Informal Sprawl?

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Abstract

Urban expansion in cities around the world is primarily driven by four factors: population growth, income growth, falling costs of transportation, and reduced opportunity costs for non-urban land use. These are exactly what would be expected by urban economic theory. In addition to these primary factors, there are other forces that are associated with larger levels of urban land use. This paper focuses on the role of informal housing.

The levels of urban expansion, particularly in developing country cities, can be astonishing, with annual growth rates in urban land cover that exceed 10 percent per annum in selected cases, sustained for several years. Some authors, although few economists, have specifically identified the presence of informal housing as a causal factor in this expansion, arguing that such development is unregulated, unplanned and uncontrolled. The presence and size of informal housing development may be a signal of a lack of urban planning and enforcement of land use regulation. It may also be indicative of patterns of development in open spaces that are difficult to defend from illegal incursion due to political or geographic factors.

I make use of a new and globally representative data set that begins with measures of changes in urban land cover from 1990 to 2000 in 120 cities around the world, and combines these measures with field observations of the extent of informal housing, house prices, planning policies, and other relevant variables. The paper considers whether the extent of informal housing is a contributing cause of urban expansion, a consequence of expansion pressures in overly constrained urban housing markets, or some combination of both.[1].

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1 Introduction

Housing constructed in violation of one or more local laws and regulations - so called "informal housing" is a common feature of the world's cities, particularly those in low-income countries. In many cities such housing constitutes a large share - sometimes as high as 80 percent or more - of the total housing stock. While in some cases the legal violations that cause the housing to be categorized as "informal" are minor, often they are manifold and serious. Housing is often constructed on land to which the builder/occupant has no title nor right to occupy. Housing is constructed without proper sanitation or water supply. Housing is constructed with only narrow alleys or walkways providing access. Conditions of extreme crowding, illness, and other deprivations rightly make such housing a focus of public policy concern at the municipal, national and international level.

These concerns have been magnified because of the rapid pace of urban growth, particularly in developing countries. Technological progress in agriculture and other sectors, increasing literacy, integration into the global economy, economies of agglomeration and the increased factor productivity in cities combine to create a powerful elixir of economic forces that make urban location relatively attractive and drive urban expansion. The expanding urban populations cannot, or do not, always find accommodation within the formal sector. Policy responses to the emerging informal sector have varied from creation of paths to legalization of the informal settlements to sporadic slum clearance and attempts at eradication. Concerns about these types of settlements and the conditions within them were elevated to specific calls for action as part of the Millennium Development Goals project of the United Nations (2007).

The growth in urban population typically translates into expanded urban land use, extending the area over which local authorities are expected to provide power, water, sanitation and other infrastructure. The difficulty in providing these services may serve as a force encouraging informal development. If the newly built housing is not going to receive water and sewer anyway (or if the municipality is using the rationing of such infrastructure as a technique for controlling development and restricting housing supply) then the incentive to pursue housing development through the formal sector is reduced. Closely related to this is the concern, expressed by some practitioners and scholars, that informal development may itself be contributing to urban sprawl. Thus Owei, Ede, Obinna and Akarolo (2008) note that urban sprawl "... in Nigeria consist of informal housing development on the urban fringe on land that is mostly privately owned." Similarly, Deng and Huang (2004) identify one of the primary types of urban sprawl in Beijing as "...migrant workers and temporary urban residents such as students, and accompanying illegal construction

... on the urban fringe that gradually become ghetto-like, sprawling migrant enclaves."

Concerns about urban "sprawl" and the associated burdens of providing infrastructure, energy use, and loss of open space have also received widespread attention recently. Attention that has also been magnified by the rapid urbanization and growth of cities around the planet. Calls for policies designed to promote compact urban form have been made, again by both practitioners and urban scholars. Clearly the phenomena of informal housing provision and urban expansion or sprawl are linked, if only by virtue of the fact that they both emerge from a common, and complex, process that determines the patterns of urban land use and development.

2 Housing Supply

In what ways, exactly, are informal housing and urban expansion linked? One view would be that extensive informal housing development is indicative of weak property rights, and poorly enforced or nonexistent land use regulation and planning. As a result, there is little prospect that the government or local authority will constrain sprawl even if it is economically efficient to do so. This view leads to an expectation of a positive relationship between informal housing and sprawl. Whether this relationship is "causal" or not depends on the relationship between housing supply and local authority. If the main problem is weak property rights, then the resource of undeveloped land is being underpriced and in consequence being overused by developers or individuals who occupy the land without payment. Alternatively, if the main problem is weak or underfunded local authority, then both informal housing and urban sprawl share a common causal source while not being, in themselves, causally linked. Either way we expect to observe a positive relationship between the size of the informal sector in the housing supply and the extent of urban land use. For many this relationship is both driven by direct observation (urban expansion and the simultaneous expansion of informal settlements) and to be expected given our understanding of the process of housing supply.

An alternative view, however, is possible. Informal housing development is almost always characterized by relatively small amounts of land consumed per household. While the densities achieved may be lower than those in very capital-intensive high-rise development, they are generally much higher than nearby formal-sector residential development. There are at least two possible reasons for this. First, once an informal settlement begins in an area, whether via an organized invasion of property or a less rapid, more organic process, it may be difficult for the community to exclude other households from crowding in.

Although DeSoto (1989) and others have documented and described the way in which property rights emerge and are enforced within informal settlements, it may be the case that weak property rights in the wider community carry over to the informal settlement and result in much higher densities within the settlement.

A more likely explanation for the low per capita land consumption in informal settlements is that higher densities play an important role in the defense of the informal settlement from eviction. Virtually all squatter settlements, in particular, are potentially vulnerable to efforts made by the titled owner of the land to evict the squatters. The efforts undertaken towards this end will increase with the value of the appropriated land, thus explaining the tendency for informal housing to be located near the urban periphery and on land that is otherwise difficult to use for formal development. Higher densities, lack of paved roadways, and chaotic internal structure all make it more difficult to organize a quick, efficient and politically acceptable eviction. For the residents of the informal settlement the tradeoff is clear: they accept a reduced level of land consumption and infrastructure in exchange for greatly reduced (or zero) rent and increased expenditures on other necessities.

We can understand the expected impacts of the informal sector on total urban land consumption by recognizing that informal housing combines the effects of a several changes that have been widely studied in other contexts. First, establishing an informal settlement reduces the supply of land available for the formal sector in a manner similar to the removal of land for open space or other uses alternative to formal development. As elaborated in Sheppard (**?**) a reduction in the land made available for internal development reduces total (formal) urban land use. The intuition is clear: the reduction in land available for formal development reduces the total supply and increases the average price paid. Unless the elasticity of substitution is zero, residents substitute away from land towards other consumption, increasing urban density.

Of course, the land occupied for informal development is not left open, but is occupied with residential structures. We can think of this as removing a subset of households N_i from the population accommodated in the formal land market, and transferring them to the areas seized by informal developers. As long as the nature of housing supply in the informal sector results in less land consumption per household than accommodation for similar households in the formal sector, the effect will be a net reduction in total urban land use. Whether this latter condition holds depends on the cost function for defending the informal settlement, but in practice (as noted above) it appears to hold in cities where informal housing is significant. If this holds then there is an inverse relationship between urban sprawl and informal housing. An increase

in total urban land use, *ceteris paribus*, would reduce the equilibrium price of land in the formal sector and reduce the incentive for households to occupy residences in the informal sector, reducing the share of housing produced informally. An increase in the share of housing produced in the informal sector would, by reducing land available for formal sector development and increasing the share of population housed in high-density informal settlements, create more compact cities.

Thus we have two perspectives that compete as explanations for linkage between total urban land use, or urban sprawl, and the extent of informal housing. In the sections below we draw upon a unique data resource to explore the nature of this relationship in a cross section of cities around the world.

3 The data

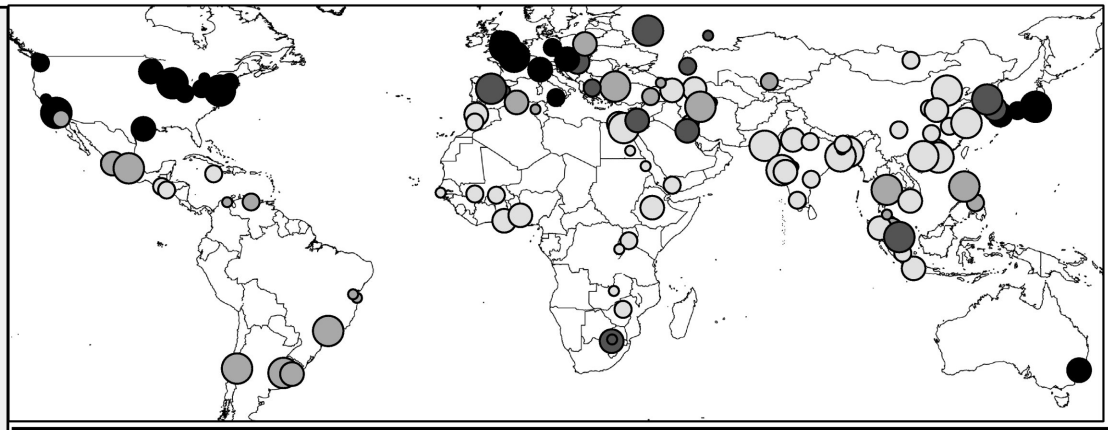
The data we analyze provide a measure of the total urban land cover in 120 cities around the world, at two points in time about a decade apart. The cities included in our sample represent a random sample of all urban places in the planet having metro area population in excess of 100,000 persons. The sample is stratified to ensure representation of cities by broad income group, size class, and global region. Thus we have a representative sample in the sense that the proportion of the global urban population that lives in small cities in low-income countries in Latin America (for example) is similar to the proportion of population in our total sample who lives in small cities in low-income Latin American cities. The location of cities, along with indicators of size and income category, is illustrated in Figure 1 .

For each of these cities, we bring together several types of data: satellite images that were analyzed to measure the total urban land cover in each city, detailed local data collected by field researchers who visited each city, mostly in 2005-06, and national level data for the country in which each city is located collected from World Development Indicators and from other global data sources.

We obtained Landsat TM or ETM[2] satellite images for two points in time, approximately ten years apart. The earliest images are from 1984, and on average the first images are from autumn of 1989. The lastest images are from late 2002, and on average the second images are from fall of 1990. Thus on average, the two images are about eleven years apart. These satellite images are divided into pixels that correspond to an area on the surface that is 28.5 meters square. For each pixel the image provides 6 or 7 brightness levels of light, three in the visual spectrum and three in the infrared region. These brightness

[2]The TM or Thematic Mapper instrument was included in Landsats 4 and 5 and so potentially provide data from late 1982 through 2007. The ETM or Enhanced Thematic Mapper instrument is on Landsat 7 and so provides data beginning in late 1999.

Sources:
World Development Indicators
National Censuses and
Author's Calculations



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

Figure 1: Distribution of global urban sample

levels are used to "classify" the image. This means that an analytical procedure is used to sort pixels into categories corresponding to an estimate of conditions on the surface. The classification scheme used was simple and sorted pixels into three categories: urban cover, non-urban cover, and water. A supervised, three-pass cluster analysis procedure was used for each image. Pixel-level analysis and comparison with ground photographs taken by the field researchers indicates that pixels are correctly classified in between 85 and 90 percent of the cases. The concern in this analysis is with the aggregate urban land cover for the entire urban area. In a typical city, there will be well over a million pixels so that on average we expect the accuracy of measurement of total urban land use to be very high.

As noted above, each of the cities in the sample were visited by a field researcher, typically someone who is familiar with the city. The field researchers collected data on local population and housing conditions, the nature of local planning systems and planning institutions, local house prices and conditions, the extent and conditions of housing located in informal or squatter settlements, local housing finance, and local transportation and travel conditions. Each field researcher was provided with survey forms to complete and instructions, and were selected based on familiarity with the local city and conditions.

The data collected on the informal sector ranged from basic information on the share of housing in the urban area that could be characterized as informal to detailed characteristics of structures and conditions in individual settlements selected to visit. In a couple of cases, extensive information was available on the nature and frequency of informal housing settlements, and before proceeding to an analysis of the entire sample, it might be instructive to consider some of these data.

One city where extensive data were available was San Salvador, the largest city in El Salvador. With a metro population of about 1.83 million, the municipality of San Salvador has identified 138 separate informal settlements. Together these accommodate over 18,000 families, just under 100,000 persons. The settlements were established as early as 1890 and as recently as the late 1990s. They range in size from 5000 houses to about 7. Their locations, projected over the Google Earth image of the city, are shown in figure 2.

Note that while there are 17 municipios that comprise the San Salvador metropolitan region, the data are collected and displayed only for the largest (and most central), San Salvador itself. While the locations of settlements are scattered over the entire municipio, they tend to be concentrated at the periphery of the jurisdiction. These are also areas where the slope of the land tends to be greater and the value within the formal sector is correspondingly reduced.

Policies towards the informal settlements in San Salvador have proceeded along lines similar to those

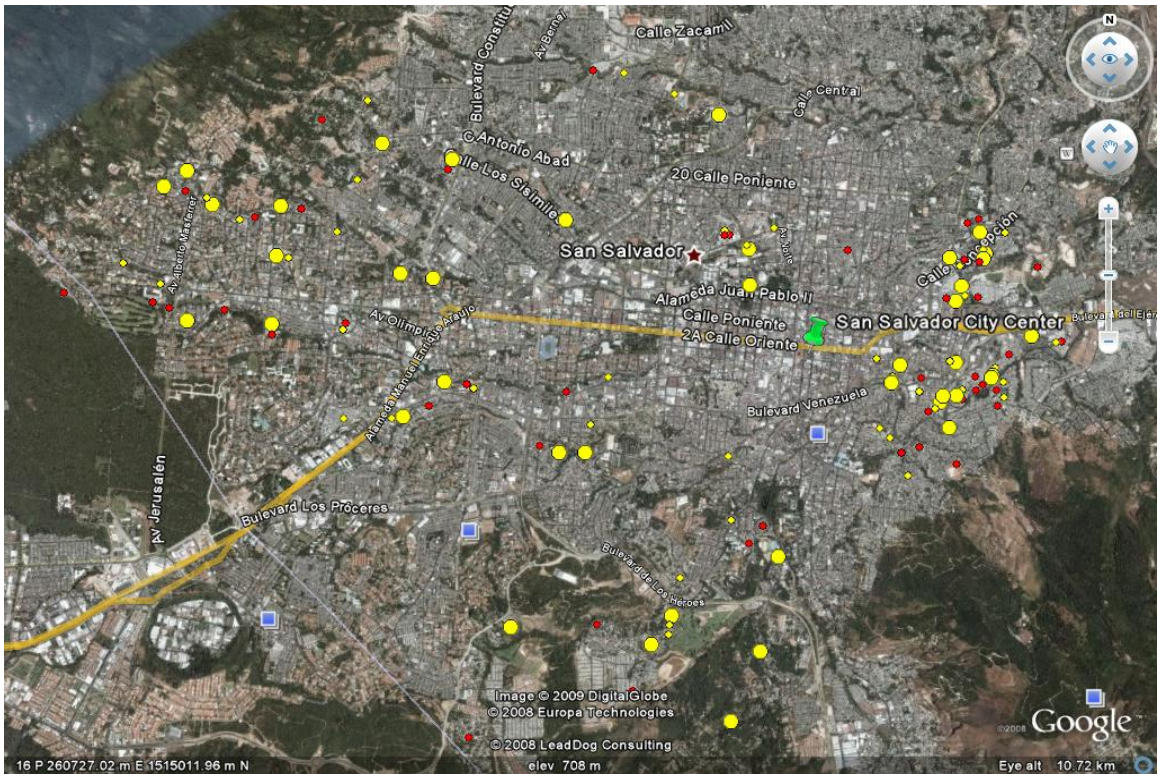


Figure 2: Informal Settlements in San Salvador

practiced in many other Latin American cities. Those settlements that are too large to evict and that are located in areas that are reasonably safe for residential location are offered an eventual path to legal status with title. This takes place over time, so that at a given point in time some settlements will be "legalized" and occupants will be given title to the land, some will be "in progress" and others will be "partially legalized." This will apply also to settlements where a subset of the residences are unsafe. For example, an informal settlement where some of the structures are subject to periodic inundation and flooding, or are built on slopes that are unstable and unsafe.

Figure 3 shows the location of the settlements with some additional information. The size of the disc representing the location of the settlement is proportional to the number of houses present, with the largest discs indicating settlements of 1900 to 5000 houses and the smallest indicating settlements of up to 86 houses. The shading of the disk indicates its legal status, with green indicating legalization that is either full or in progress. Yellow indicating partial legalization (which may never be complete). Orange discs have been ruled illegal settlements and have no pending plans for legalization. Red discs are officially "unknown" but most of them are newer settlements and will eventually make their way into one of the other categories.

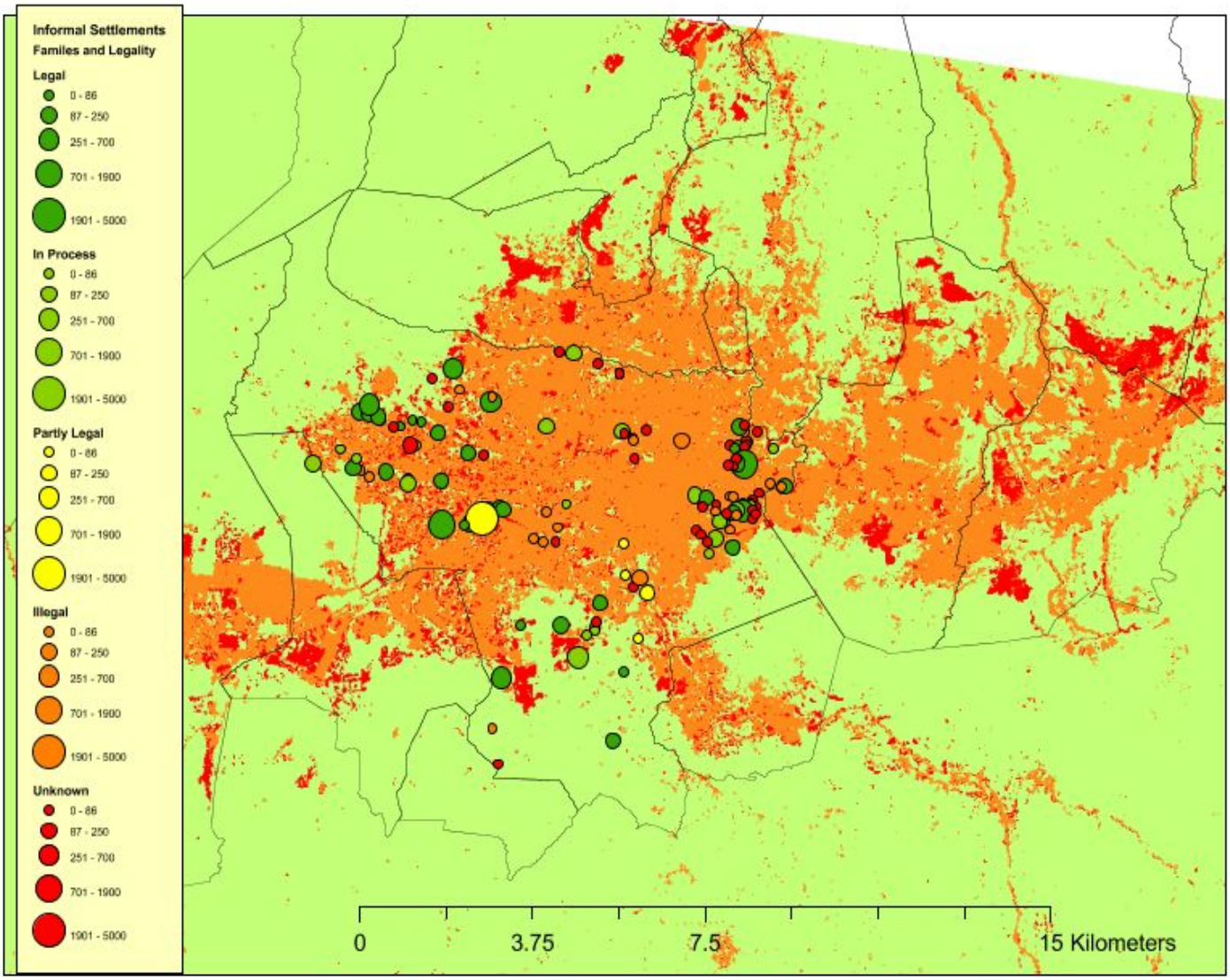


Figure 3: Informal Settlements and Urban Expansion in San Salvador

Figure 4: Community of 10 October, San Salvador

The orange shaded areas in figure 3 show the 98.5 square kilometers of urban land cover that have been measured from the satellite image taken in January of 1990. The red areas show the added 30.4 square kilometers of new urban development that occurred between the time of the first image and the second image taken in October of 1999. While the largest blocks of this new development take place near the urban periphery, closer inspection shows that there has been considerable "infill" development, particularly in the west or northwest portions of San Salvador municipio itself, an area where there is also considerable amounts of informal development. During the 1990s (between the times of our two satellite images) there appears to have been about 1400 houses built within the informal sector, accommodating about 7000 persons.

It is interesting to see what in individual informal housing area within the city looks like. Figure 4 shows an example of one area, located in the west-central area of the city. The figure shows a typical signature, with no (or very few) visible streets or roadways within the settlement itself, and apparently very high density of structures. The settlements are often located along or near streams, which initially are used as a source of water and provide a type of waste removal. In the high resolution data available via Google Earth and illustrated in figure 4, the informal settlements can sometimes be readily identified, although smaller

settlements, often associated with occupied buildings that have been taken over by occupants, are less clearly distinguishable. The higher resolution data are of limited value for analysis of retrospective data such as that presented below. The higher resolution data are mostly not available prior to the middle or late 1990s. For future studies, however, such data might be usefully studied and used to try to distinguish the land area that is used for provision of informal housing.

The data collected in San Salvador presented a special opportunity made possible by cooperation and unusual level of organization and professionalism of the municipal planning system. More generally, such data are not available, and in order to obtain our estimates we use the data collected by our field researchers, augmented by other data available from UN Habitat, national censuses, and other sources in each country or city. Table 1 present basic descriptive statistics on the variables that are of central interest to us and are used in our analysis below.

Data on income, cost of motor fuel, prices, exchange rates, and other national level variables available in World Development Indicators are combined. These include, where required, estimates of real value added per hectare of land under cultivation (as a proxy for the value of agricultural land). Data for the informal sector, on specific informal settlements visited, and on the planning system were all collected by the field researchers. As indicated, cities in our sample have an average of about 15 percent of households accommodated through the informal sector, about 9 percent of these reside on land to which they do not have title. While a large majority of informal housing units have access to electricity, fewer than half have access to piped water or a toilet within the residence. On average, they are over 300 meters from a paved road and over 400 meters to the nearest bus stop. While the amount of land occupied by each household varies widely, on average they are very small - averaging just over 160 square meters of land for a household of more than 5 persons.

Population data from national censuses was used for subareas within each city. These varied in size, and for some cities (Paris, Johannesburg, all US cities) the areas were small (similar to census tracts) but for other cities (for example, Accra and Cairo) the subareas for which population data were available were relatively large, and often extended well outside the built up area of the city. When the jurisdictions were completely covered by the available satellite imagery, we included the entire jurisdiction. If the image did not cover the entire jurisdiction, we estimated the population that would be expected to be within the image area by assuming an exponential population density function. We also assumed constant rates of change in population between the two censuses nearest our image dates, and interpolated (or extrapolated)

Table 1: Descriptive Statistics

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs**
Date T_1	Sept. 1989	821 days	June 1984	Jan. 1995	240
Date T_2	Nov. 2000	312 days	July 1999	Dec. 2002	240
Years between T_1 and T_2	11.24	2.21	5.19	16.97	240
Population T_1	3,070,370	4,093,421	93,041	25,100,000	240
Population T_2	3,655,243	4,780,547	126,042	27,200,000	240
Urban Area T_1	345.2	583.95	8.92	3748.22	240
Urban Area T_2	460.41	677.55	15.79	4268	240
Income T_1	8884.54	8897.84	609.88	29553.1	240
Income T_2	10943.62	10741.58	678.13	35354	240
Income Growth	0.02	0.03	-0.08	0.09	240
Fuel cost T_1	0.48	0.27	0.02	1.25	240
Fuel cost T_2	0.76	0.38	0.09	1.56	240
Agri land value T_1	3522.33	14393.31	84.9	150542.9	240
Agri land value T_2	3172.96	10429.28	68.84	109631.4	240
Location:					
East Asia	0.13	0.34	0	1	240
Europe	0.13	0.34	0	1	240
Latin America	0.13	0.34	0	1	240
North Africa	0.07	0.25	0	1	240
Other Developed	0.13	0.34	0	1	240
South-Central Asia	0.13	0.34	0	1	240
Southeast Asia	0.1	0.3	0	1	240
Sub-Saharan Africa	0.1	0.3	0	1	240
West Asia	0.07	0.25	0	1	240
Informal sector:					
Share Informal	0.15	0.2	0	0.8	224
Share Squatter	0.09	0.12	0	0.55	218
Recent illegal subdivision	0.58	0.49	0	1	182
Recent land invasion	0.55	0.5	0	1	178
For informal settlements:					
Persons in household	5.78	2.54	1	23.33	166
Income	574.81	762.33	0.58	5794.28	164
Price paid for plot	92.72677	136.7323	0	624.5878	130
Average plotsize	161.57	253.5	0	1633.33	164
Share with electricity	0.88	0.33	0	1	176
Share with piped water	0.45	0.46	0	1	166
Share with toilet	0.4	0.43	0	1	166
Distance to bus route	422.66	421.52	10	2000	146
Distance to paved road	312.48	548.88	0	3500	164
Planning system:					
Planning has police power	0.55	0.5	0	1	194
Share Applications Denied	0.31	0.34	0	1	140
Share Applications Allowed	0.6	0.36	0	1	126
Number demolition orders	193.74	1180.94	0	10000	154
Number stop-work orders	240.26	625.91	0	3500	146
Months to subdivide land	5.68	8.78	0.08	75	206
Months to convert land	13.8	44.48	1	416	182

the population to the date of the satellite image[3].

4 Results

A central concern in estimating the determinants of urban land use (and the size of the informal sector) is the extent of endogeneity in the relationships. This endogeneity may be manifest in several ways. Consider modeling of urban land use. A standard model of the urban land market implies that total urban land use should depend on population, income levels, transport costs and agricultural land values. To these variables we will add the share of housing made available in the informal sector in order to investigate the alternative views of the impact of informal housing on sprawl, as well as fixed effects for global regions.

Factors such as income, population, and the level of informal housing itself will not generally be deterministic and fixed, but will vary with local economic conditions. Thus, for example, a metro area that randomly receives a negative shock to its stock of urban land cover will likely have its income level affected as well[4]. This implies that the assumed stochastic independence between the model error and the "independent" variables will fail, and OLS estimates will be biased and inconsistent.

More specifically in the case of understanding the informal sector, this lack of independence may arise because there is causal simultaneity between total urban land use and the size of the informal sector. In this case we desire a full analysis of the relationship both to understand the nature of the processes determining these forces and to potentially inform policy decisions about them.

We approach this problem in two ways. First, we use an instrumental variables approach in modeling total urban land use, taking the share of housing produced in the informal sector as an explanatory variable. For instruments we rely on several variables that have proven useful as instruments in earlier papers using these data. We make use of the indices of ethnic, religious and linguistic "fractionalization" discussed in Alesina, *et al.* (2003). The location of the center of each urban area was determined (the centroid of the measured urban land cover) and used to determine latitude and longitude. These locations were combined with data on "biomes" - a classification of soil type and prevailing climate conditions - and these agri-climate indicators were used in the analysis. The global distribution of biomes is illustrated in Figure 5.

[3]This explains why the smallest city in our sample is listed as having a population in the earlier time period of less than 100,000. While all of our urban areas had 1990 populations of 100,000 for the metropolitan region, this was not quite true once we had truncated some sub areas to account for portions not covered by the satellite image and adjusted for the satellite image date.

[4]Cities damaged in earthquakes would be an example.

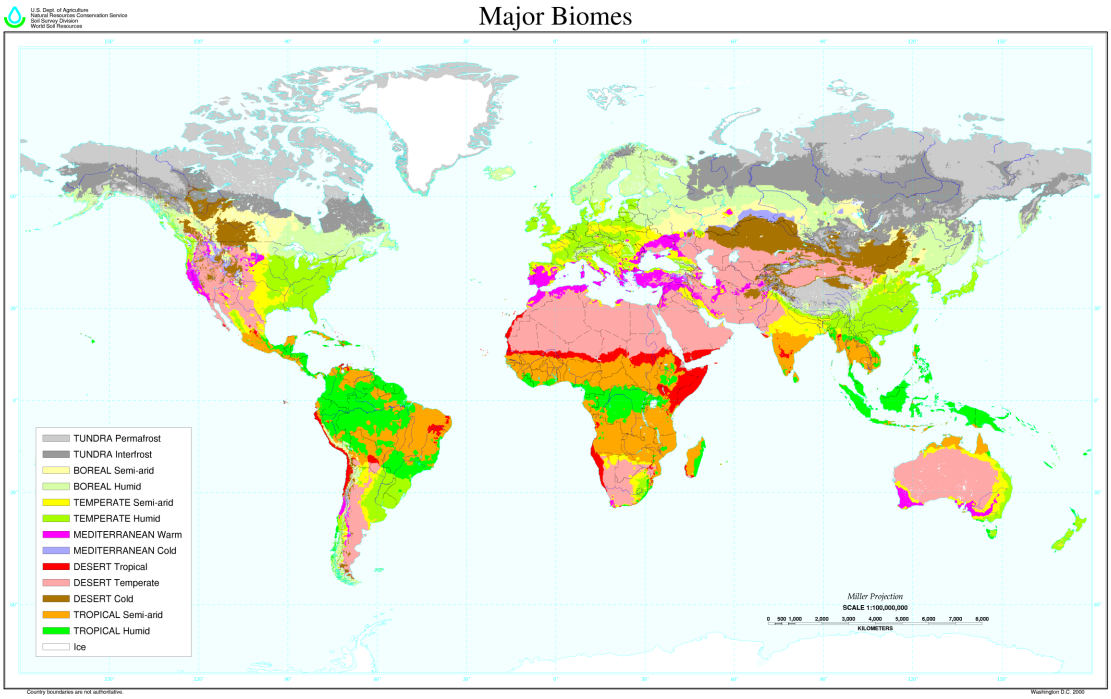


Figure 5: Map illustrating biomes used as instruments

The intuition behind the use of these variables is that the biome in which a metro area is located is stochastically unrelated to how much urban land cover occurs in the city, but it does provide an indicator of some of the types of shocks to which urban and other local land uses might be subject. Beyond this, the fractionalization of the country in which the city is located provides an indicator of the social responses that might take place when these shocks occur, but the the fractionalization itself is the product of a more lengthy history and development in the region and so is (at least mostly) independent of the level of total urban land use. In addition we use the physical location (latitude and longitude) of the city and the presence of shallow ground water as instruments. The model estimated is of a logarithmic form, so that estimated parameters can be interpreted as elasticities. Table 2 presents the results of the instrumental variables estimation.

The instrumental variable model estimates provide an interesting and encouraging view of the relationship. First, note that population, income, and agricultural land value all have the expected sign and are statistically significant. They also make sense in the context of the standard model of urban land use. Doubling population should increase total urban land use, but not double it. The estimates indicate that doubling population is associated in our cross-sectional data with an increase of urban land use of about 62 percent. Doubling per capita income is associated with a 53 percent increase in urban land use. Increasing

Table 2: Instrumental Variables Estimates

Population	0.6221***
	0.097
Income	0.5353***
	0.087
Informal Share	-0.2081***
	0.050
Fuel Cost	-0.0274
	0.050
Agri Rent	-0.2363***
	0.038
East Asia	0.6352**
	0.251
Europe	-0.1083
	0.158
Latin America	0.5607**
	0.249
North Africa	0.7304**
	0.367
South-Cent Asia	0.4252
	0.272
Southeast Asia	0.3405
	0.278
SubSah Africa	1.1193***
	0.306
West Asia	0.5943**
	0.255
Constant	-7.8164***
	1.337
Observations	212
Fuel Cost	23.19
Centered R^2	0.8
Kleibergen-Paap underid	11.57
Hansen J	22.39***

fuel costs, while not statistically significant, is at least working in the direction we expect.

Most interestingly, the impact of informal housing is negative and significant. A doubling of the share of housing produced in the informal sector (for example from the sample mean of 15 percent to 30 percent) is associated in our data with about a 21 percent decline in urban land use, holding all other factors constant. This relationship appears to have been little studied and clearly deserves further and wider investigation. If supported and confirmed it underscores an important tradeoff for policy makers: that the cost of reducing the amount of informal housing in a city may be an increase in the total amount of urban land use.

A second and arguably superior way to explore this tradeoff is to view total urban land use and the share of housing produced in the informal sector as simultaneously determined. Again utilizing a logarithmic functional form, table 3 presents estimates of the determinants of total urban land and the share of housing produced in the informal sector. The model for total urban land use is identical to that used above. Informal housing production is modeled as a function of total urban land cover, population, income and regional fixed effects. Both equations also make use of the instrumental variables approach discussed above.

Again, the urban land use model performs very well, with variables having the expected signs and, except for fuel costs and some of the regional fixed effects, being statistically significant. Again, informal housing production is associated with reduced urban land use and exhibits a surprisingly strong impact on total urban land cover.

The model of informal housing's share in the total housing stock also performs well and presents some interesting results. Increasing population, holding everything else constant, tends to increase informal housing. Contrary to what many might expect, increasing income has essentially no statistically significant effect, although this might be understood as reflecting the fact that in the context of the equation, an increase in income alone will hold total urban land cover constant and this would be associated with an increased scarcity of urban space.

The effect of urban space is large and statistically significant. It is important to remember that these estimates are obtained in less than ideal circumstances. They represent the relationship that emerges in cross sectional data over a limited time span, and not necessarily the relationship that would hold in a particular city responding to a policy initiative. Consider, however, the implications for policy makers if this did hold in a particular city. In the approximately 11 years that elapse over which we measure urban expansion, the average city increased its urban land use by 25 to 30 percent. Suppose increases of this magnitude had occurred without the associated increases in population and income that did, in fact, take

Table 3: Simultaneous System Estimates

	Urban Land Use	**Share Informal**
Total Urban Land		-1.6221***
		0.302
Informal Share	-0.2903***	
	0.041	
Population	0.6207***	0.9646***
	0.079	*0.272*
Income	0.4058***	0.4300
	0.111	*0.295*
Agri Rent	-0.1667**	
	0.067	
Fuel Cost	-0.1901	
	0.149	
East Asia	0.5880*	2.0446***
	0.305	*0.720*
Europe	0.0762	0.5003
	0.185	*0.451*
Latin America	0.5979**	2.8388***
	0.266	*0.607*
North Africa	0.6666	3.3812***
	0.408	*0.879*
South-Cent Asia	0.4870	3.0494***
	0.364	*0.872*
Southeast Asia	0.2176	1.5143**
	0.320	*0.756*
SubSah Africa	1.1610***	4.1232***
	0.387	*0.908*
West Asia	0.5135*	1.6515**
	0.279	*0.681*
Constant	-7.5689***	-14.4129***
	1.437	*3.980*
Observations	212	212
R^2	0.76	0.52
χ^2	370.08	298.37

place. The estimates presented in table 3 imply that this would be associated with a 40 percent reduction in the share of housing produced in the informal sector.

5 Conclusion

Informal housing is widespread, particularly in the rapidly growing cities of the developing world. These cities are not only rapidly growing in terms of population, but are also characterized by extensive conversion of land from rural to urban use. Some policy makers and scholars have identified the informal housing sector as responsible in some way or indicative of the causes of urban sprawl. This view seems misplaced, and is not supported in the data analyzed.

Making use of a new and extensive data source providing a representative sample of urban places around the world, we analyze the determinants of total urban land use and investigate the extent to which a larger informal sector is associated with more or less sprawl. In these data, a larger informal sector is unambiguously associated with less urban land use. This effect is surprisingly strong.

Perhaps more interestingly, we find that permitting an expansion of urban land use could exert a potentially strong effect diminishing the extent of informal housing. This is supportive of the view that urban centers characterized by extensive informal housing sectors may be overly restrictive, and that facilitating expansions of urban land use on the scale that has been typical during the past decade could reduce by as much as half the number of households that are accommodated in residential conditions considered unacceptable by many.

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