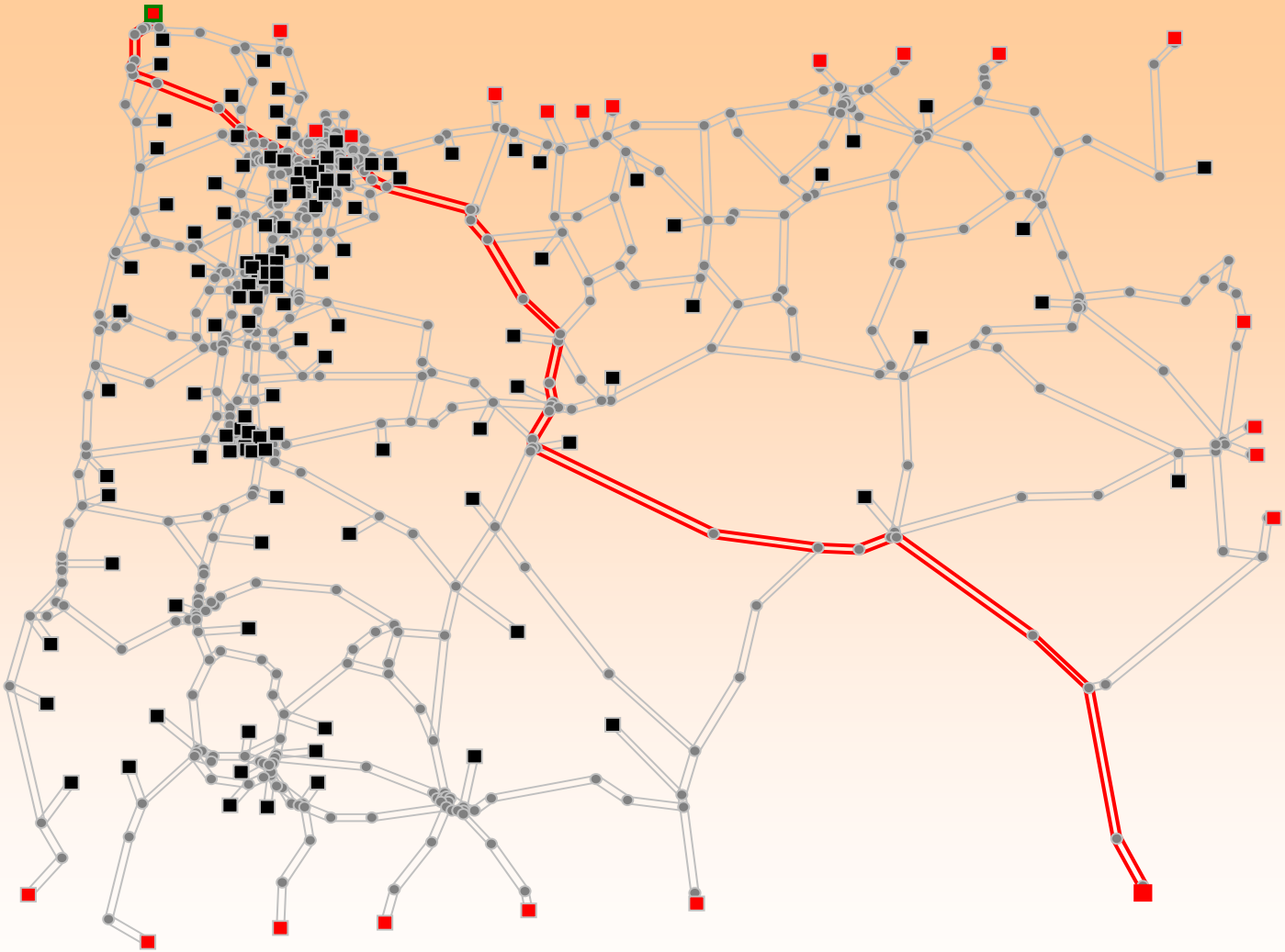
TRANSPORT MODEL

- General Structure
- Generalized Disutility with Scaling
- Prototype Simplifications
- Sample Path Selections
- Trip Generation Functions
- Capacity Restriction Functions

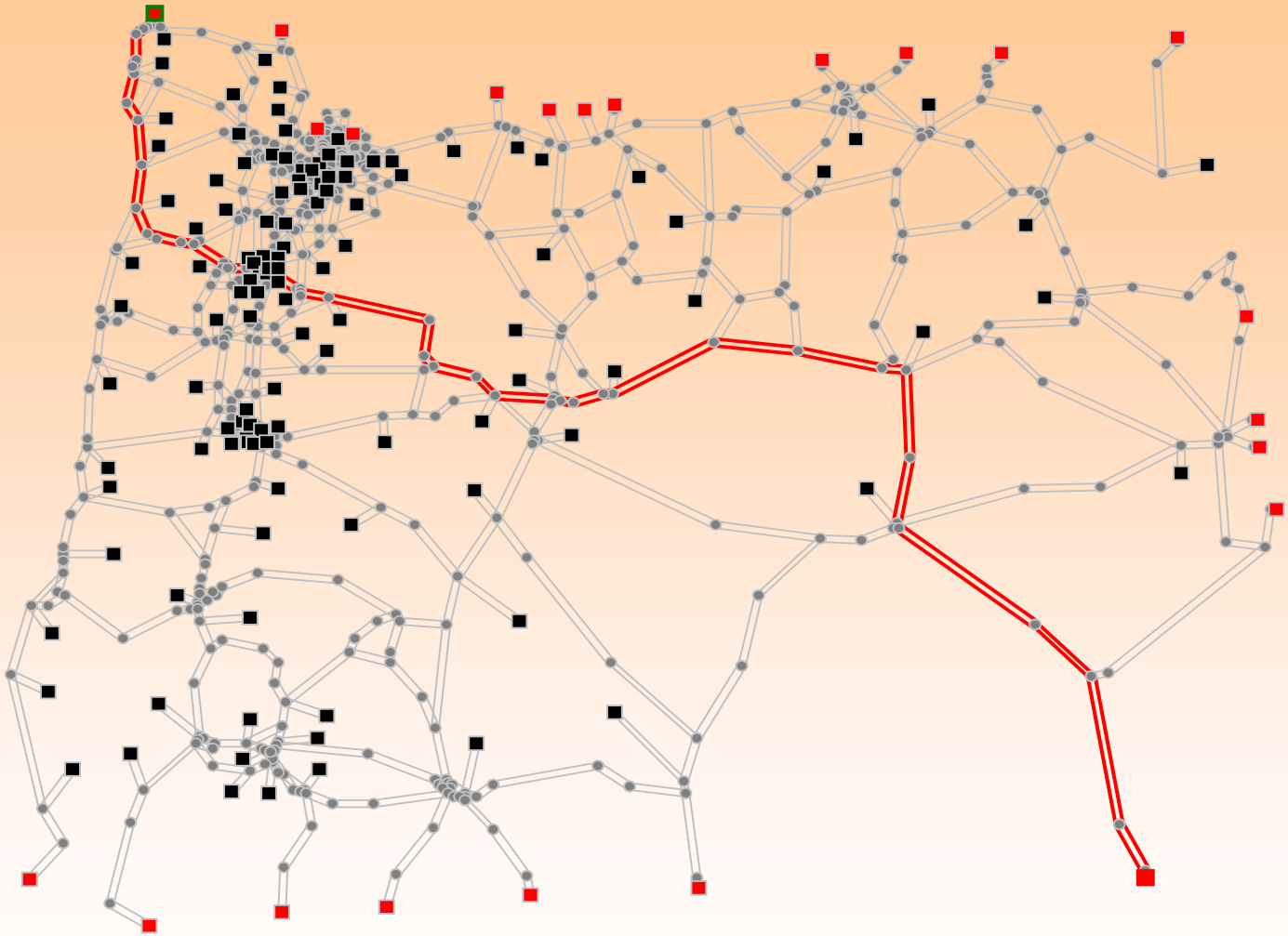
Transport Model Structure



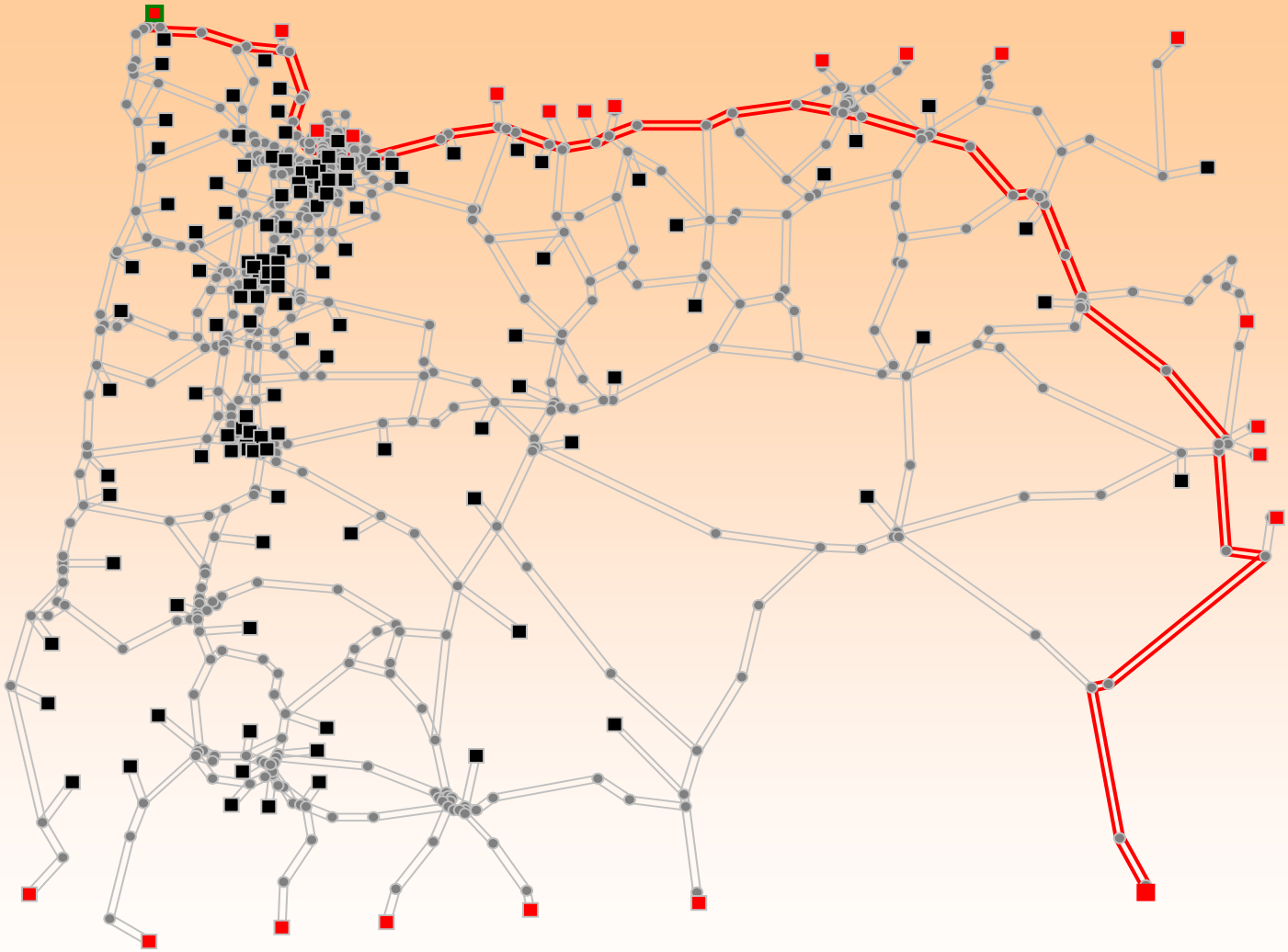
ZONE 1 TO ZONE 19 PATH 1: MILES = 556.7; HOURS = 10.7



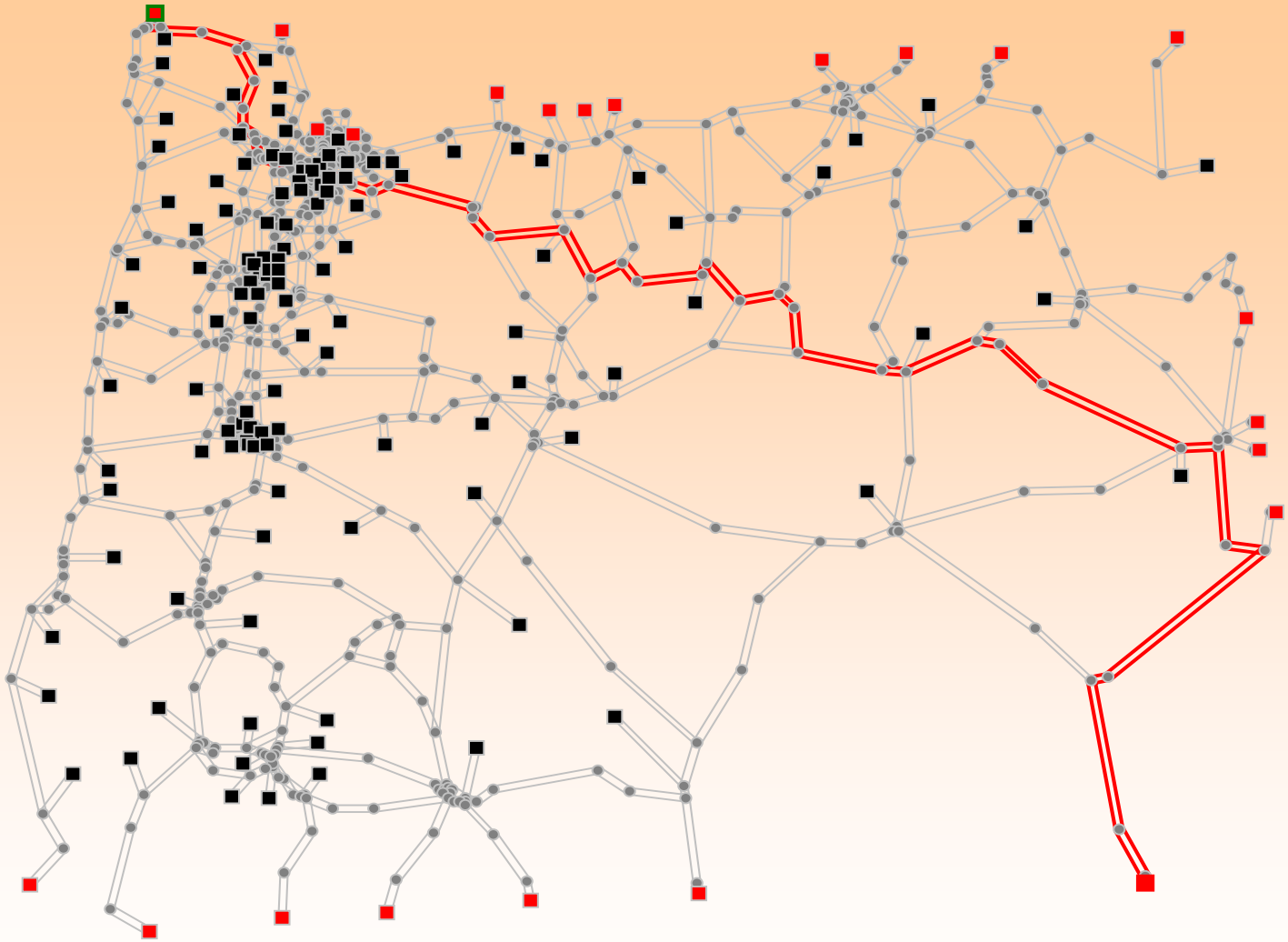
ZONE 1 TO ZONE 19 PATH 2: MILES = 611.8; HOURS = 11.7



ZONE 1 TO ZONE 19 PATH 3: MILES = 683.2; HOURS = 12.1



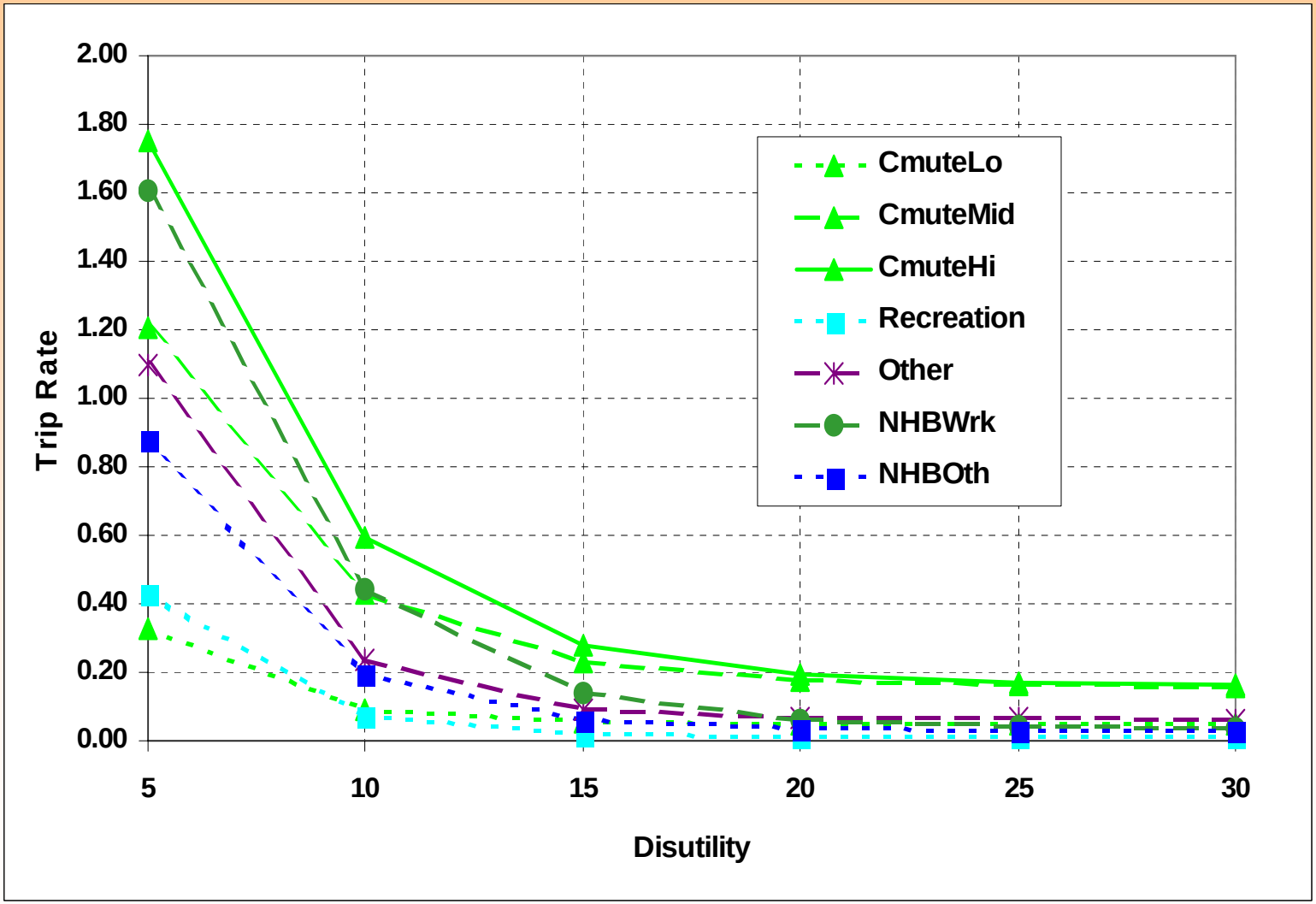
ZONE 1 TO ZONE 19, PATH 4: MILES = 693.1, HOURS = 13.5



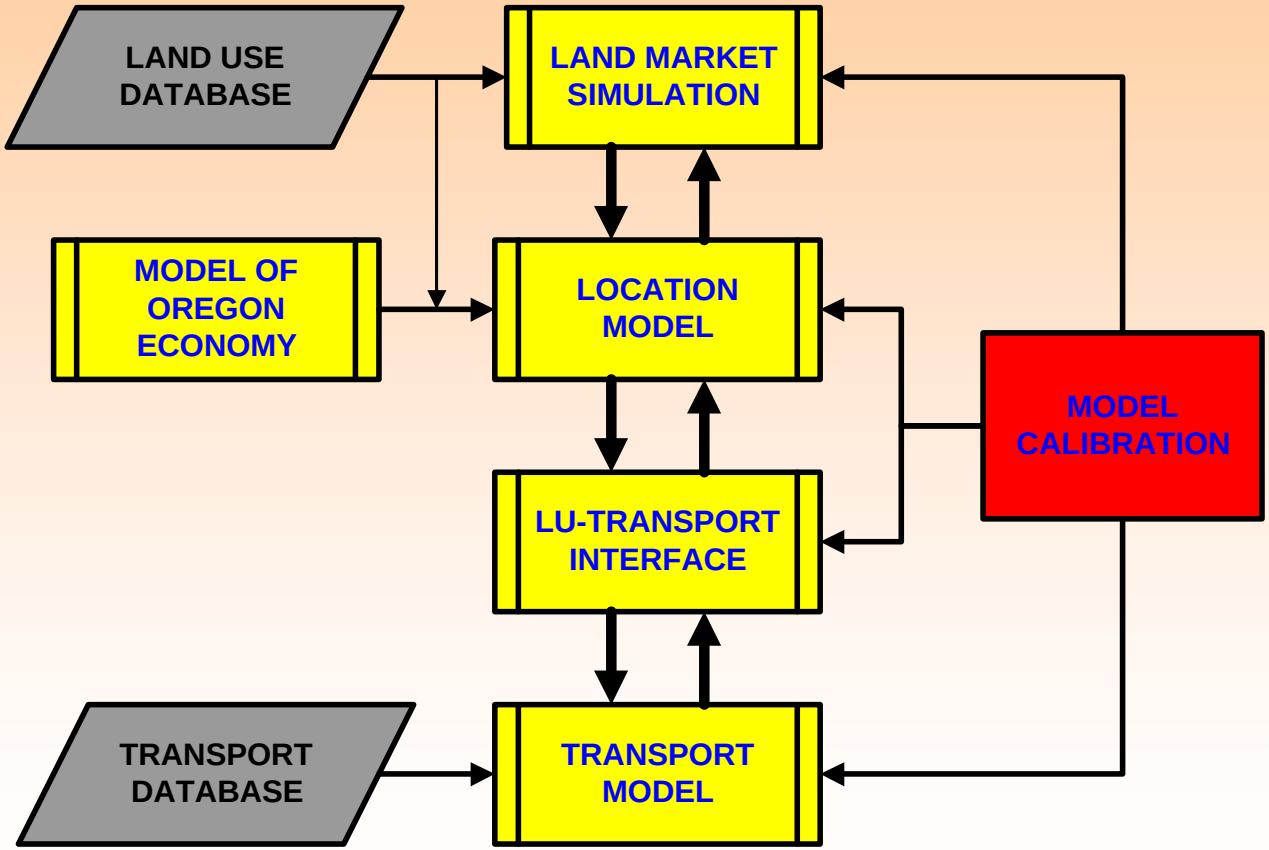
Path Summary: Zone 1 to 19

PATH #	MILES	HOURS	COST	GenCost HH_Lo	GenCost HH_Hi
1	556.7	10.7	$94.42	161.9	296.9
2	611.8	11.7	$103.77	177.5	325.0
3	683.2	12.1	$115.80	189.0	335.3
4	693.1	13.5	$117.58	202.7	372.8

Trip Generation Functions



MODEL CALIBRATION



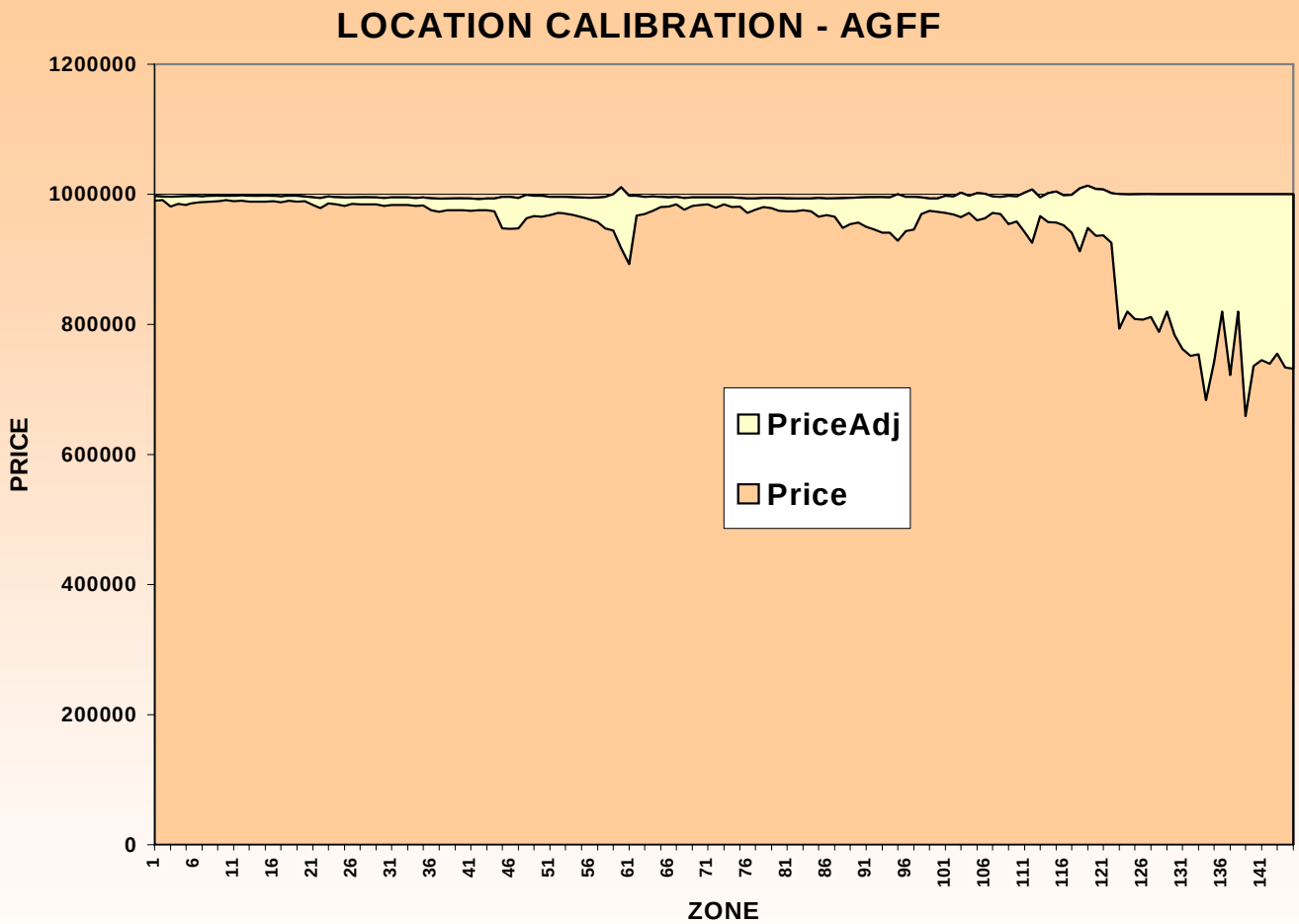
MODEL CALIBRATION

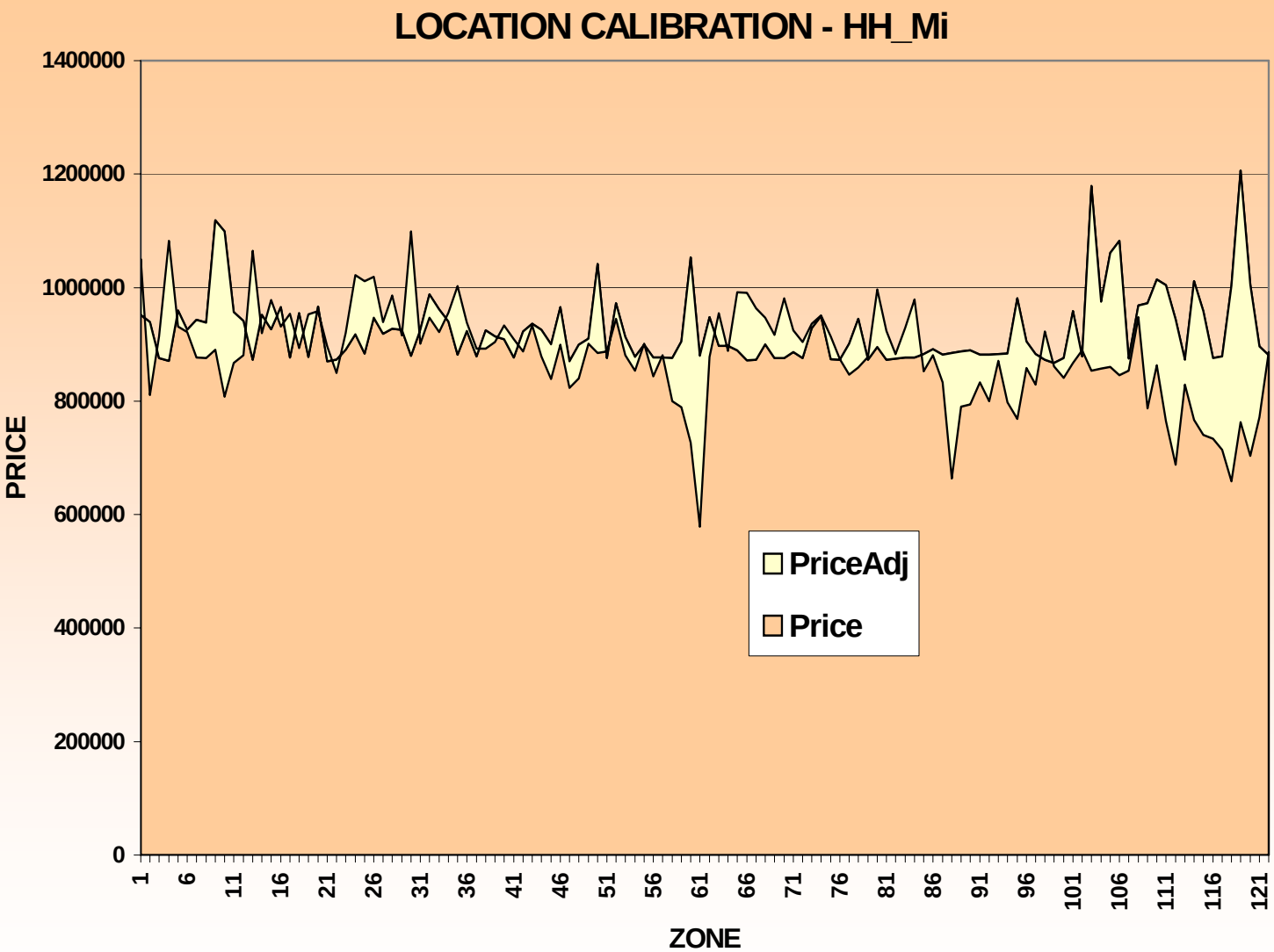
- Base Year Location Calibration
  - Zonal Production Constraints
  - Zonal Shadow Prices
  - Adjusted vs Observed Prices
- Transport Calibration
  - Estimated vs Observed Trips
  - Estimated vs Observed Trip Lengths
- Temporal Calibration

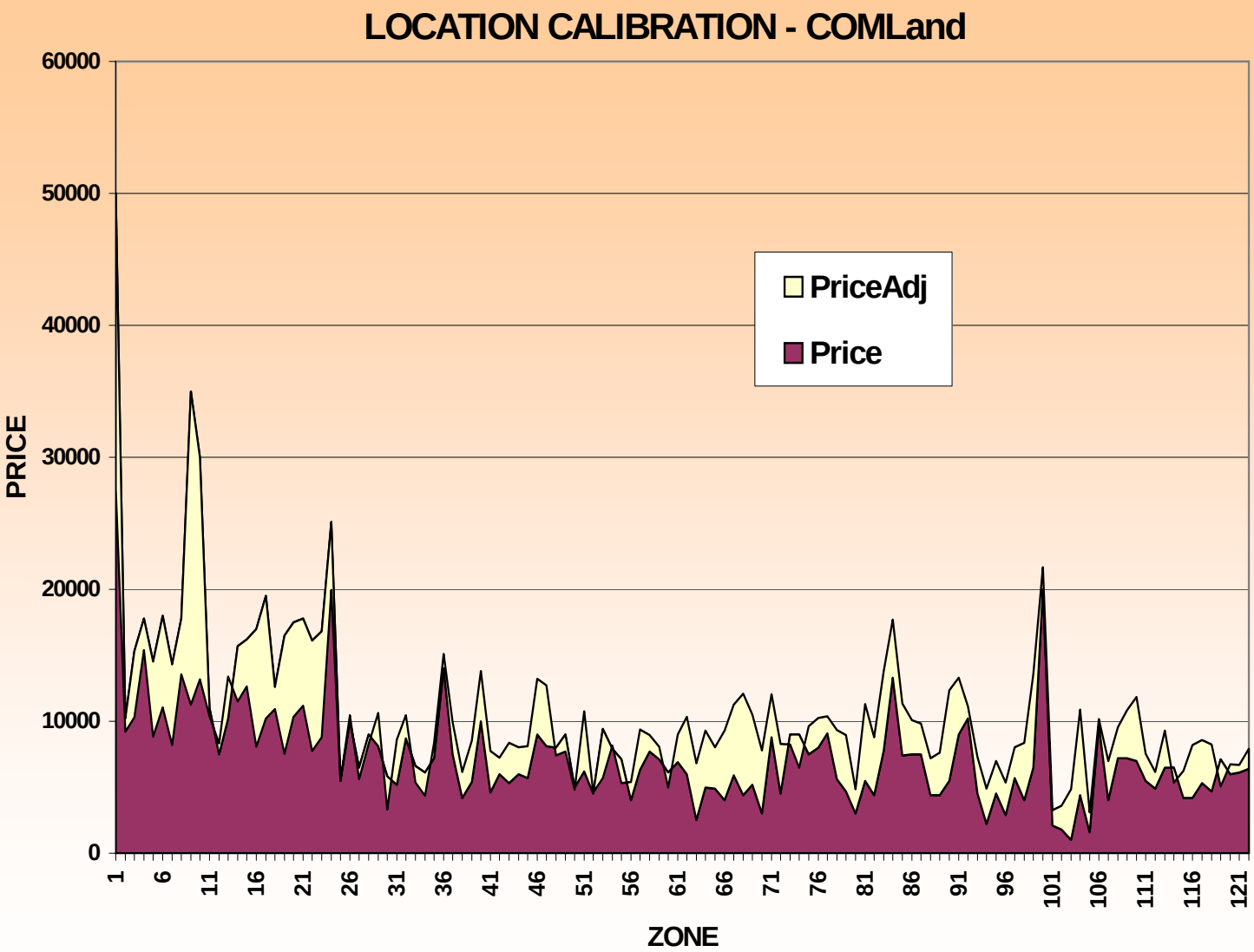
Zonal Production Constraints?

SUMMARY OF BASE YEAR EMPLOYMENT AND PRODUCTION (1990)

SECTOR	EMPLOYEES	ANNUAL PRODUCTION($m)	ANNUAL PROD/EMPL ($m)
AGFF	68,296	$4,458.2	$0.06528
CONS	68,311	$9,122.7	$0.13355
OMFG	71,171	$11,048.8	$0.15524
WOOD	78,202	$11,071.8	$0.14158
PRNT	14,704	$1,280.8	$0.08710
TECH	64,580	$8,169.3	$0.12650
TCPU	91,531	$9,672.2	$0.10567
WHSL	75,780	$4,311.6	$0.05690
RETL	248,581	$9,581.5	$0.03854
FIRE	92,434	$12,961.2	$0.14022
SERV	298,689	$19,577.5	$0.06533
GOVT	236,172	$7,574.7	$0.03207


LOCATION CALIBRATION - AGFF
PRICE
1200000
1000000
800000
600000
400000
200000
0
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81
86
91
96
101
106
111
116
121
126
131
136
141
ZONE
PriceAdj
Price

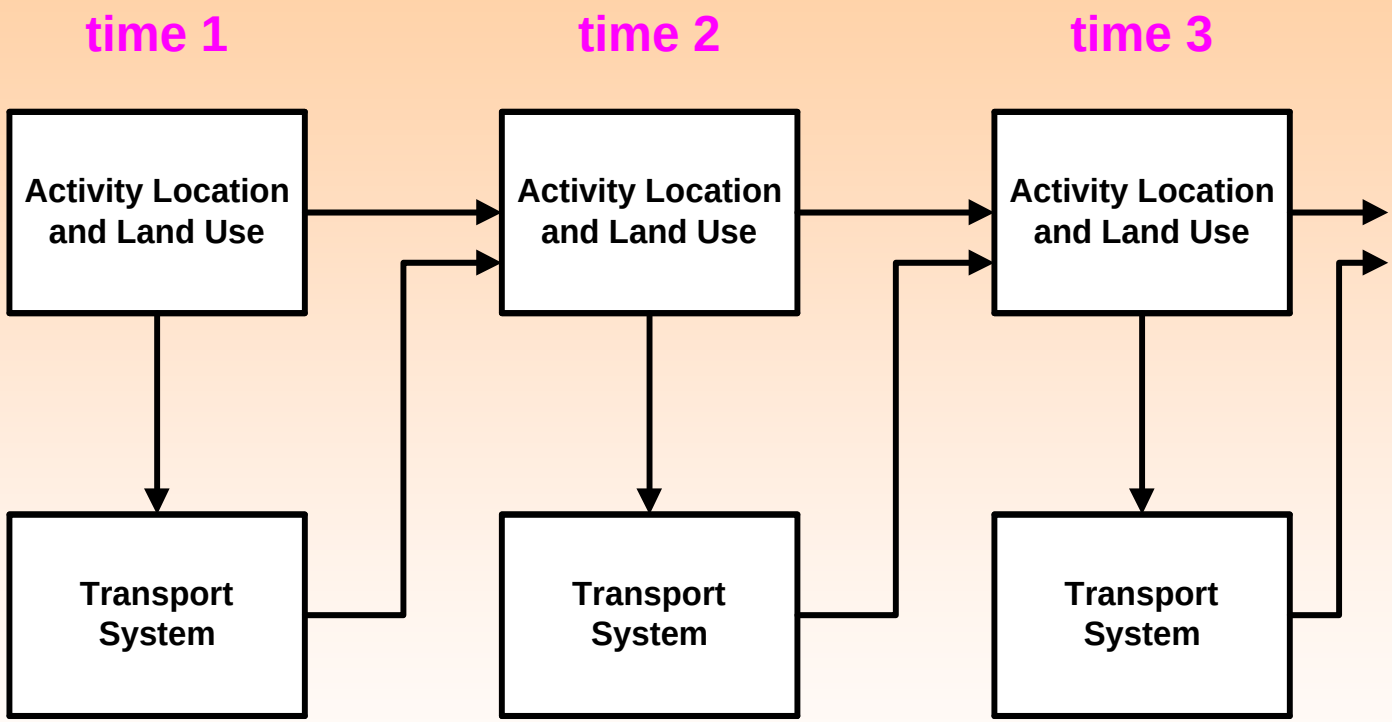

LOCATION CALIBRATION - HH_Mi
PRICE
1400000
1200000
1000000
800000
600000
400000
200000
0
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81
86
91
96
101
106
111
116
121
ZONE
PriceAdj
Price


LOCATION CALIBRATION - COMLand
60000
50000
40000
30000
20000
10000
0
PRICE
PriceAdj
Price
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81
86
91
96
101
106
111
116
121
ZONE

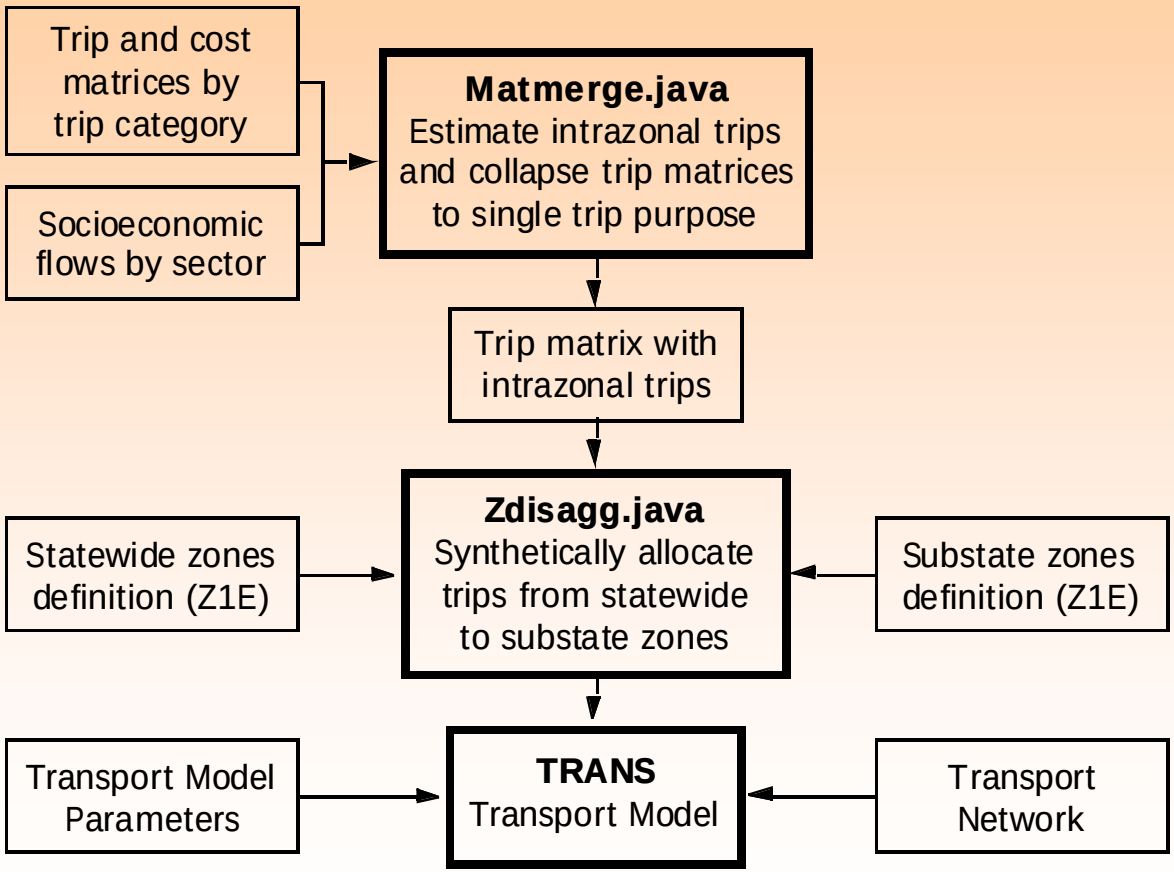
Transport Calibration

CATEGORY	NUMBER OF TRIPS		AVERAGE TRIP MILES	
	OBS	EST	OBS	EST
CmuteLo	129,531	128,938	12.89	14.23
CmuteMid	436,076	442,637	14.13	16.44
CmuteHi	210,485	214,375	15.71	17.70
Recreation	457,644	449,998	17.75	25.14
HBOther	1,577,152	1,583,381	16.44	21.42
NHBWrk	433,584	441,334	15.53	20.52
NHBOth	768,171	773,579	18.10	26.73
TOTAL	4,012,643	4,034,242	16.41	21.78

TEMPORAL DYNAMICS



Substate Model Structure



"The work plan is exciting and excellent, but I think you're crazy to think you'll ever pull this off in the time you've allotted for it…"

Michael Wegener, 12 June 1996