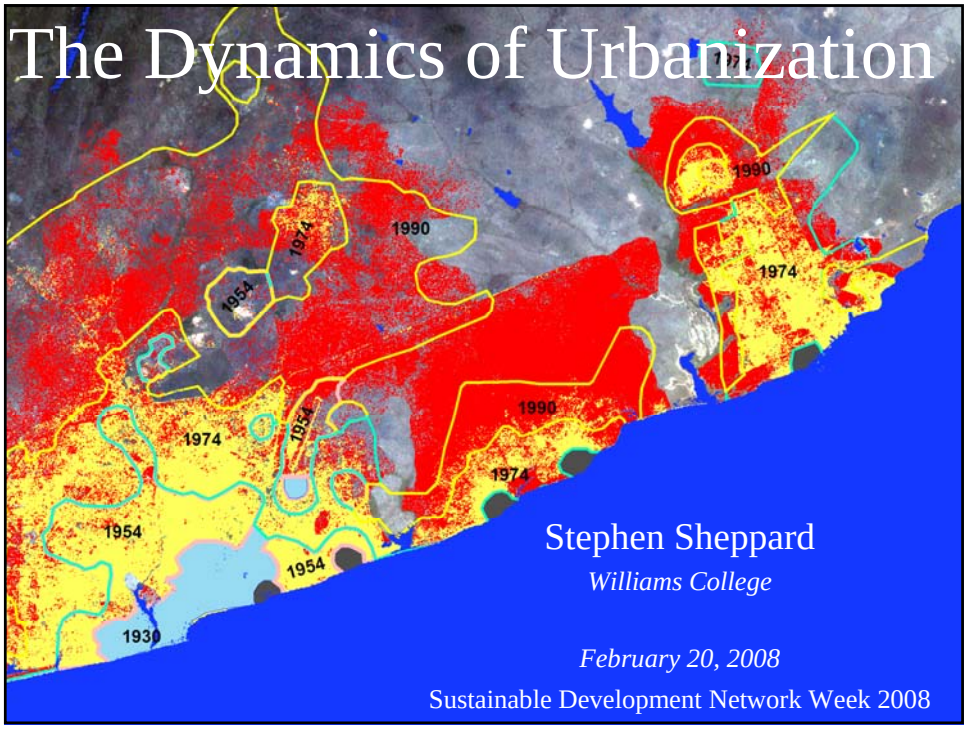
The Dynamics of Urbanization



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Williams College

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Sustainable Development Network Week 2008

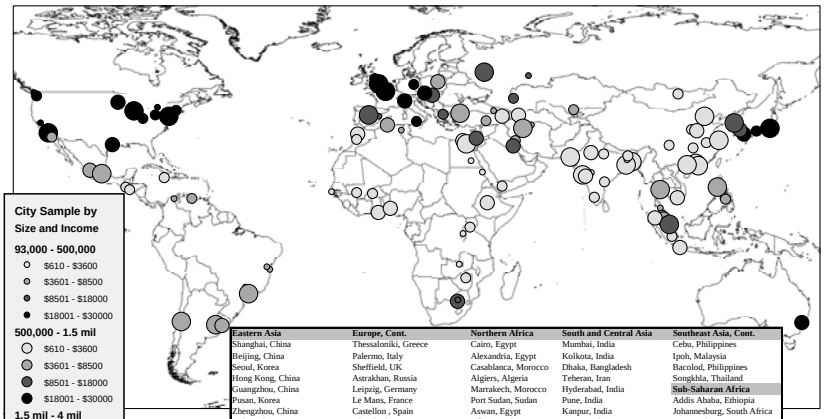
Urban Expansion – questions and measurement

- The spatial structure of cities affects the economic well-being of the residents
- The dynamic patterns of land use impacts (and is impacted by) the structure of the economy and of policy making
- An urgent need to identify the driving forces that determine the dynamics of urban land use
  - Device policies to harness those forces and improve cities where possible
  - Understand the forces and prepare for urban dynamics where they cannot be changes
  - Develop the theoretical and practical understanding to know the difference

Why …

- Is urban land cover expanding faster than urban population?
  - Is average land consumption rising because of
    - Income growth and development?
    - Changing preferences or social change?
    - Policy failures?
    - Lack of land use planning?
    - Falling transport costs and agricultural land rents?
    - Conflict and urban insecurity?
- Should we care?
  - Lower density cities lead to
    - Higher infrastructure costs per capita
    - More commuting or increased dispersion of firms
      - Pollution/congestion or
      - Reduced agglomeration economies/spatial mismatch
    - Different configurations for open space
      - More accessible to households?
      - More private consumption of open space
      - Smaller contiguous parcels of open space
- Aid agencies have a responsibility: first do no harm!

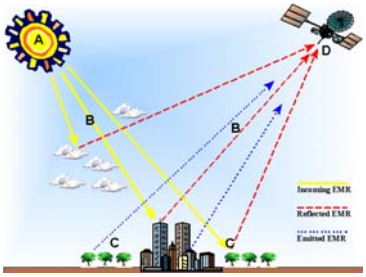
Measuring Urban Expansion – global sample



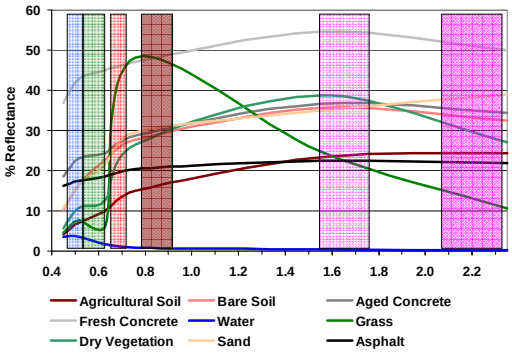
Eastern Asia	Europe, Cont.	Northern Africa	South and Central Asia	Southeast Asia, Cont.
Shanghai, China	Thessaloniki, Greece	Cairo, Egypt	Mumbai, India	Cebu, Philippines
Beijing, China	Palermo, Italy	Alexandria, Egypt	Kolkota, India	Ipoh, Malaysia
Seoul, Korea	Sheffield, UK	Casablanca, Morocco	Dhaka, Bangladesh	Bacolod, Philippines
Hong Kong, China	Astrakhan, Russia	Algiers, Algeria	Teheran, Iran	Songkhla, Thailand
Guangzhou, China	Leipzig, Germany	Marrakech, Morocco	Hyderabad, India	**Sub-Saharan Africa**
Pusan, Korea	Le Mans, France	Port Sudan, Sudan	Pune, India	Addis Ababa, Ethiopia
Zhengzhou, China	Castellon , Spain	Aswan, Egypt	Kanpur, India	Johannesburg, South Africa
Yulin, China	Oktyabrsky, Russia	Tébessa, Algeria	Jaipur, India	Accra, Ghana
Yiyang, China	**Latin America & Caribbean**	**Other Developed**	Coimbatore, India	Harare, Zimbabwe
Leshan, China	Mexico City, Mexico	Tokyo, Japan	Vijayawada, India	Ibadan, Nigeria
Ulan Bator, Mongolia	Sao Paolo, Brazil	Los Angeles, USA	Rajshahi, Bangladesh	Pretoria, South Africa
Changzhi, China	Buenos Aires, Argentina	Chicago, USA	Ahvaz, Iran	Kampala, Uganda
Anqing, China	Santiago, Chile	Philadelphia, USA	Shimkent, Kazakhstan	Bamako, Mali
Ansan, Korea	Guadalajara, Mexico	Houston, USA	Jalna, India	Ouagadougou, Burkina Faso
Chinju, China	Guatemala City, Guatemala	Sydney, Australia	Gorgan, Iran	Ndola, Zambia
Chonan, Korea	Caracas, Venezuela	Minneapolis, USA	Saidpur, Bangladesh	Banjul, Gambia
Europe	San Salvador, El Salvador	Pittsburgh, USA	**Southeast Asia**	Kigali, Rwanda
Paris, France	Montevideo, Uruguay	Cincinnati, USA	Manila, Philippines	**Western Asia**
Moscow, Russia	Tijuana, Mexico	Fukuoka, Japan	Bangkok, Thailand	Istanbul, Turkey
London, UK	Kingston, Jamaica	Tacoma, USA	Ho Chi Minh City, Vietnam	Tel Aviv, Israel
Milan, Italy	Ribeirão Preto, Brazil	Springfield, USA	Singapore, Singapore	Baku, Azerbaijan
Madrid, Spain	Valledupar, Colombia	Modesto, USA	Bandung, Indonesia	Sana'a, Yemen
Warsaw, Poland	Guarujá, Brazil	St. Catharine's, Canada	Medan, Indonesia	Yerevan, Armenia
Vienna, Austria	Ilhéus, Brazil	Victoria, Canada	Palembang, Indonesia	Kuwait City, Kuwait
Budapest, Hungary	Jequié, Brazil	Akashi, Japan	Kuala Lumpur, Malaysia	Malatya, Turkey
				Zugdidi, Georgia

Measuring Urban Expansion – remote sensing

- Measuring actual urban outcomes – and actual changes in urban land use using remote sensing techniques

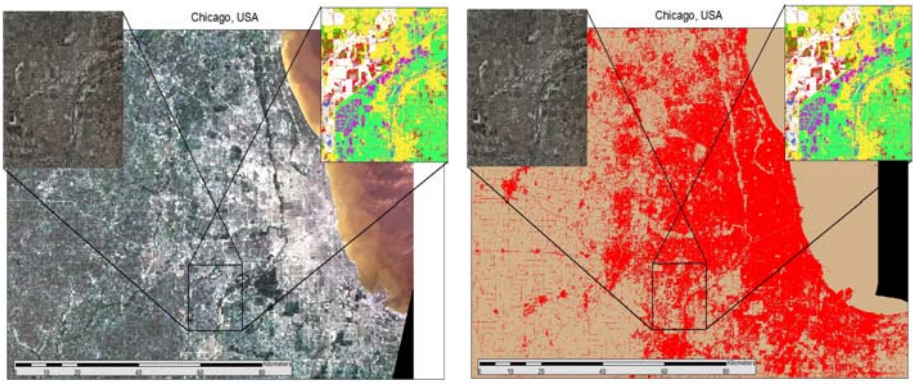


The relative brightness in different portions of the spectrum identify different types of ground cover.



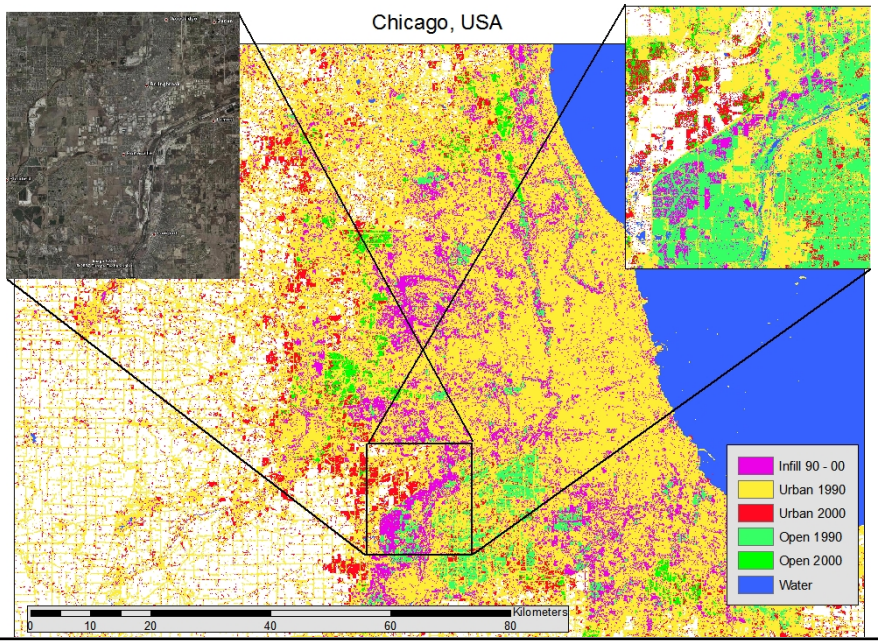
Satellite (Landsat TM) data measure reflectance in different frequency bands

Classification of urban land cover



- 2 Landsat TM/ETM images, approximately 10 years apart
- 28.5 meter resolution, 3 visual brightness, 3 IR
- 3-pass supervised cluster analysis used for both times
- Pixels classified as urban, non-urban or water

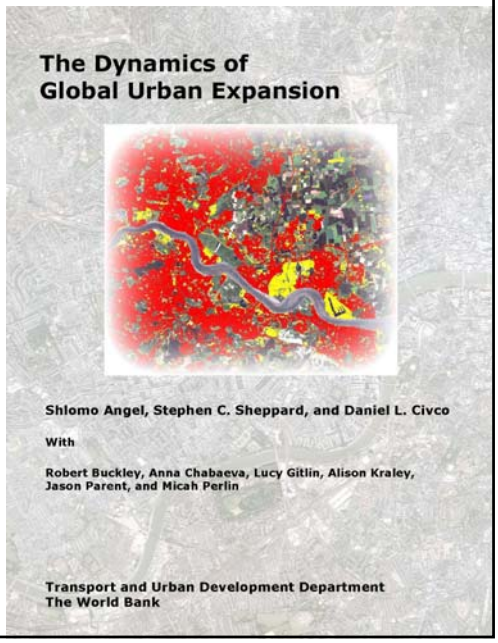
Detecting Urban Development Dynamics



Measuring Urban Expansion – first report

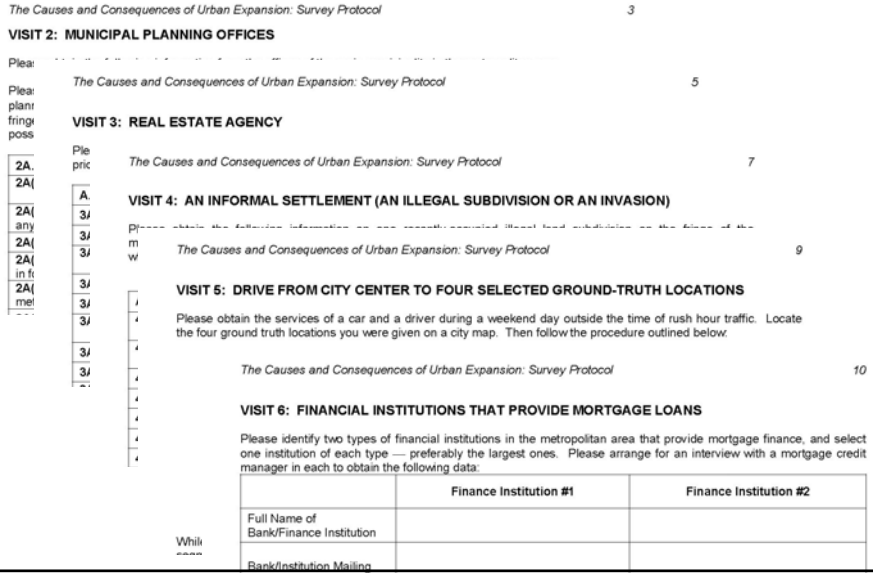
- Provides detailed analysis for 90 cities, including measures of:
  - Total urban land cover and changes in urban land cover
  - Population density and changes in density
  - Initial tests of model to provide foundation for prediction and decision making
- Available online:

www.williams.edu/Economics/UrbanGrowth/HomePage.htm



Causes and Consequences of Urban Expansion

- Field research in each city to collect data not available from other sources



The Causes and Consequences of Urban Expansion: Survey Protocol 3

VISIT 2: MUNICIPAL PLANNING OFFICES

The Causes and Consequences of Urban Expansion: Survey Protocol 5

VISIT 3: REAL ESTATE AGENCY

The Causes and Consequences of Urban Expansion: Survey Protocol 7

VISIT 4: AN INFORMAL SETTLEMENT (AN ILLEGAL SUBDIVISION OR AN INVASION)

The Causes and Consequences of Urban Expansion: Survey Protocol 9

VISIT 5: DRIVE FROM CITY CENTER TO FOUR SELECTED GROUND-TRUTH LOCATIONS

Please obtain the services of a car and a driver during a weekend day outside the time of rush hour traffic. Locate the four ground truth locations you were given on a city map. Then follow the procedure outlined below:

The Causes and Consequences of Urban Expansion: Survey Protocol 10

VISIT 6: FINANCIAL INSTITUTIONS THAT PROVIDE MORTGAGE LOANS

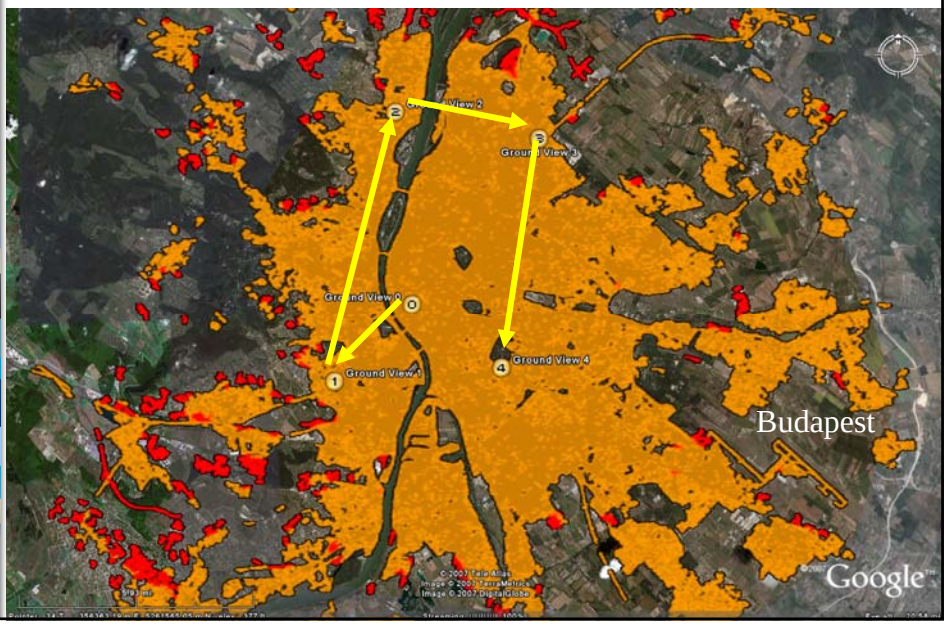
Please identify two types of financial institutions in the metropolitan area that provide mortgage finance, and select one institution of each type — preferably the largest ones. Please arrange for an interview with a mortgage credit manager in each to obtain the following data:

	Finance Institution #1	Finance Institution #2
Full Name of Bank/Finance Institution		
Bank/Institution Mailing		

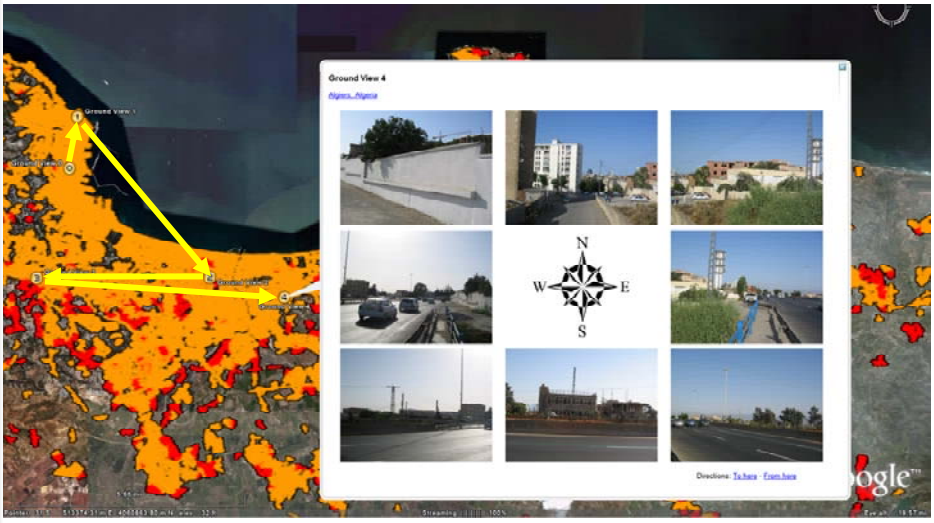
Measuring Urban Expansion – descriptive statistics

Variable	Expect Impact	Mean	Std. Dev.	Min	Max
Total urban land (km^2)		402.81	635.11	8.92	4,268.00
Total Population	+	3,363,025.00	4,459,765.00	93,040.91	27,200,000.00
Per capita income (ppp $)	+	$9,914.08	$9,916.70	$609.88	$35,354.00
Agricultural rent (ppp$ / ha)	-	$3,347.65	$12,569.78	$68.84	$150,542.90
Fuel cost (ppp$ / US gallon)	-	$0.62	$0.36	$0.02	$1.56
Air linkages	+	108.21	133.39	0	659
Shallow ground water	+	0.24	0.43	0	1
Years between images		11.24	2.21	5.19	16.97
Change in total urban land		115.21	126.09	3.19	549.66
Growth rate in urban land		0.05	0.05	0	0.36
Urban rank		19.09	38.05	1	196
Cars per 1000 in country		139.47	180.55	0.39	573.28
Non rush hour travel speed (KPH)		27.11	13.64	2.61	75
Maximum urban slope (%)		25.96	14.96	4.16	78

Measurement of average travel speed



‘Ground truth’ record of land use to check classification



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

Measuring Urban Expansion – descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Planner has police power	194	0.546	0.499	0	1
Plan land use	194	0.742	0.439	0	1
Light rail transit	210	0.543	0.499	0	1
Months to convert land	180	13.752	44.730	1	416
Pct. parcels registered	180	0.811	0.239	0	1
Residence permit required	216	0.324	0.469	0	1
Pct. changes allowed	126	0.605	0.358	0	1
Pct. Changes denied	140	0.306	0.342	0	1
Number stop orders	146	240.260	625.907	0	3500
Number demolished	154	193.740	1180.937	0	10000
Share with no permit	164	0.186	0.231	0	0.82
Share squatters	174	0.092	0.141	0	0.6
Total zoning staff	178	128.893	284.691	0	1600
Inspector salary ppp	184	1341.620	1210.443	1.264206	4687.843
Zoning staff per 100k	178	4.610	8.050	0	63.72

Causes and consequences of urban expansion: data

- Three types of geography, three data sets
  - **Metro area:** 120 cities, two time periods
  - **District subareas:** 120 cities, two time periods, 36992 districts
  - **Pixels:** well over 100 million pixels
- Availability of metro area data from field research
  - Data are being checked for consistency, corrected and verified
  - Not all data are yet available: “alpha release”
  - Within next month: “beta release” to research collaborators
  - Later in year after corrections in population and planning data: “general release” via web site
- Problems:
  - Calculations of urban dynamics
  - Checking population – China and others pose particular difficulty
  - Planning data from submitted maps
- Important resource for research on urban dynamics

First results: estimation strategy

- Analysis of these data require special strategy
  - Population, income, land use policy, etc. are **endogenous**
  - For example, cities with unusually large stock of developed land
    - May experience greater population due to increased availability of structures
    - May develop sophisticated and restrictive planning policies to affect value of properties
    - May experience greater income growth due to enhanced stock of physical capital
- Similar problems arise frequently in econometric analysis
- Testing theories and developing models requires that we deal with endogeneity
- We use an instrumental variables approach

First results: primary causes of urban expansion

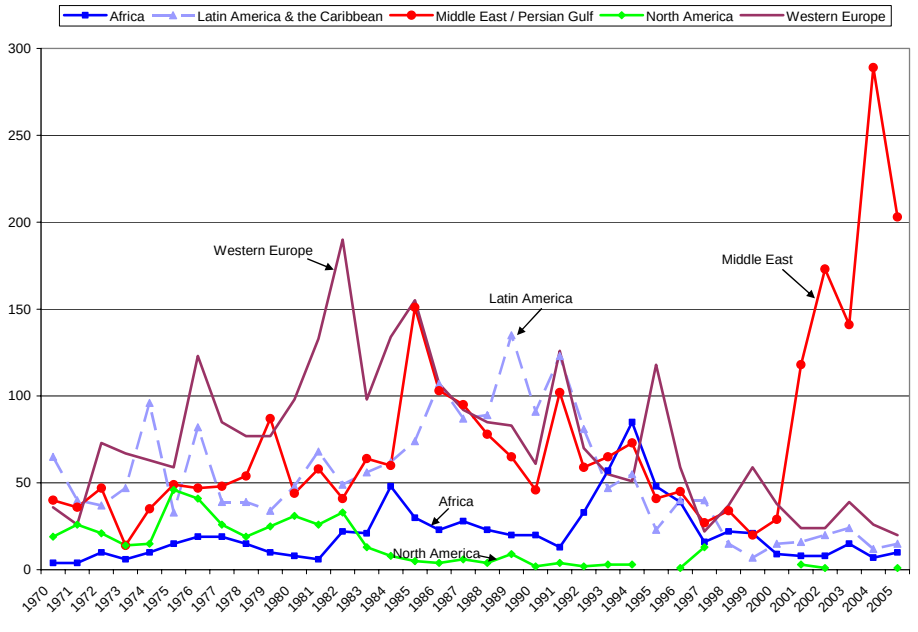
- Estimate a logarithmic model in levels

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

  - 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
t-statistic	*9.76***
Income	0.709
t-statistic	*7.37***
Agricultural Rent	-0.185
t-statistic	*3.86***
Fuel Cost	-0.099
t-statistic	*1.68*
East Asia	0.296
t-statistic	*1.09*
Sub-Saharan Africa	0.65
t-statistic	*2.48**
Constant	3.915
t-statistic	*3.19***
Observations	232
R^2	0.76

First results: urban expansion and civil conflict



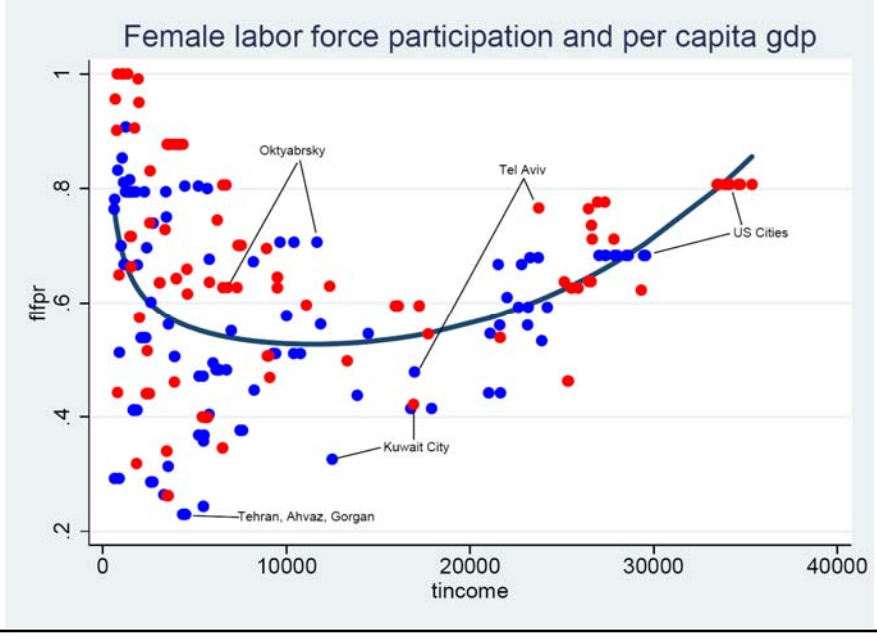
First results: urban expansion and civil conflict

	Incidents	Injuries	Fatalities
Population	0.3836*	0.417*	0.4314*
Income	0.6657***	0.6427***	0.6023***
Air Linkages	0.2876**	0.2388*	0.2518*
Terrorism	-0.3208**	-0.1648**	-0.2407*
Agricultural Rent	-0.167***	-0.1974***	-0.2162***
Fuel Cost	-0.191**	-0.1682**	-0.1588*
West Asia	1.0225***	0.7641***	0.75**
Constant	-5.9104**	-5.8596*	-5.586*
R^2	0.7073	0.7289	0.7308
Anderson LR (Relevances)	22.33***	14.179	14.385
Hansen J (Over identification)	7.476***	7.668***	7.077***
4th Power RESET test	0.24***	0.17***	0.26***

Urban expansion and civil conflict: governance?

	Democracy	Checks	Executive
Population	0.4458**	0.4181**	0.5123***
Income	0.7324***	0.6756***	0.7222***
Air Linkages	0.2497*	0.2726**	0.2061*
Terror Incidents	-0.3506**	-0.3291**	-0.3161***
Agricultural Rent	-0.1726***	-0.1695***	-0.184***
Fuel Cost	-0.109	-0.1591*	-0.1324*
West Asia	1.0767***	0.9762***	1.0049***
Democracy Index	-0.1762*		
Checks/Balances Index		-0.0901	
Unelected Executive			0.1605
Elected 1 Candidate Executive			0.0425
Parties legal, one party dominates			-0.5075
Elected Executive by > 75%			0.0472
Elected Executive by 75%			-0.4551
Elected Executive by < 75%			-0.1666

First results: urban expansion and social change

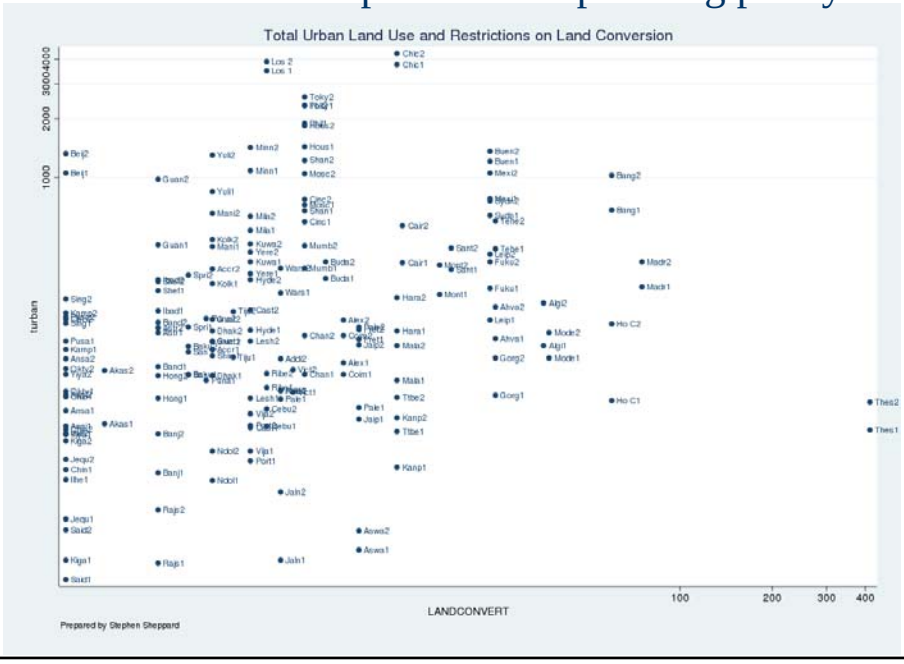


First results: urban expansion and social change

- Instruments: Biome, location, slope
  - Pass usual tests for independence & relevance
- All models estimated with city fixed effects
- Only partial data available
  - All models estimated with data from 99 cities

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Population	0.5206***	0.9539***	0.8622***	0.6783***	0.6806***
Income	1.686***	0.0569	0.5303***	0.5275***	0.7861***
Wage/KM	-0.6162***	0.0955	-0.1993	-0.1556	-0.0987
Fuel Cost	0.0933	-0.3541**			0.0347
Air Linkages	0.2138***		-0.0465		0.1157**
Agric. Rent	-0.1364	-0.3676***	-0.3867***	-0.4355***	-0.3078***
FLFPR	-1.5173***	0.1374	-1.0925***	-0.2967	-0.9764***
Pct Ag Fem	0.2845	-0.3095**	-0.2472	-0.3003***	
F	22.55	26.09	22.24	36.2	30.31
Adj R^2	0.914	0.926	0.913	0.947	0.936
Root MSE	0.373	0.347	0.375	0.294	0.322

First results: urban expansion and planning policy



First results: urban expansion and planning policy

Urban Land Use	I	II	III	IV
Population	0.7193***	0.7766***	0.8132***	0.8437***
Income	0.7077***	0.6745***	0.7608***	0.6417***
Land Use Regulation			-0.156***	-0.1391**
Agricultural Rent	-0.2508***	-0.2341***	-0.2609***	-0.2616***
Fuel Cost	-0.1109*	-0.2355***	-0.2131***	-0.3516**
South Central Asia		-0.4448*	-0.2603	-0.6415**
Sub-Saharan Africa		0.3847	0.5115*	0.2005
Constant	-9.6269	-10.2169***	-11.1229***	-10.4411***
Observations	210	210	176	176
F	94.09	46.74	90.06	51.01
R^2	0.7926	0.8378	0.8523	0.8496

- Properly analyzed, we see that land use regulation affects total urban land cover as expected
- Doubling restrictiveness (time taken to convert land) is associated with a 14% reduction in urban land use

New directions

- The availability of these new data permits exploration in a variety of new directions.
- Work is just getting underway to explore:
  - Linkage between housing affordability and urban expansion
  - Impacts of urban expansion on housing quality
  - Urban expansion into areas subject to flooding risk associated with climate change
  - Tradeoff between access to open space, distribution of environmental benefits, and urban expansion
- Preliminary preparations to collect an additional round of remote sensing data to compare ongoing urban expansion

Concluding remarks

- Measurement of urban land cover combined with field data provides an important resource for understanding urban dynamics

- Questions of central importance for development policy
  - Considerable urban expansion is linked to economic development
  - Population growth (rural-urban migration) and income growth are of approximately equal importance
  - Robust agricultural sector makes cities more compact
  - Increasing fuel prices makes cities more compact
  - Civil conflict and terrorism does not appear to reduce urban density
  - Increasing role of women in labor market is associated with more compact urban areas
  - Planning policies appear capable of restraining urban growth – but are generally somewhat less powerful than other forces (at least as applied)
  - Accounting for income, population, and economic factors used in the models above accounts for most of the differences among cities – while every place is “special” there are not large regional differences in the forces that drive urban expansion