

Infill and the microstructure of urban expansion



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Presentations and papers available at
<http://www.williams.edu/Economics/UrbanGrowth/HomePage.htm>

Introduction

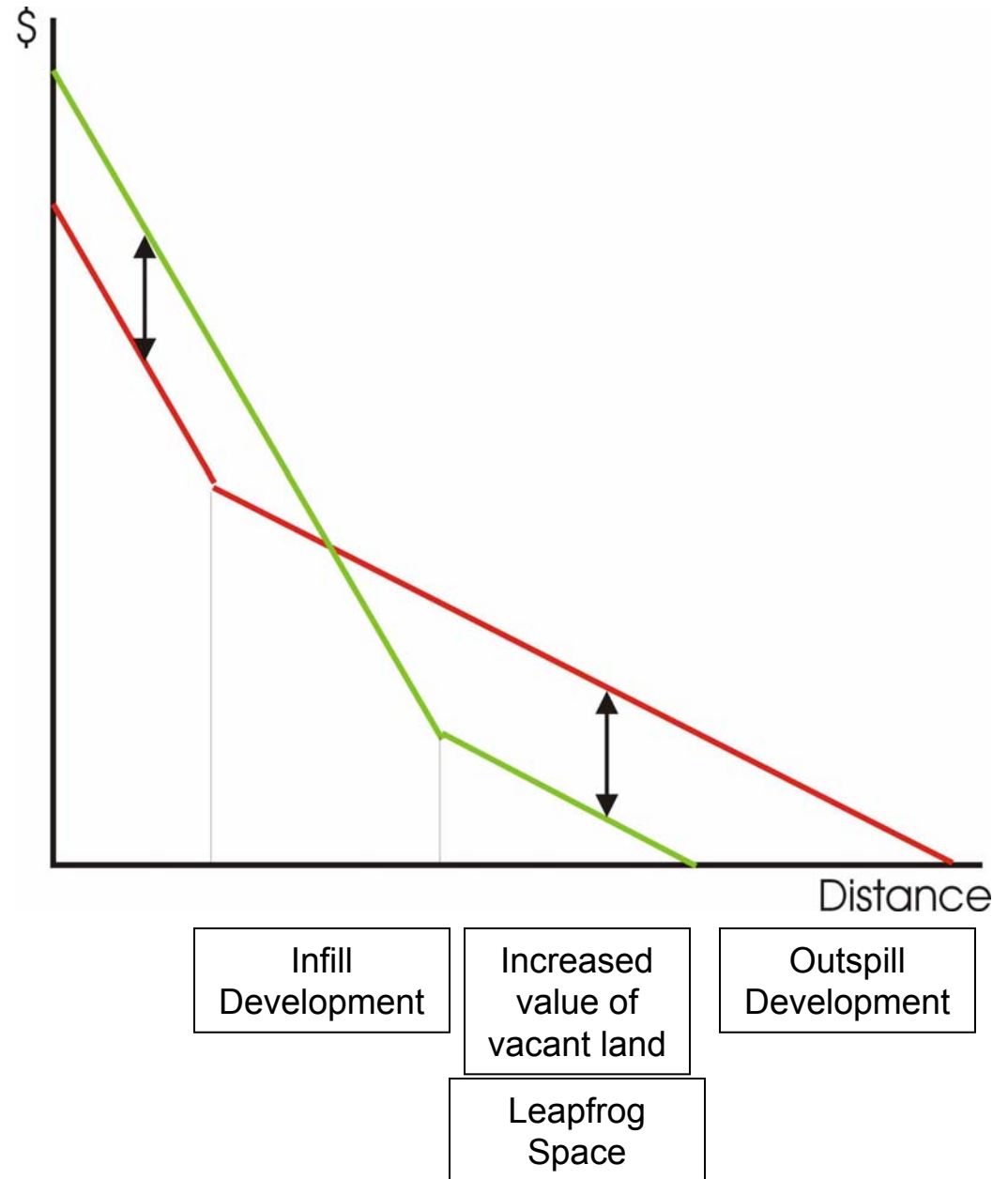
- Expanding urban land use
 - Global phenomenon
 - Linked to economic development?
- Policy concerns
 - Infrastructure provision
 - Congestion and mobile-source pollution
 - Employment decentralization and job access
 - Open space access externality
 - Should policies encourage the “compact” city?
- Expansion is complex with rich microstructure
 - Interior open spaces
 - Infill development
 - Peripheral or “outspill” development
- Relation to more intensive development
 - Building up rather than building out
 - Difficult to measure on global scale

Vacant Land in Urban Areas

- Preserved as public good or for public purposes
 - Increased land values may not induce infill development
 - Possibility of invasion by squatters displaced from other locations when land values increase?
- Land is not homogeneous – differential cost to develop
 - Increased land value will generate development of marginal ‘difficult’ parcels
- Idiosyncratic payoff/utility functions for private or commercial land owners
 - Family farm or centrally located estate
 - Open space functioning as a “consumption good”
 - Increased land values increase price, reduces consumption and generates infill
- Heterogeneous volatility increases value of vacant land in selected areas
 - How does this work?
 - Where (in the city) would this vacant land be located?

Vacant land as an option to develop

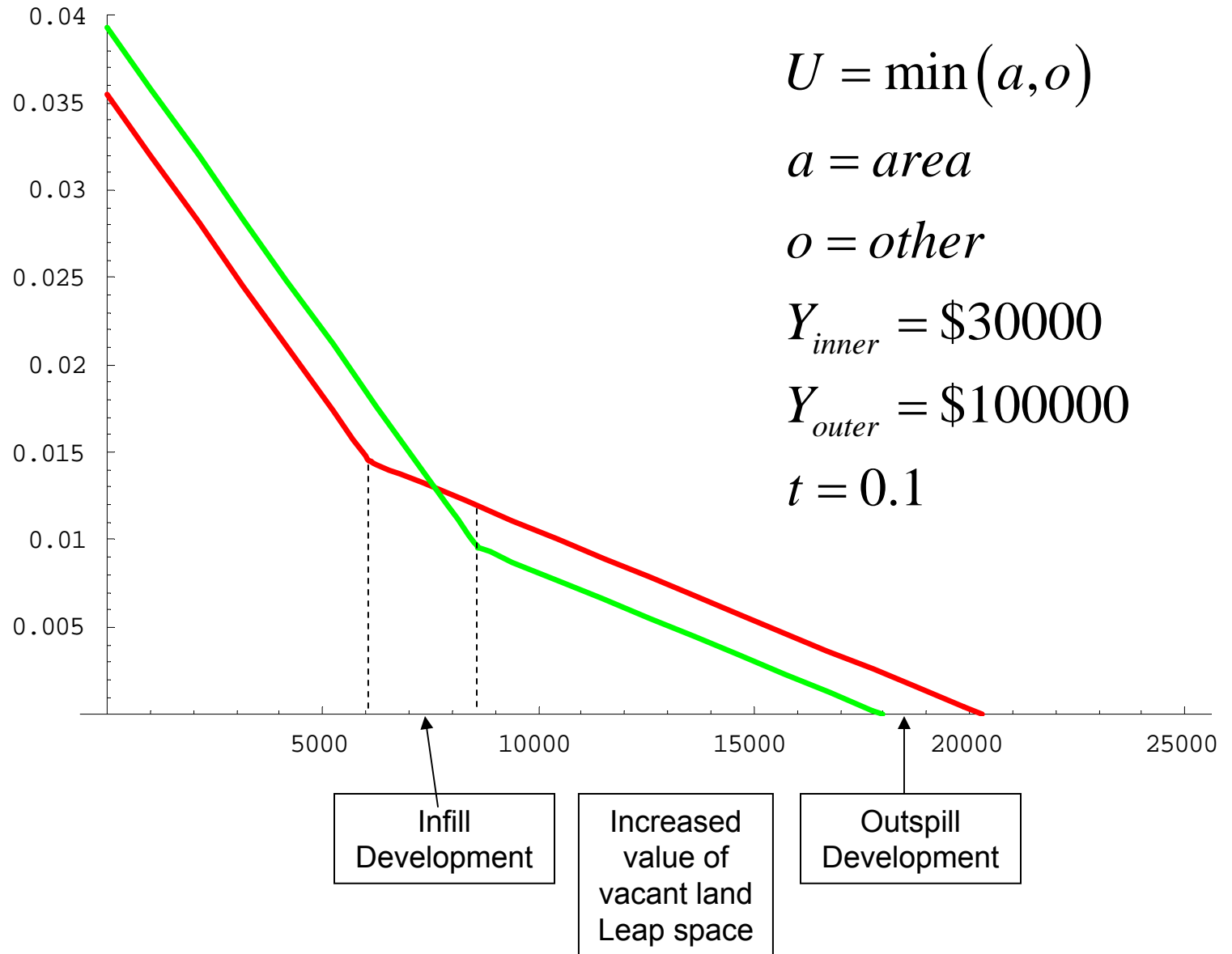
- Titman (1985)
- Simple model:
 - 2 agent types – steep and flat
 - 2 states of nature – green & red
 - Uncertainty in allocation of fixed population between agent types
 - Generates volatility in land values between states of nature
- Cunningham (2006)
 - 1 σ increase in price volatility reduces $P[\text{development}]$ by 11%



Heterogeneous volatility and infill

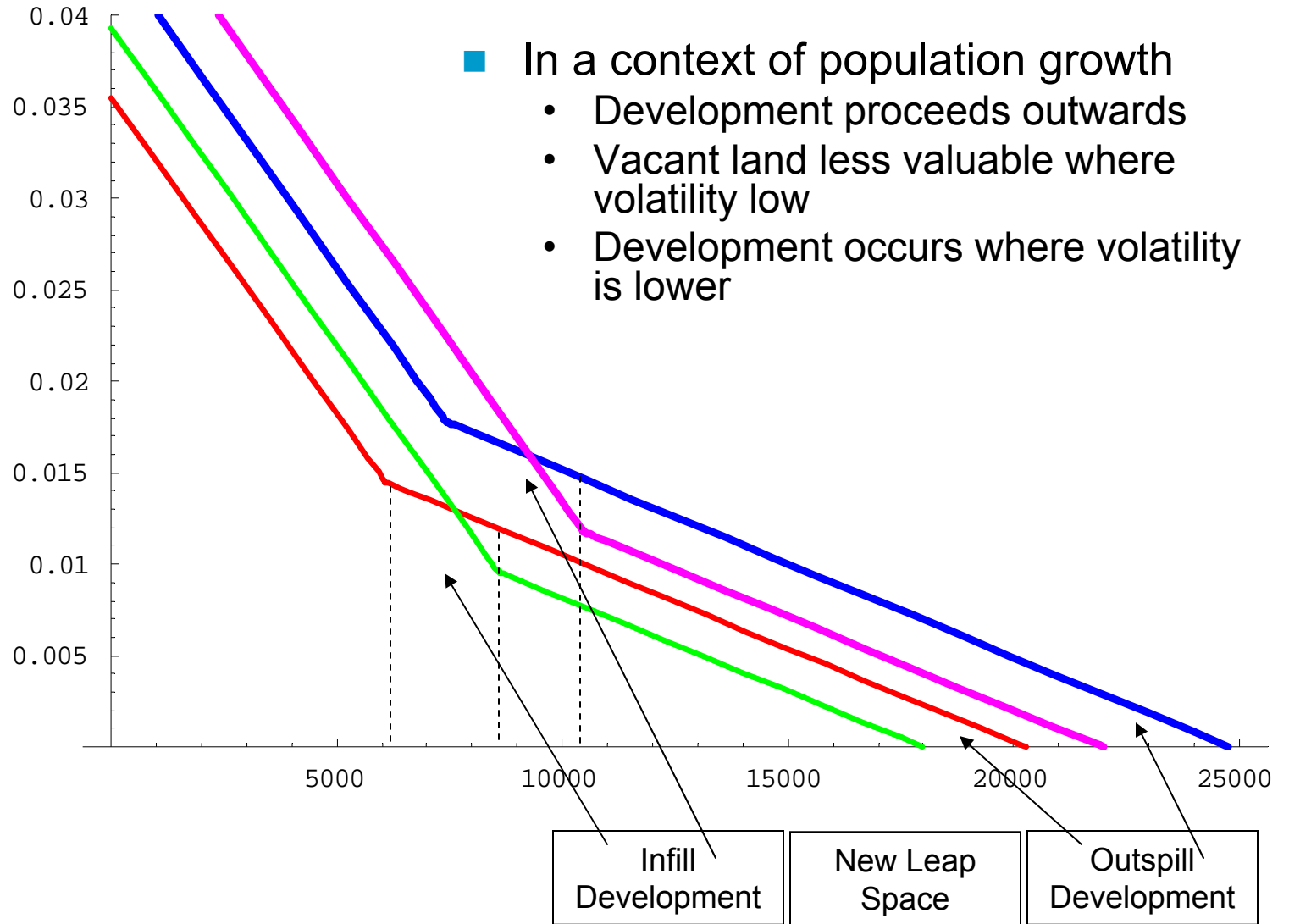
Numerical example

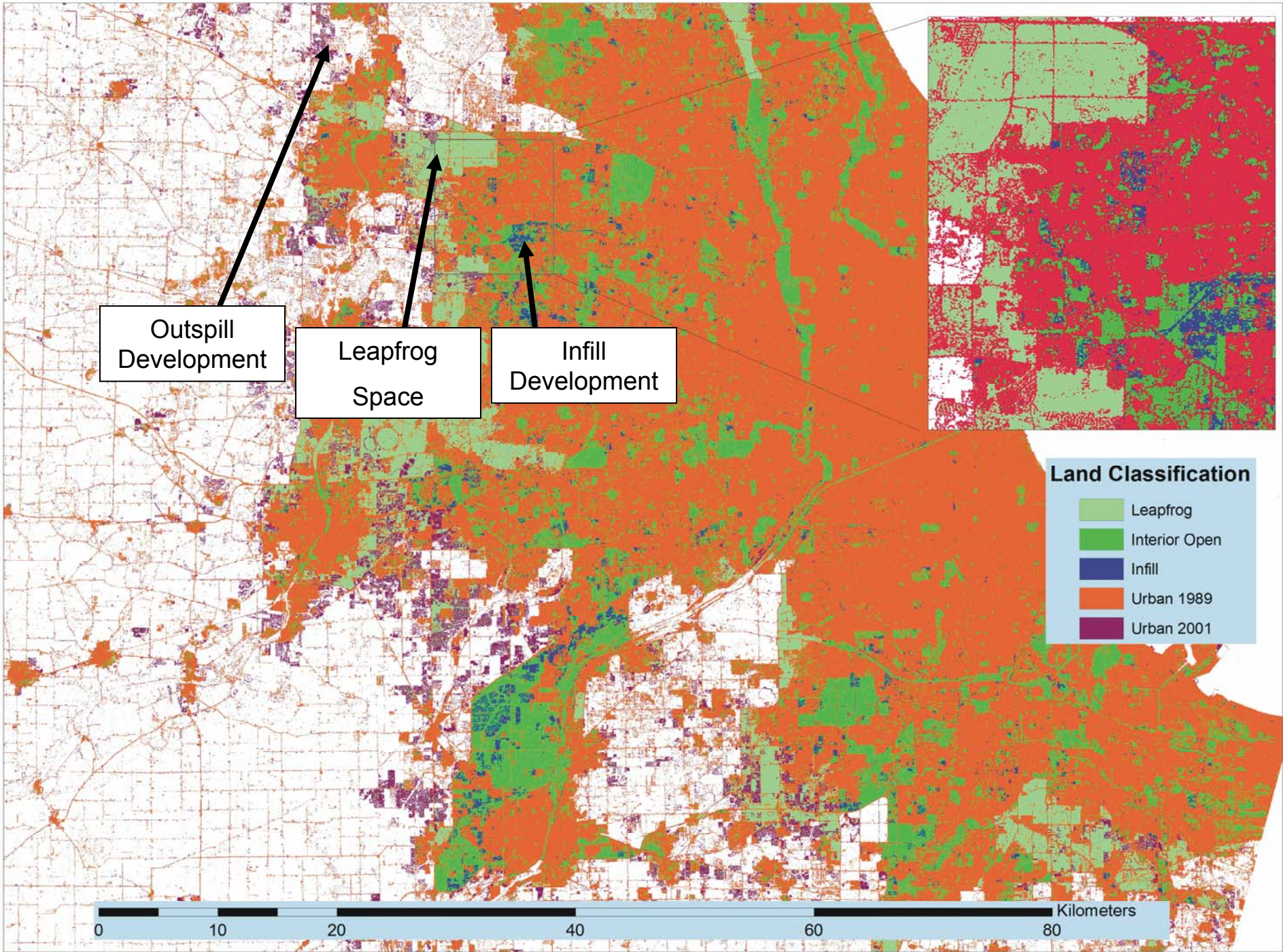
- Green: 8000 of each agent type
- Red: 4000 low income, 12000 high income



Heterogeneous volatility with growth

- Growth
 - Blue: 6000 low income, 18000 high
 - Violet: 12000 of each income class
- Growth leads to urban expansion
 - NOT only at the periphery

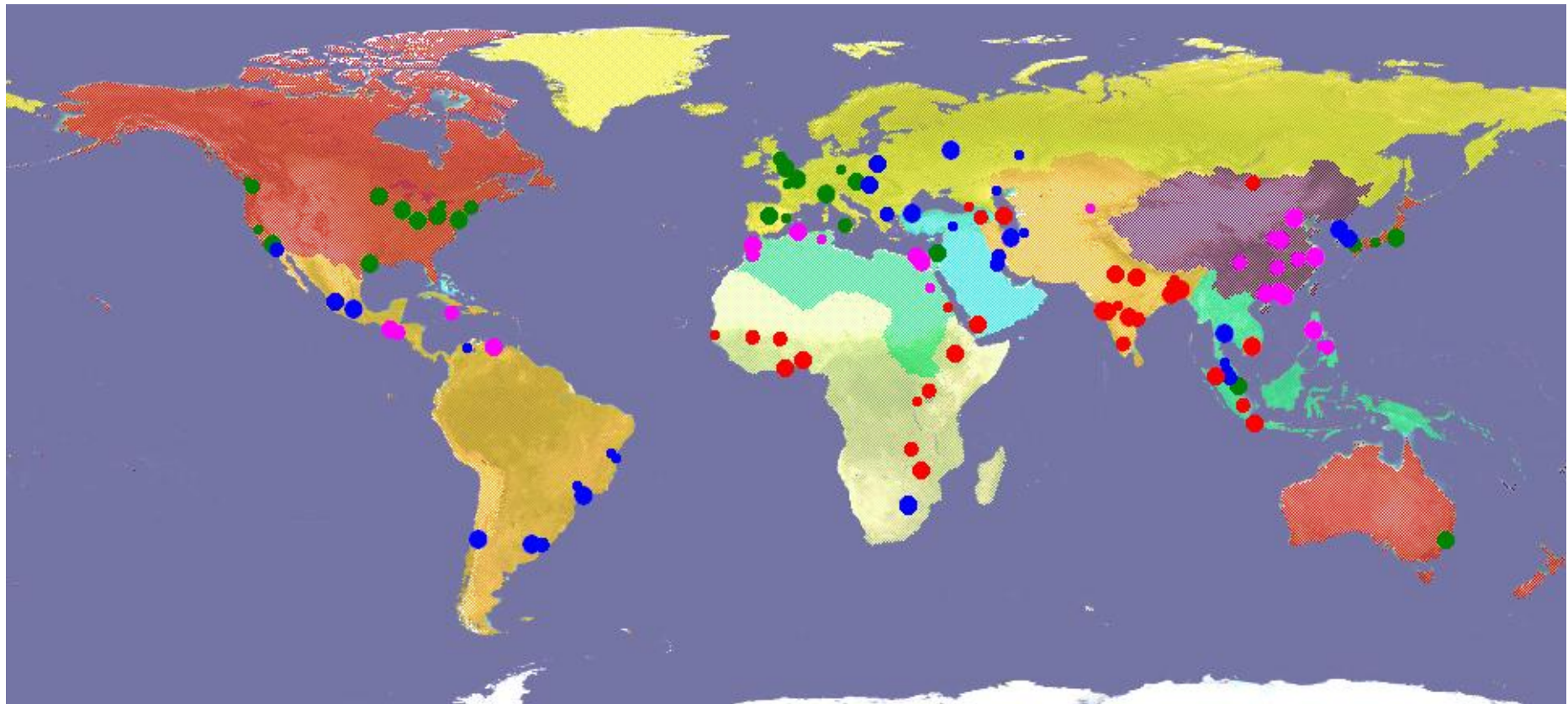




Approach to analysis

- Infill and outspill development should respond to the factors that drive urban expansion
 - Population growth
 - Income growth
 - Transportation costs
 - Agricultural land values
 - Institutional structure
- A global phenomena – test using global data
 - Increased variance in data
 - Policy interest in areas that are rapidly urbanizing

Data – a global sample of cities



Regions

Population

Size Class

Income
(annual per

Class
capita GNP)

- East Asia & the Pacific
- Europe
- Latin America & the Caribbean
- Northern Africa
- Other Developed Countries
- South & Central Asia
- Southeast Asia
- Sub-Saharan Africa
- Western Asia

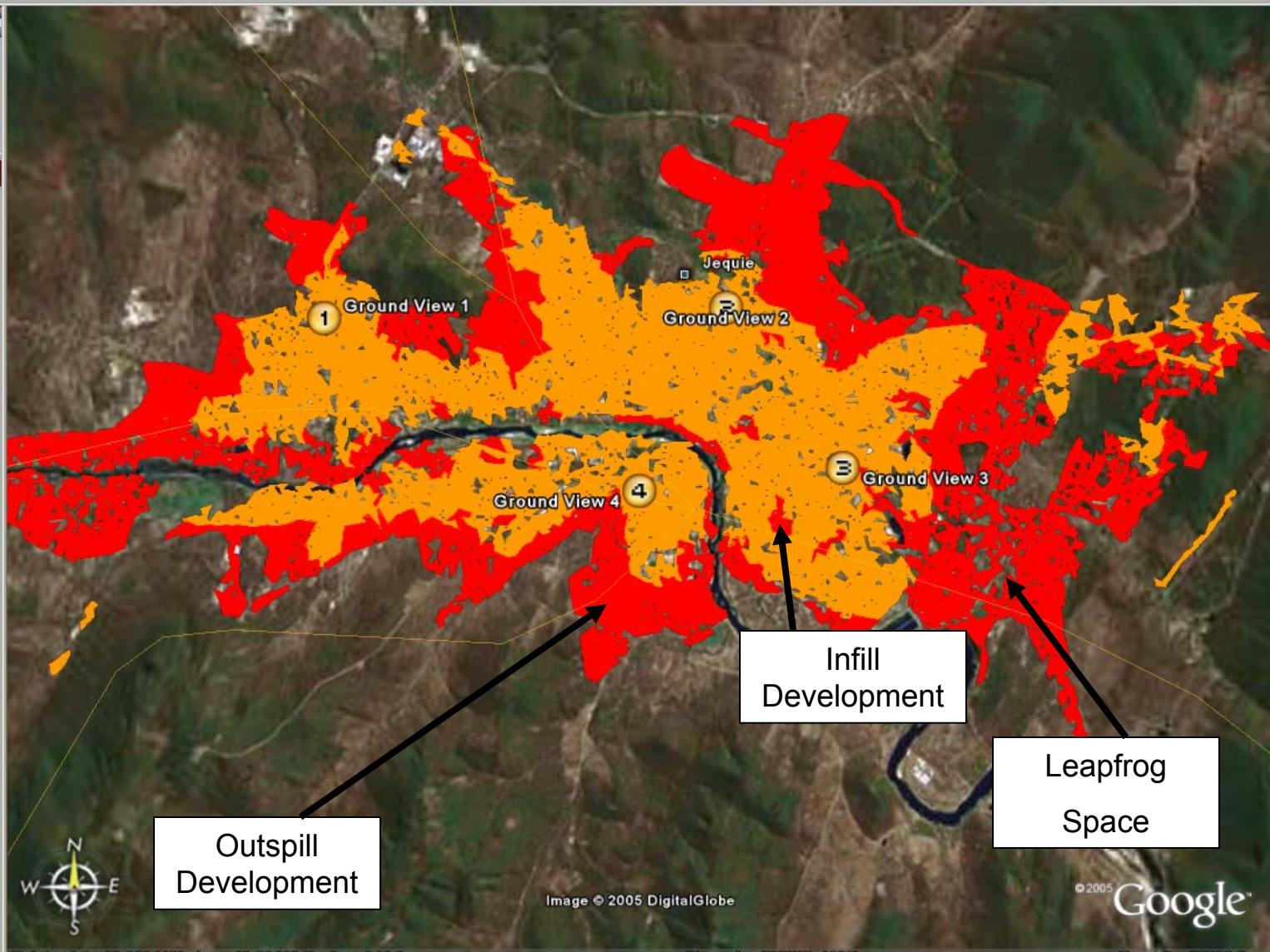
- 100,000 to 528,000
- 528,000 to 1,490,000
- 1,490,000 and 4,180,000
- > 4,180,001

- < \$3,000
- \$3,000 - \$5,200
- \$5,200 - \$17,000
- > \$17,000

Reservoir Rd. Clayville

Places

- My Places
 - Google Earth - N
 - Sightseeing
 - Start your Google Earth world tour here!
 - default
 - Google Earth default view.
- Temporary Places
 - Jequie.kmz
 - Jequie
 - Ground View 4
 - [Jequie_Brazil](#)
 - Ground View 3
 - [Jequie_Brazil](#)
 - Ground View 2
 - [Jequie_Brazil](#)
 - Ground View 1
 - [Jequie_Brazil](#)
 - Jequie Boun
 - Jequie 2000
 - Jequie 1990



Outspill Development

Infill Development

Leapfrog Space

Pointer lat -13.869410° lon -40.084164° elev 644 ft

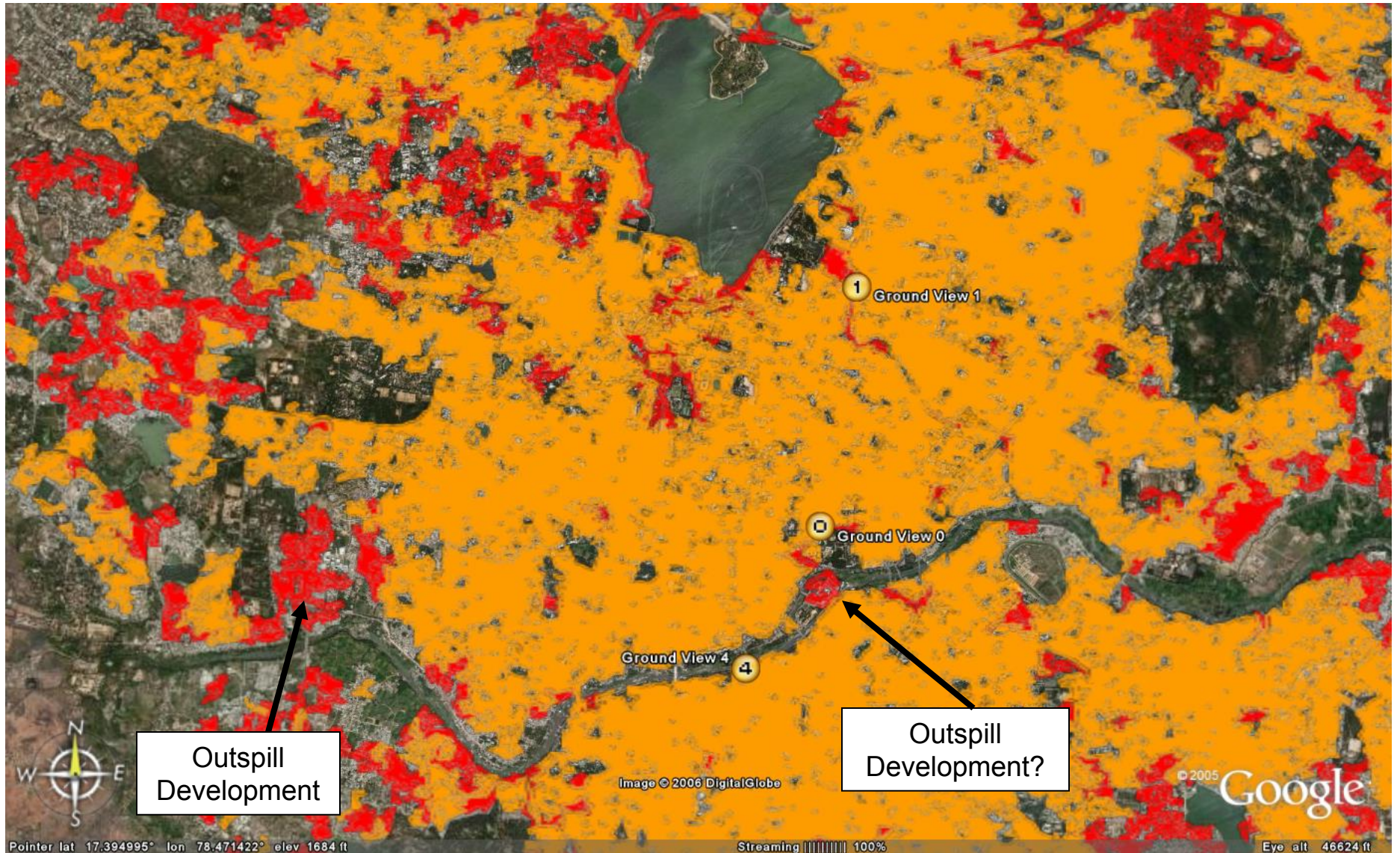
Streaming 100%

Eye alt 37680 ft

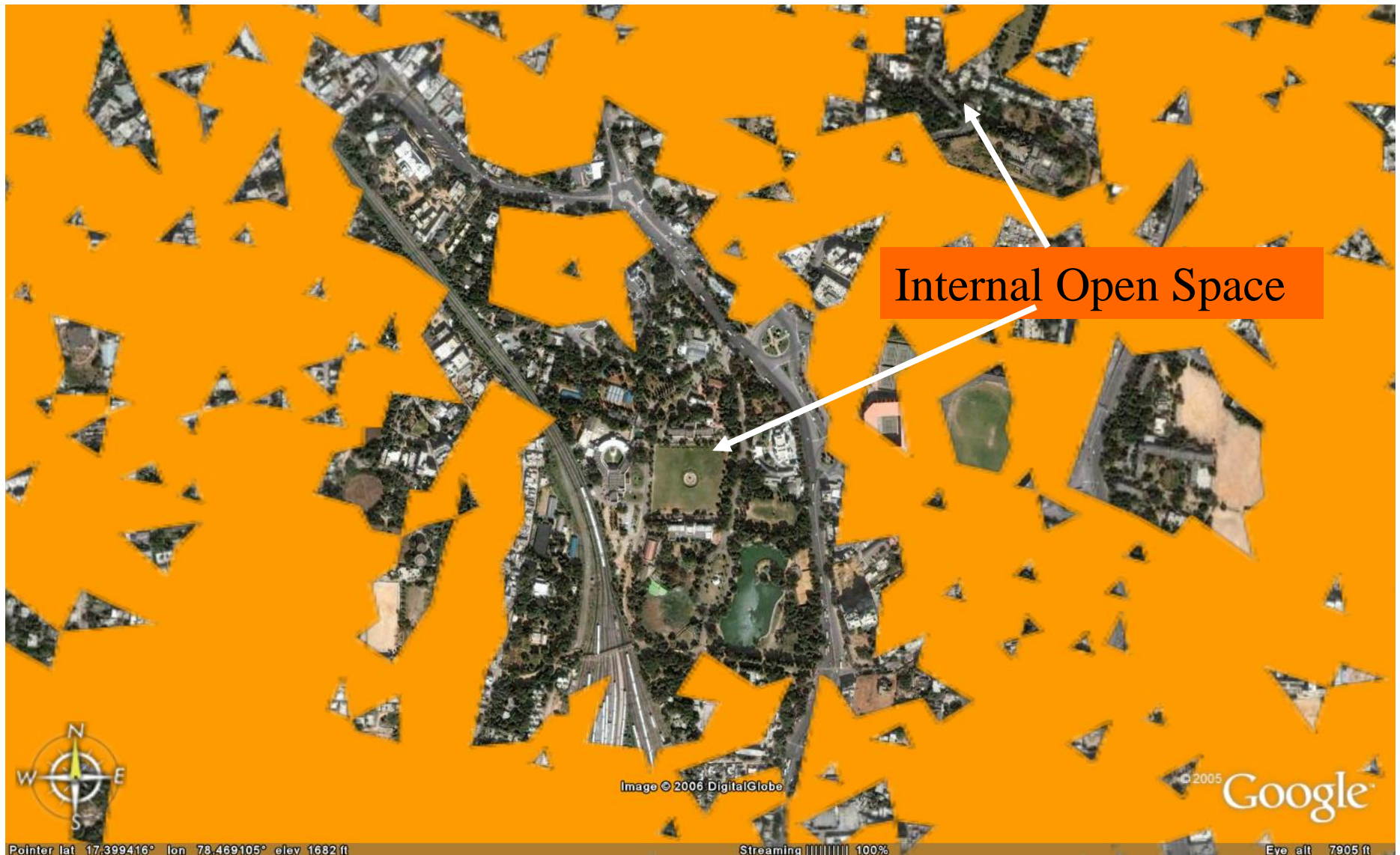
- Lodging
- Roads
- Terrain
- Dining
- Borders
- Buildings

Layers

Hyderabad, India showing 'Outspill'



Hyderabad, India – November 1989

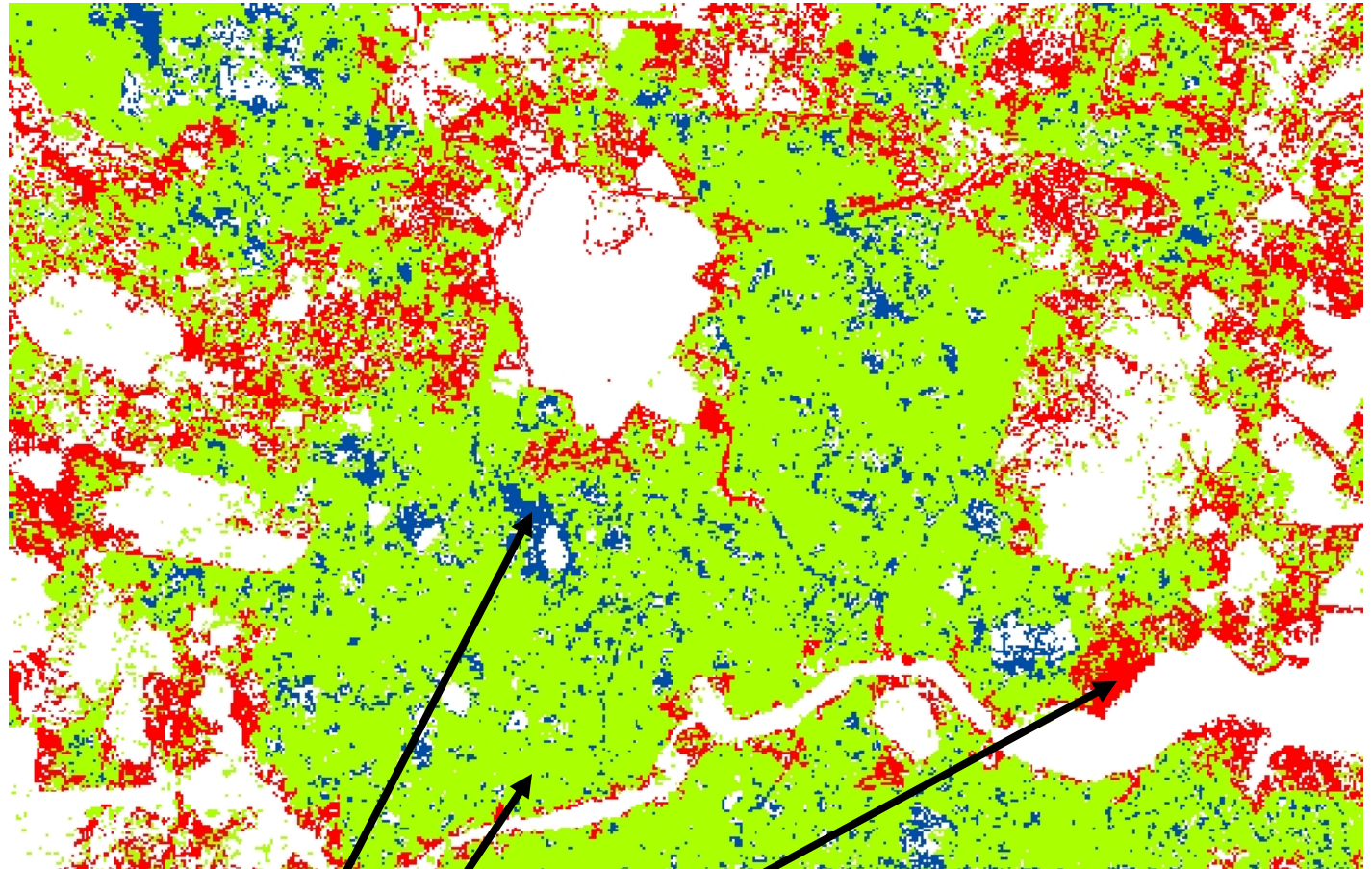


Hyderabad, India – October 2001



Complete Classification

- Internal open space and infill measured between image dates
- Space is internal if it is impossible to find a path from the space to the edge of the image without crossing developed space



Data concerns

■ Classification accuracy

- Evaluation underway using ground truth photographs
- Preliminary evaluation of 12 cities encouraging
 - T_1 accuracy approximately 84%
 - T_2 accuracy approximately 82%
 - Compare to NLCD accuracy of 72% to 87%

■ Land use versus land cover

- Remotely sensed data capture land cover
- Theory (mostly) relates to land use (entire parcels are purchased and used privately, commercially, etc.)
- Limited experience on success of using land cover as a proxy for land use
- Land use data not available on global scale

Descriptive Statistics

Variable	Mean	Std. Dev	Min	Max
T ₁ Urban	398.858	647.247	10.706	3847.187
T ₂ Urban	542.256	776.907	20.258	4391.454
T ₁ Open	65.558	141.661	0.012	822.869
T ₂ Open	94.215	193.135	0.237	1109.965
Infill	21.881	41.119	0.007	261.672
Outspill	121.517	147.691	6.072	1003.179
Leapfrog	16.745	82.920	0	639.679
ΔOpen Space	28.658	70.390	-81.889	443.709
ΔPopulation (millions)	9.293	94.854	-0.899	1035.279
ΔReal GDP per cap	1811.031	2377.095	-4125.445	7593.987
T ₁ Agrent	3138.589	14121.420	84.900	150542.900
T ₂ Agrent	2993.892	10440.210	68.837	109631.400
ΔAgri Rent	-144.698	3926.792	-40911.500	3364.859
ΔFuel Cost	0.283	0.186	-0.170	0.880
EastAsia	0.133	0.341	0	1

Variation around the globe

Region	Infill	% Infill	Outspill	% Outspill	Freq.
East Asia	12.608	6.159	234.849	93.841	16
Europe	14.714	4.962	282.265	4.962	16
	22.174	14.231	116.851	85.769	
	3	Expansion = 1 part infill 15 parts outspill		9.166	
LAC	19.489	17.339	68.138	82.661	16
	26.967	10.9	Expansion = 1 part infill 3 parts outspill		
North Africa	7.248	9.263	77.807	90.737	8
	8.553	7.578	69.979	7.578	
	Other Developed	73.309	22.830	184.889	
South Central Asia	85.016	20.012	157.840	20.012	16
	7.815	7.554	74.883	92.446	
Southeast Asia	9.628	5.155	55.208	5.155	12
	16.461	12.646	113.593	87.354	
Sub-saharan Africa	22.892	7.007	124.924	7.007	11
	9.590	9.216	75.170	90.784	
	13.376	7.	Expansion = 1 part infill 7 parts outspill		
West Asia	9.562	9.179	96.786	90.821	8
	12.056	4.686	100.448	4.686	
	Total	21.881	12.525	121.517	
	41.119	11.235	147.691	11.235	

Determinants of total urban land use

- Estimate a logarithmic model in levels

$$L = \beta_0 + \beta_1 Pop + \beta_2 Inc + \beta_3 AgriVal + \beta_4 Fuel + \varepsilon$$

- IV strategy is indicated
- Environment and location as instruments
- Regional indicators to account for level fixed effects

- Basic hypotheses of theory confirmed

- Population
- Income
- Agricultural land value
- Cost of transportation (fuel)

Variable	Coefficient
Population	0.723
<i>t</i> -statistic	9.76**
Income	0.709
<i>t</i> -statistic	7.37**
Agri Rent	-0.185
<i>t</i> -statistic	3.86**
Fuel Cost	-0.099
<i>t</i> -statistic	1.68
East Asia	0.296
<i>t</i> -statistic	1.09
Sub-saharan Africa	0.65
<i>t</i> -statistic	2.48*
Constant	3.915
<i>t</i> -statistic	3.19**
Observations	232
R ²	0.76

Determinants of Infill and Outspill

$$\Delta L_{i,k} = \beta_0 + \beta_1 \cdot \Delta Pop_i + \beta_2 \cdot \Delta Inc_i + \beta_3 \cdot \Delta AgriVal_i + \beta_4 \cdot AgriVal_i + \beta_5 \cdot \Delta Fuel_i + \varepsilon_i$$

	Infill KM ²			Outspill KM ²		
	1	2	3	1	2	3
Population	0.054	0.054	0.048	0.282	0.282	0.233
	4.46**	4.46**	4.93**	7.60**	7.60**	5.90**
GDP per cap	0.008	0.008	0.006	0.027	0.027	0.013
	2.76**	2.76**	2.91**	3.69**	3.69**	1.84
T ₁ Agrent		-0.002			-0.015	
		1.83			3.01**	
T ₂ Agrent	-0.002			-0.015		
	1.83			3.01**		
Agri Rent	-0.004	-0.005	0	-0.033	-0.048	0.002
	1.93	1.91	0.71	2.74**	2.82**	0.73
Fuel Cost	-33.14	-33.14	-41.599	-30.777	-30.777	-103.847
	1.47	1.47	1.93	0.54	0.54	1.45
EastAsia	-21.303	-21.303	-31.679	184.317	184.317	94.692
	1.79	1.79	2.66**	1.95	1.95	1.24
R ²	0.26	0.26	0.25	0.27	0.27	0.18

Interior Open and Leapfrog

	Change in Internal Open Space				Leapfrog Open Space			
	1	2	3	IV	1	2	3	IV
Population	0.105 <i>5.25**</i>	0.105 <i>5.25**</i>	0.092 <i>5.27**</i>	0.185 <i>1.68</i>	0.006 <i>0.3</i>	0.006 <i>0.3</i>	-0.002 <i>0.14</i>	0.026 <i>0.23</i>
GDP per cap	0.013 <i>3.07**</i>	0.013 <i>3.07**</i>	0.01 <i>2.96**</i>	0.019 <i>2.25*</i>	0.013 <i>1.88</i>	0.013 <i>1.88</i>	0.01 <i>1.96</i>	0.007 <i>0.82</i>
T₁ Agrent		-0.004 <i>2.34*</i>		-0.004 <i>2.08*</i>		-0.002 <i>1.53</i>		-0.001 <i>0.63</i>
T₂ Agrent	-0.004 <i>2.34*</i>				-0.002 <i>1.53</i>			
Agri Rent	-0.006 <i>1.78</i>	-0.01 <i>1.96</i>	0.002 <i>2.75**</i>	-0.013 <i>1.9</i>	-0.005 <i>1.44</i>	-0.007 <i>1.47</i>	0.001 <i>1.59</i>	-0.004 <i>0.62</i>
Fuel Cost	-18.363 <i>0.68</i>	-18.363 <i>0.68</i>	-36.418 <i>1.22</i>	6.117 <i>0.27</i>	-61.816 <i>2.17*</i>	-61.816 <i>2.17*</i>	-74.273 <i>2.22*</i>	-28.694 <i>1.24</i>
EastAsia	-2.711 <i>0.1</i>	-2.711 <i>0.1</i>	-24.857 <i>0.98</i>	37.567 <i>1.42</i>	-40.946 <i>1.98</i>	-40.946 <i>1.98</i>	-56.226 <i>2.14*</i>	-9.201 <i>0.52</i>
R²	0.18	0.18	0.16	0.1017	0.17	0.17	0.16	0.0891
Wu-Hausman		8.83279	Anderson	53.224**		4.6828	Anderson	53.224**
P-value		0.00029	Hansen J	5.63		0.01135	Hansen J	4.171
		17.26876				9.84374		
P-value		0.00018				0.00729		

Concluding remarks

- Global variation in microstructure of urban expansion
- Boundaries can give rise to spatial heterogeneity in price volatility
 - Commercial and residential
 - Different classes of residential
 - Residential and agricultural
- Cross-sectional variation in levels of urban land use consistent with implications of theory
- Cross sectional variation in changes in urban land use also largely consistent with theory
 - Less total variance accounted for
 - Some variation in what “theory” predicts for infill versus outspill
 - Support for both non-homogeneity of land and for “vacant land as an option” explanations
- Surprisingly little role for regional ‘fixed effects’
 - Limited role for policy and institutional structure?
- Directions for future research
 - Location of open space within the city
 - Impact of land use regulation and enforcement
 - Measures of volatility of structure demand and supply

Concluding remarks

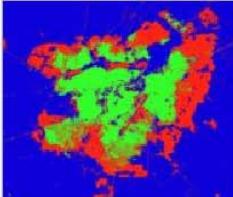
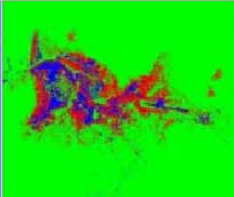
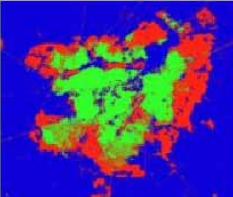

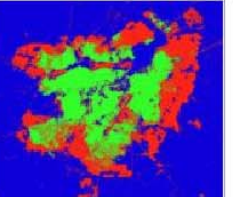
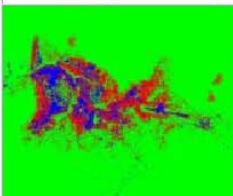
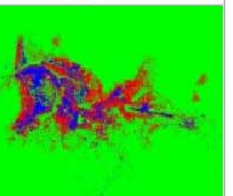
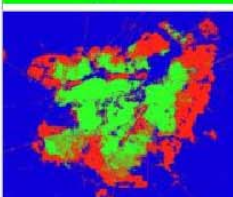
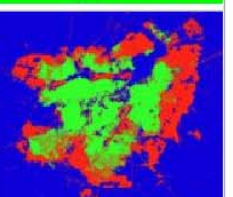
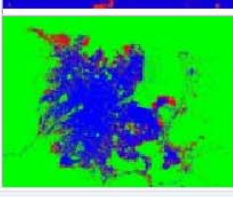
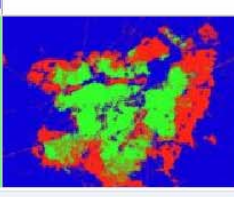
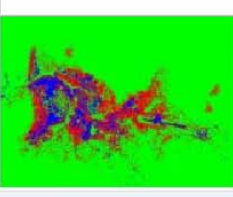

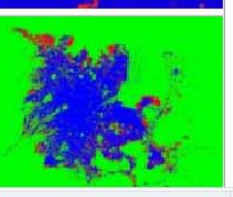
■ Future papers

- Test sensitivity to other sources of price volatility
 - interest rate risk and regulatory taking
- Test spatial sorting
 - Infill → Leapfrog → Outspill consistent with option value model
 - Idiosyncratic explanations or heterogeneous development costs would show less spatial structure

<http://www.williams.edu/Economics/UrbanGrowth/HomePage.htm>

Urban Growth Management Initiative

Causes and Consequences of Urban Expansion

				
	Working Papers	The Project	Slide Shows	
	Contacts	Data Entry	Data Download	
				

Internet

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