Urbanization in the developing world: Too fast, too slow or just right?[1]

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Abstract: *We describe patterns of urbanization in the developing world and the extent to which they differ from the developed world. We next consider the extent to which urbanization in the developing world can be explained by conventional models of spatial equilibrium. Despite their relative poverty, developing world cities are relatively productive, provide surprisingly good access to safe water, sanitation, schooling and inoculations. They are home to a surprisingly small number of factory workers and a surprisingly large number of farmers. Developing world cities seem to do less well at protecting their residents from lifestyle diseases and crime, their female residents from domestic violence and their children from illness. The literature has suggested that urbanization in the developing is occurring `too fast' and also `too slow' to be consistent with conventional models of spatial equilibrium that are widely applied to the developed world. Despite many differences between developing and developed world cities, our new results combined with those in the literature suggest that models of spatial equilibrium remain a useful guide to understanding the process of urbanization in the developing world.*

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1. Introduction

We consider three questions about urbanization in the developing world. First, how does the ongoing urbanization of Africa and Asia differ from the historical experience of more developed countries, and what do these differences imply for policy? Second, parts of the literature challenge the relevance of the classic Roback model (JPE 1982) of spatial equilibrium to the developing world. What changes does the standard framework require in order to describe developing countries? Third, what evidence is there about the costs and benefits of living in African and Asian cities?

The dual sector model of urbanization links urbanization to technological change and structural transformation: over generational time scales, people move from rural farms to urban factories in response to higher productivity in cities.[4] East Asia and regions that urbanized prior to the late 20th century seem to follow this path. However, Sub-Saharan Africa [SSA] is different. Cities in Sub-Saharan Africa are growing when they are relatively poor and without the expected increase in manufacturing or decline in agriculture. There are many more urban farmers in Sub-Saharan Africa than we would predict from observing cities in other places and times.

Moreover, efforts to understand the equilibrium process governing the growth of today's developing world cities have given rise to a puzzle. The literature suggests that Africa is urbanizing `too early'. That is, at levels of income that are low enough to preclude the provision of basic infrastructure that `later' developing cities elsewhere could afford (e.g., Lall, Henderson and Venables 2017; Bryan, Glaeser and Tsivanidis 2019). However, a careful look at the available evidence, and some new results that we present, suggest that the puzzle is not why urbanization is happening so fast, but rather, why it is not happening even faster. Gollin, Lagakos, and Waugh (2013) point to the huge productivity gap between agriculture and urban industries especially in Africa, while Chauvin, Glaeser, Ma and Tobio (2017) find evidence of huge differences between urban and rural real incomes looking across four non-African countries. However, Gollin, Kirchberger and Lagakos (2017)'s research suggests that amenities in cities in Africa dominate those in rural areas. Together, this suggests that there are dollar bills left on the sidewalk: if people would just move to the cities, their incomes would rise, as would their access to the various other benefits that cities provide. Hence the puzzle, why aren't people moving to cities even faster?

We suggest two answers to this question. One possibility is that people are so attached to rural locations or that the rural-to-urban move is so costly that the large apparent benefits of urban life are still not large enough. In fact, empirical investigations into the importance of attachment to place and moving costs for location choices are just starting to emerge. On the other hand, casual empiricism is compelling: people have migrated away from hardship throughout history. Together, this makes it hard to place a lot of confidence in this answer.

As an alternative, we provide new evidence on the magnitude and importance of rural-urban differences in incomes and amenities. This evidence will suggest a second possible resolution of the puzzle of slow urbanization. The rapid early urbanization of developing world cities, in Africa in particular, provides many benefits; higher incomes, and access to electricity, clean water and inoculations. However, it also entail costs, a higher incidence of lifestyle diseases, poorer child health outcomes and greater exposure to crime. This suggests that the rural-urban trade-off may be richer than previously imagined and the

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[4] For example, Caselli and Coleman 2001, Lucas 2004, Michaels, and Rauch and Redding 2012. See Desmet and Henderson 2015 for a review.

apparent reluctance to urbanize may partly reflect an unwillingness to bear the urban burden of lifestyle diseases, poorer child health and crime.

Our new results are not based on the distinction between rural and urban per se, but rather on the way that various outcomes change with population density. We use the Global Human Settlements Layer [GHLS] data to measure population density all over the world at about 1km spatial resolution. This has several advantages. It allows a comparison of conditions in denser versus less dense places and skirts answering the tricky question of `what is a city?' It correctly treats space as a continuum, as in Michaels, Rauch, and Redding (2012) or Desmet and Rappaport (2017). It is consistent with studies that suggest that increases in urban productivity, `agglomeration economies', do not derive from total city population, but from population density (Ciccone and Hall, 1996; Combes, Demerger and Wang, 2019; Henderson, Kriticos and Nigmatulina, 2019).

Apart from the GHS, our new results rely on five main data sets. Using World Bank and UN data describing country level patterns of urbanization, incomes, and economic structure, we provide an overview of the urbanization process. Then, to construct density gradients for (dis)amenities and productivity, we use three geocoded surveys reporting on income and wages, amenities and crime. More specifically, the World Bank Living Standards and Measurement Survey [LSMS] reports urban incomes and wages for 6 countries in Africa. The Demographic and Health Surveys [DHS] report a variety of health, public facility, education, and household violence outcomes for about 40 countries, primarily in Sub-Saharan Africa and South Asia but also in South East Asia and Latin America. Crime data come from Afrobarometer which covers much of Sub-Saharan Africa.

We proceed by documenting key facts about cities and urbanization that have emerged in the literature over the last five years or so. We next turn to a discussion of spatial equilibrium and of the differences between rural and urban life that inform the rational choice of location. Finally, we will show that there are health and safety costs from living in very dense locations that the literature has overlooked.

2. Facts about urbanization

In this section we discuss facts about urbanization on which recent papers have focused.

2.1 The last frontiers of urbanization

Most major regions of the world seem to be fully urbanized. As shown in Figure 1, North America, Europe, Latin America and the Caribbean, and West Asia all have shares of the population living in urban areas over 68%, with most regions near 80%. They also have small growth rates in this share, all under 0.62% a year and most near 0.25% (UN, 2018). North Africa is only just over 50% urban but that number is stable with little further urbanization. The action is in East Asia, South-East Asia, South Asia, and Sub-Saharan Africa. Here, urban shares are generally lower and most annual growth rates range from 1.16 (South Asia) to 1.86% (East Asia). Among these four regions, East Asia seems to be following a different path. While it still has rapid urbanization, it is now over 60% urbanized and should soon top 70%, as in more developed regions. Given this, much of our attention will focus on Sub-Saharan Africa and South Asia.

2.2 Early urbanization

Lall et al. (2017) and Bryan et al. (2019) observe that Sub-Saharan Africa is urbanizing `early'. Specifically, SSA surpassed 40% urban share in 2010 at a 1990 PPP GDP per capita of just $1481. Latin

America passed the 40% mark in 1950 at a 1990 PPP GDP per capita of $2500, about double the SSA level. East Asia surpassed a 40% urban share in 2000 at $5451[5], twice as large again. For reference, in 2010, the 1990 PPP GDP pc in Western Europe was $20841, 15 times that of Sub-Saharan Africa; while in 1900, 1990 PPP GDP pc in Western Europe was at least twice that of Sub-Saharan Africa today. In short, the developing world is urbanizing at low levels of income. This is particularly true in SSA.

Why does urbanizing while poor matter? The productivity benefits of high employment density require high settlement densities, and poverty affects the ability of the public sector to deal with the negative externalities involved in dense settlements. We know from Fujita and Ogawa (1982), Heblich, Redding and Sturm (2018), Akbar et al. (2019) and Tsivanidis (2019) that clustering of employment requires transportation infrastructure to allow large numbers of workers to reach firms in city centres or peripheral industrial and commercial zones, and also to allow firms to get their goods to markets. This infrastructure is expensive. The sewer systems and safe water supplies required to improve health and reduce mortality from disease (Kappner 2019) at high population densities are also expensive. Poor countries lack the money to undertake significant investments to make their cities run better; and, with rapid urbanization, are always playing a game of catch-up. But it not just money. Cities require institutions to collect taxes, keep order and govern land. It is natural to suspect that institutions and state capacity reflect the income and education of the population. Given this, early urbanization poses enormous challenges in governance.

2.3 Why is urbanization happening?

While East and South East Asia have followed the traditional structural transformation path, we see in Table 1 that parts of South Asia and Sub-Saharan Africa have not developed a large manufacturing sector. SSA, in particular, is not following the same path of spatial and structural transformation as the rest of the world. Countries like Brazil and Argentina each had about 30% of GDP in manufacturing in 1980 even as urbanization was starting to slow, while China was over 40% in 1980 as urbanization was taking off (World Development Indicators (2018)). As of 2017, East Asia has 27% of GDP from manufacturing, China about 29% and South East Asia 22%. East and South East Asia maintained high manufacturing shares over the whole 1990 to 2017 time period. Latin America's manufacturing share started at over 20% in 1990 and declined to just over 15%.

In contrast, the 33 countries of Sub-Saharan Africa that our data describe (excluding South Africa) have the lowest regional share of manufacturing worldwide in 1990, a share that has only declined over time. While other regions have experienced declines in manufacturing share, they tend to be richer countries that are deindustrializing in favour of traded services. In general, most of Sub-Saharan Africa has never had a developed manufacturing sector beyond production of traditional goods for within country consumption. The dual sector model of urbanization predicts that urban populations arise as farmers move to cities to work in factories making manufactured goods. SSA, and to a lesser extent South Asia, has few manufacturing employees and their numbers are growing slowly. Thus we are led to wonder what, exactly, is driving urbanization in these regions?

This question has led to a literature on consumer cities. This literature began with Glaeser et al. (2001) and was extended to developing countries by Gollin, Jedwab and Vollrath (2016). The latter paper demonstrates that in Asia and Latin America there is a strong positive correlation between urban share and the GDP share of manufacturing and services. However, they find that in Africa and the Middle East, no such correlation exists. They conclude that urbanization in Sub-Saharan Africa and the Middle East is

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[5] These numbers on GDP are from Bolt, Timmer and van Zanden (2014). In 2010 the 1990 PPP income for South and South East Asia was $3537 with South Asia still well under 40% urbanized today and SE Asia only having passed that mark about 2005.

driven by rents from natural resource exports, which they conjecture are distributed in cities. Related evidence shows that natural resource exports revenues affect exchange rates and wage costs, crowding out manufacturing and its technological spillover benefits (Sachs and Warner, 2001; Ismail, 2010; Alcott and Keniston, 2017)

Henderson and Kriticos (2018) also examine the relationship between urbanization and the GDP share of manufacturing, services, and rents from natural resource exports. Consistent with Gollin, Jedwab and Vollrath (2016), urbanization in SSA is not correlated with the manufacturing and services share of GDP, while in much of the rest of the world it is. However, while natural resource rent increases are associated with increased urbanization in Asia, North Africa and the Middle East, the relationship is weak to non-existent for Latin America and Sub-Saharan Africa. This differs from Gollin et al. (2016). More generally, variation in urbanization within Sub-Saharan Africa is not well explained by GDP shares in manufacturing, services and resource extraction, although this may partly reflect measurement error or outliers in SSA data.

If urbanization in SSA is not a consequence of structural transformation and is not related to natural resource rents, then what drives urbanization?

Agricultural productivity in Africa is low, reflecting low irrigation, fertilizer usage rates, and an attachment to old seed technologies (Ray et al. 2012, Sanchez 2010). Cereal yields in SSA are half those of South Asia which in turn are half those of those of high income countries and well below East Asia and Latin America (Henderson and Kriticos, 2018). Henderson, Kriticos, and Nigmatulina (2019) show that urban incomes are enormously higher than rural incomes in Africa, conditional on education, age, gender and the like. While this is an important benefit of urban density in Africa, it reflects a big increase relative to low rural productivity.

Table 2 shows that African cities house an inordinate number of farmers. In a sample of 12 African countries with a total population of 220 million for which there is relevant IPUMS data, the share of agriculture in urban employment ranges from 14 to 40%, and averages 20.5%. In fact, in the bottom 75 percentiles of cities by size, the share of agriculture in urban employment averages 40% in SSA. In contrast, in Brazil, India and Malaysia, shares of urban farmers are all under 7.5%. Table 2 also shows that in these African countries, 88% of rural sector employment is in farming. This is far higher than other countries, where rural services, construction and even manufacturing employment are more important. Note the especially small manufacturing share in smaller African cities and towns. Most likely, any manufacturing in these places is traditional food processing, non-metallic minerals, locally made furniture, weaving and the like.

These facts suggest that, apart from primate cities, African cities are home to many farmers who live in cities and work nearby. Why do farmers move to these small and middle size cities? One answer may be to access better amenities and public services, as well as consumer services (related to the absence of anything but farming in the rural sector). Another answer may be the better employment opportunities for other family members, both in terms of hours worked and the diversity of occupations available (Henderson, Kriticos, and Nigmatulina 2019). We note from Henderson and Kriticos (2018) that potentially tradable urban services, like finance seem, to be growing at extraordinary rates, but from a very low base. With this said, evidence for the current level and trajectories of urban employment by sector is fragmentary. Understanding how Sub-Saharan Africa is developing remains a subject of debate, and one that would benefit from more and better data.

2.4 What kind of cities do people live in

When people think of urbanization, they tend to think of very big cities. However, on the basis of UN definitions, Figure 2 shows that in most regions of the world 52-75% of the urban population lives in cities under 1 million, with only North America and East Asia having lower shares. Moreover only in South Asia, East Asia, and North Africa (Cairo effect) does the share of the urban population living in cities over 10 million reach 15%. In many regions this share is around 4%. In Figure 2 we see that the differences between regions in the population shares of big versus small cities is small. Given the high universal share of urban population in cities of small and medium size, surprisingly little of the policy debate is focused on living conditions in these places.

There is a large literature on why sizes of cities differ, starting with Henderson (1974) on city specialization in production, with many subsequent papers (e.g. Duranton and Puga 2001; Rossi-Hansberg and Wright 2007). There is also a literature on Zipf's law, beginning with Gabaix (1999), which focuses on stochastic processes which generate differential city sizes. Finally, there is a more recent literature focused on natural amenities as drivers of city size differentials (e.g., Duranton, 2007; Albouy, Behrens, Robert-Nicoud and Seegert, 2019; and Behrens, Duranton and Robert-Nicoud, 2014). To date, there has been little effort to investigate the extent to which these ideas apply to the developing world, SSA in particular.

3. Cities versus density

Much of the literature focuses on total city population or employment as the source of agglomeration economies that operate uniformly on all city employment. There are notable exceptions, however. Michaels, Rauch and Redding (2012) or Desmet and Rappaport (2017) both allow agglomeration economies to vary continuously with space and density in their work. Our results belong to this second strand of the literature; we estimate gradients describing how a variety of outcomes vary with population density. There are two main reasons that we pursue this strategy.

First, classifying people as `urban' or `rural' presupposes a definition of cities that is consistently applied across locations. This is a difficult problem on its own. Available classifications of a place or person as `urban' are based on country specific definitions implemented using data that may also vary qualitatively from country to country. As in Figure 3, the basic data source is the UN world cities data. These data rely on host-country definitions to classify people as urban or rural and to calculate city sizes. Unsurprisingly, these definitions are not consistent across countries and may involve subjective assessments of whether an area is urban. Such assessments may depend, for example, on whether an area has certain public facilities, administrative responsibilities, or has a central economic core. Moreover, the extent of metropolitan areas is typically based on the boundaries of country specific administrative units (e.g., counties). In some cases, national definitions, especially for capital cities, tend to severely restrict official urban area size on the basis of historical criteria like a defined national capital zone (e.g. Jakarta).

There has been at least one effort to overcome these problems and provide consistent city definitions for the entire world. The GHS Settlement Model (GHS-SMOD L1) bases city status purely on density and population cut-offs. Starting from gridded population data, `cities' are defined as sets of contiguous 1 km grid cells having density over 1500 people and summing to over 50,000 people. The GHS also constructs `towns' and `suburbs'. These sets of contiguous pixels have density and size thresholds of 300 people per sq km and 5000 in total. Ultimately, such definitions seem arbitrary and not well grounded in economic theory. That is, it would be hard to argue that an agglomeration of people satisfying such a definition would precisely describe a labor market.

By basing our investigation directly on population density, we avoid this classification problem altogether.

The second reason for basing our investigation on population density rather than city population is that outcome measures actually seem closely connected to density. For developing counties, there is evidence that agglomeration economies may arise more from density rather than absolute labor market size (Chauvin et al., 2017; Combes et al., 2019; Quintero and Roberts, 2018; and Henderson, Kriticos and Nigmatulina, 2019).

3.1 How to measure density

Gridded Population of the World version 4 (GPWv4; CIESIN 2017) [GPW] is the best known gridded population data. Its population estimates are based solely on population numbers for administrative regions (polygons), typically from circa 2010 censuses. While its nominal resolution is about 1km, it is based on population data that is organized by census enumeration units that may be larger or smaller than its uniform grid cells. Rich countries often provide data based on small enumeration units, although such units are often drawn to contain approximately constant population and so may vary dramatically in area. Of the 12.9 million polygons that form the basis for the global GPW, only 2.4 million are from outside the United States. The GPW prorates enumeration unit population to GPW grid cells by assuming population is spread uniformly with each enumeration unit.

Rather than use the GPW data, we rely on the European Union's Global Human Settlements population layer (GHS-POP; Schiavina et al. 2019; Freire et al. 2016). These data are gridded population data that attempt to improve upon the GPWv4 by using remotely sensed measures of built cover to allocate population to grid cells within GPW enumeration polygons. The GHS allocates GPWv4 population to cells within enumeration polygons on the basis of the area of built cover reported in the GHS-BUILT gridded data (Corbane et al., 2018, 2019).[6]

Landscan data is an alternative source of gridded population data. These data rely on a proprietary algorithm to construct population estimates based on higher resolution satellite imagery than Landsat and information on airports and rails (see Rose and Bright, 2014). The algorithm is not publicly documented and changes from year to year. Moreover the estimates are for ambient population averaged throughout the day, whereas GHS-POP for the night-time (residential) population. We choose the GHS data because it is consistently defined over time and the algorithm is public.

3.2 Density and population

In Figures 3 a & b and 4, we present information about density based on density per sq km, for grid squares whose size is 1 sq. km at the equator (0.0099 degrees). We compare (UN definitions) Europe, North America, Sub-Saharan Africa, Latin America, and South Asia. We pool East and Southeast Asia together to improve the legibility of our figures.

In Figure 3a we graph the cumulated share of population by density. There is a clear takeaway. First the density gradients for the different regions display a pattern of (almost) first degree stochastic dominance. North America and then Europe have the highest accumulated shares of population at low densities. Sub-Saharan Africa and East and South East Asia have that lowest accumulated shares at low density, or equivalently, the highest degree of density inequality.

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[6] The GHS-BUILT defines `built cover' on the basis of Landsat 30-meter resolution satellite data circa 2015. In the rare cases where there is no built cover in an enumeration polygon, it reverts to the GPWv4 estimates. More information about the GHS data can be found in Florczyk et al. (2019).

Figure 3a makes clear that people in different regions of the world live at very different densities. In America and Europe less than 10% of the population lives at densities above 10,000 people per sq km. In Sub-Saharan Africa and in East and Southeast Asia 30-40% of the population lives at densities above this threshold, while for Latin America and South Asia, it is about 20%. To improve legibility, our graphs stop at 20,000 people per sq km, but the difference between the gradient and one at the figure's right-most edge gives the share of population living at densities above 20,000 per sq km. In Southeast and East Asia, 18-20% of the population lives at densities above 20,000 sq. km. In the developed world the proportion of people living at such densities is tiny. For the purpose of understanding density and its implications, the developed world probably cannot teach us much about the very high densities experienced by a significant portion of the developing world's population.

Figure 3b is complementary to Figure 3a. It graphs the cumulated share of population by area. For legibility it shows only the 3% of regional area that is most densely populated. Looking at the y-axis in this figure, we see that about 25% of the population of South and South East Asia occupy the 97% of regional area that is least densely populated. Gradients for North America and Europe lie below those for other regions, so that most of these regions' populations live on a very tiny fraction of regional land area. Combining the results of the two figures, North Americans live at relatively low densities, but occupy a large region, so most land is very sparsely populated. In most regions, over 90% of the population lives on 3% of the land area and in Latin America the number is close to 100%. Asia is the outlier and has 25 percent of the population living outside the 3% of densest GHS grid squares. That reflects two things. First is the larger fraction of Asian land employed in labor intensive agriculture. Second, in much of Asia compared to the rest of the world, there is a high ratio of national population to land area, forcing use of a greater proportion of land.

However, even in Asia, there is still a lot of room for people to live at higher density: 25% of the population occupies 97% of the land area. Moreover, many Africans live at high densities, while most land is unoccupied. There are many other factors apart from regional land availability per person determining the patterns of population density and land use that we see in Figures 3a and b.

Figure 4 describes the relationship between city size and urban population density. To construct Figure 4, we rely on the 657 cities described by the UN World Cities data. These are cities that housed more than 300,000 people at any time between 1950-2010. For each city, the UN World Cities data reports the latitude and longitude of the center of the city. We draw a 50km radius disc around each such centroid and sum GHS population in this disc. This is our measure of `city population' in 2015. To measure population density for these cities, we calculate the person weighted density of grid cells within each city's disc. Figure 4 presents local polynomial regressions of the relationship between city population and density by region.

In most regions of the world, higher densities are associated with larger city populations. This pattern is clear in North America. However, in Africa the relationship is weak. For most regions of the world, mean population density in the 50km disk rises quickly with total population above about 450,000, although in North America the take-off point is near 750,000. Africa differs. Below 450,000 and above about 2 million, African cities have higher densities than in other regions. Second, as city sizes then increase in Africa, density rises relatively slowly.

4. Roback meets urbanization

The Roback (1982) model is the workhorse model for thinking about spatial equilibrium. In the original model, people are identical and move across space to equalize utility levels. An important innovation in the recent literature has been to introduce moving costs and different forms of individual heterogeneity. In such a model, the notion of equilibrium is qualitatively different. People do not move across locations until all agents everywhere have the same utility. Rather, all agents choose their favorite location, taking account of the cost of moving there from their starting point. As a consequence, not all agents in a location receive the same level of utility. This means that welfare calculations require, for example, that we consider the surplus captured by infra-marginal agents who stay in locations they like or that we consider the losses to those stranded in places that they don't like by high migration costs.

To illustrate, suppose there are urban and rural locations, *U* and *R,* indexed by *j.* A continuum of people, indexed by *i*, choose between these two locations. Let I_{ij} denote the income person *i* realizes in location *j.* Each location has an 'amenity', A_j , that is valued similarly by all agents, e.g., up to income effects. These amenities represent location specific attributes like the availability of safe water, the prevalence of crime, or the difficulty of commuting. In addition, each person receives a pair of idiosyncratic `affinities', $(\varepsilon_{iR},\ \varepsilon_{iU})$, that reflect how strongly person i is attracted to each location. These draws reflect things like a taste for local weather or landscape and can also represent the presence of family members or roots in the home location.[7] To move between locations, agents must pay a migration cost, τ. Finally, agents derive utility from income, amenities and their idiosyncratic attachment to places according to $V(I-\tau, A, \varepsilon)$, which we assume to be increasing and continuous in all arguments.

In a static spatial equilibrium where at the margin real incomes are declining in population in each region, no one should want to move. Using the notation above, this requires that,

$$V(I_{iU}, A_U, \varepsilon_{iU}) \geq V(I_{iR}-\tau, A_R, \varepsilon_{iR})\ \forall\ i \in U$$

$$V(I_{iU}-\tau, A_U, \varepsilon_{iU}) \leq V(I_{iR}, A_R, \varepsilon_{iR})\ \forall\ i \in R$$

That is, no one wants to move badly enough to pay the cost of moving required to do so.

The notion of spatial equilibrium provides us with a powerful framework for organizing our ideas about what causes people to arrange themselves across the landscape in the ways that we observe. At its heart, the model assumes that people act to arbitrage differences in productivity and amenities by changing locations. Their ability to conduct such moves is hampered by `frictions', moving costs and idiosyncratic attachment to a particular location.

In the simple case considered in Moretti (2010), where $\tau = 0$ and all people *within* a region receive identical real incomes and amenities, there is there is a marginal person whose draws of $(\varepsilon^*_{iR}, \varepsilon^*_{iU})$ make her exactly indifferent between U and *R*. In equilibrium, all individuals with affinity draws such that, $\varepsilon_{iR}-\varepsilon_{iU} \leq \varepsilon^*_{iR}-\varepsilon^*_{iU}$ will live in *U* and conversely. That is, everyone with a weaker relative affinity for *R* than the marginal agent chooses *U* . Note that the resulting equilibrium utility levels are not equalized across agents nor generally are real income equalized across regions.[8]

To illustrate ideas, we have stated the model in a very simple form. We suspect that people are `more biased' towards the place they are born. To accommodate this, some formulations shift the distribution of

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[7] In practice, these different draws are typically imagined to arise from an econometrically convenient distribution, most often an extreme value distribution.

[8] If the two regions offer identical amenities, endowments and technologies, agents are identical absent their affinity draws, and the distribution of the differences in draws is symmetrical about zero, then real income will be equalized and the marginal person will have $\varepsilon^*_{iR} - \varepsilon^*_{iU} = 0$. But if, say, the urban region has superior endowments or technologies we generally expect an equilibrium where the marginal person indifferent between regions has $\varepsilon^*_{iR} - \varepsilon^*_{iU} > 0$ and real incomes are higher in the urban region.

affinity draws for the `birth location' to the right of the other locations. While this is intuitively appealing, practically, it is similar to a change in moving costs in our formulation. While we assumed that moving costs are the same across people and independent of the direction of move, this assumption is clearly incorrect in many contexts. In China, for example, one would expect moving costs to vary on the basis of hukou status and the direction of the move.

Note that without restrictions on moving costs or idiosyncratic affinities, the model has no content. If moving costs are sufficiently high, we can rationalize any observed outcome. People are like trees, they stay where they are planted no matter how much their wages might increase if they moved over the hill. Similarly, we can always choose affinity draws such that everyone will want to stay where we observe them. We are just beginning to learn about the importance of frictions for mobility. In a static model, Tombe and Zhu (2019) find enormous moving costs for Chinese migrants from rural farms to urban factories. Moving within province costs migrants over half of their real income (at destination) and moving across provinces increases this to more than 90%. Similarly, Bryan and Morten (2019) on Indonesia argue that moving 1000 kms from the place of birth costs 40% of real income and moving 200 kms costs 20%. Note that these two papers, like us, rely on a static model, while 'migration' is explicitly a dynamic concept. This is a common issue in the literature, and reflects the difficulty of working with models of spatial equilibrium in which dynamics are explicit. This is, however, an important and active area of research (e.g., Balboni, 2019; Caliendo, Dvorkin, and Parro, 2019; and Ahlfeldt, Bald, Roth and Seidel, 2019).

Putting aside the relative lack of empirical evidence attachment and moving costs, if we are willing to assume that moving costs are not too large and that people are more-or-less all the same (i.e., that the differences in ε 's across people are small), then we should not observe the case where both amenities and incomes are much higher in one populated place than another. This logic forms the basis of the two critiques of spatial equilibrium noted in the Introduction.

The 'puzzle of early urbanization' arises from two observations. First, the highly productive urban manufacturing jobs that motivated much developed world urbanization are missing in much of the developing world. Second, the public sector of modern developing world cities seems inadequate to the provision of basic public services. In the language of the model, this suggests that urban amenities are either inferior to or not better than rural amenities, while urban incomes should not be much higher, if they are higher at all. Positing these facts, spatial equilibrium could require an exodus from developing world cities or little to no growth. Contrary to the observed rapid growth of population and slums in developing world cities, there should be no early urbanization.

The puzzle of early urbanization rests on two seemingly reasonable but probably incorrect deductions. The first is that the dearth of manufacturing jobs in developing world cities requires rural and urban wages and incomes be about the same. In fact, in spite of the lack of manufacturing jobs, recent empirical work and our own results indicate wages and household incomes in developing world cities are dramatically higher than in the countryside, even after we condition on individual age, gender and education. The second deduction is that the inadequacy of the public sector in developing world cities will result in worse provision of public services than is available in the countryside. This also appears to be at least partly incorrect. As we will see, the data show clearly that access to safe water, electricity and modern sanitation improve rapidly with urbanization. This leads to the symmetric opposite `puzzle of too slow urbanization'. If incomes are higher and so many other aspects of life seem better, then why don't we see more rapid migration to developing world cities?

Both of these puzzles pose a challenge to the relevance of spatial equilibrium for understanding economic geography. However, neither puzzle really challenges the hypothesis of spatial equilibrium. Rather they challenge the joint hypothesis of spatial equilibrium and economically unimportant mobility costs and spatial attachment. Given that we still know so little about migration costs and the role of individual heterogeneity in mobility, discounting the importance of spatial equilibrium seems premature. Moreover, as we will show below, a more exhaustive accounting will suggest that, while much about urban life is better than rural life, at least some things are worse. Therefore, even if mobility costs and spatial attachment are not economically important, provided people trade off the costs and benefits of urban life at plausible rates, current rates of urbanization in developing countries can be consistent with the sorts of spatial arbitrage that is the foundation of models of spatial equilibrium.

5. Evidence on how living conditions in developing countries vary across space.

Much as we do below, Gollin, Kirchberger and Lagakos (2017) look at the relationship between various outcomes reported by the DHS and population density in an area around survey respondents (really, around the location of survey clusters). They then examine the difference between the mean amenities of respondents living at the 80 or 90th percentile of the set of DHS cluster densities and those for people living at the 20th or 10th percentile. They find that survey respondents living in the higher density deciles typically have better amenities.

These results are interesting and important, but somewhat difficult to interpret. The DHS oversamples low density areas. Only 27% and 22% of the Sub-Saharan Africa and South Asia population measured by the GHS live in areas classified as rural by the GHS Settlement Model. However, these areas are home 74 and 71% of recent DHS respondent households respectively. As we see in Figures 3a and 3b, population is highly concentrated into very small, very dense regions in Sub-Saharan Africa and South and South East Asia. Learning about these centers of population requires that we focus attention on the densest grid cells and DHS clusters. The 80th or even 90th percentile of DHS clusters by density is not very dense.[9]

To learn more about how peoples' lives change with population density, we match various geocoded individual level surveys to GHS population density. This done, we are able to examine how survey responses describing income, health, education, public health and public goods vary with density in a large sample of developing world countries.

Our empirical methodology is simple. We regress survey respondent outcomes on the logarithm of population density in a 5km disk surrounding the respondent in two different specifications. In the first specification, we include the population density measure and an intercept. In the second, we add country indicators and a short list of demographic controls. Our control variables vary somewhat as the outcome in question reflects a household, person or child level outcome, and as the survey instrument varies. Broadly, they reflect the education, gender, and age of the household, person or child whom the survey response describes. What we present below is a first pass in analyzing multiple data sets, which deserve more in-depth work. Our results are suggestive.

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[9] This is really a question of weighting. Deciles of survey clusters tell us about the frequency of densely populated places, subject to rural over-sampling in the DHS. Yet, from Figures 3a and b, we know that high proportions of people live at high density. Thus, implicitly, the Gollin, Kirchberger and Lagakos (2017) methodology is telling us about the distribution of amenities across places, rather than across people. While this is interesting, given the small proportion of the landscape occupied by cities, it does not give us much information about the difference between the rural and urban experience.

This methodology has well known weaknesses. We will find a rapid rise in income with density. This rise persists, unattenuated, after controlling for a variety of household characteristics such as education, gender and age of the household head, and country fixed effects. However, omitted variables such as ability and ambition are surely also important, and may be the basis upon which people sort across places. If so, our regressions confound the effect of ambition with the effect of density. Resolving this inference problem is difficult, and beyond the scope of this project. There have been a few experiments which induce random variation in subject locations. Most are within city or involve refugee and other programs applied to very special populations (reviewed in Bryan et al, 2019). Extending these experimental and quasi-experimental methods to the larger set of outcomes that we consider is an obvious area for further research.

As is common, each of the surveys we use relies on clustering techniques to reduce costs. That is, they survey many randomly selected people near a smaller number of randomly selected `cluster' points and assign all such respondents the location of the cluster. For the Afrobarometer and LSMS surveys, cluster are generally located at the centroid of a small administrative unit, e.g., the finest census enumeration unit. To protect respondent privacy, DHS clusters are displaced by up to 2kms for urban respondents and up to 5km for rural respondents. This introduces some error into the respondent relevant measure of population density. Note that we also truncate respondents with population density below about $e^2 \approx 7.4$ people per km. We are suspicious of the accuracy of GHS estimates at low population densities, and observe dramatically wider confidence bands around non-linear regressions of outcomes on log density below this threshold.

Tables 3a and b present our regression results. For each outcome listed in the left column we report from left to right: coefficient of log density in a regression with no controls, the R-square of this regression, the corresponding coefficient and R-square from a regression that also includes the demographic controls listed at the bottom of each panel, the mean of the outcome and log population density in the no-controls regression sample, and finally, the count of survey respondents, survey clusters and countries upon which the no-controls regression sample is based.

Table 4 lists the countries covered by each of the three surveys, LSMS, DHS and Afrobarometer. Table 3's count of the countries on which each regression is based will sometimes be lower than that from Table 4. This primarily reflects the fact that some of the DHS survey units are conducted in only a subset of DHS countries. Throughout our analysis, we consistently use the largest set of survey respondents that is available for each particular question. As a consequence, some of the density gradients we report are based on quite different samples of countries. Given this, some caution is required in comparing regression results across outcomes. Refinements of these estimates are an obvious area for further work.

In addition to the linear regression of Table 3, in Figures 5-7 we conduct non-parametric and semi-parametric regressions of outcomes on log density in a 5m disk and we show these for *net income*, *access to sanitation*, and *diarrhea in a child five and under in the last two weeks*. In the non-parametric estimates we do not include controls. In the semiparametric regressions, we include linear terms for the same controls as listed in the relevant panel of Table 3a or b.

More specifically, Figures 5-7 rely on the binscatter methodology described in Cattaneo, Crump, Farrel and Feng (2019), as implemented in Stata. In these plots we show the outcome for an endogenous number of equal size bins. The confidence bands describe the region around local polynomial regressions in which we expect a local polynomial regression line to lie with 95% probability. Thus, the width of these bands informs us about the likelihood of highly non-linear relationships between outcomes and data. The figures also report a line of best fit, corresponding to what is reported in Tables 3 a and b. If this line falls outside the confidence band then a linear relationship can be rejected, at least locally. While generally the regression lines lie within the confidence bands, the illustrative graphs on which we report show very different widths for confidence bands.

To simplify analysis, we group outcomes by their source survey. Income and wages come from LSMS and crime from Afrobarometer. Female outcomes, child outcomes, infant mortality, household utilities, schooling, and adult lifestyle outcomes come from relevant sub-units of the DHS. These differ slightly in the information they collect. For example, only the DHS birth unit reports the gender of recently deceased children or infants. Details on the DHS variables and definitions are in Henderson et al. (2020).[10]

5.1 Incomes

For survey respondents in six African countries totalling over 400 million people, the LSMS panel of Table 3a reports regressions of the log of net household income and the log of hourly wages (for all wage workers) against our population density measure, with and without the demographic controls listed at the bottom of panel. Household income is constructed from various LSMS survey questions. It includes all wage income and business receipts (including farm) less business expenses per month. Details of variable definitions are available in Henderson et al. (2019a).

These estimated elasticities are high. Doubling density increases household net income by about 31% and hourly wages by about 5%. These estimates are virtually unchanged by the added controls although the regression R-square's increase very dramatically. At 5%, the density elasticity of hourly wages exceeds those typically found in developed countries, but is in the range of estimates in recent work on other developing regions and countries (Quintero and Roberts (2018), Duranton (2016), Combes et al. (2019), and Chauvin et al. (2017)). We find no comparison for the density elasticity of net income in the literature. Yet this elasticity is probably the more important. In the end, it is families that migrate permanently to cities. The fact that the density elasticity of net income reported in Table 3 is multifold that for wages likely reflects both an increase in hours worked and varieties of job opportunities for family members, as analysed in Henderson et al. (2019). This is also an area for future research.

Figure 5 presents results analogous to the net income regressions in Table 3a. In particular, Figure 5a shows the binscatter plot of the log of net household income against log of density. Figure 5b is similar, but controls for the same demographic variables as listed in the LSMS panel of Table 3a. While a linear fit is reasonable, the graph suggests a potential non-linearity. The density gradient is flatter from 2 to about 6.3, about 7 to 550 people per sq km in levels. From Figure 4, this is well below the average density of African cities. The gradient increases sharply from 6.3 to the middle of the largest bin point, at about 9 log points or about 8100 people per sq. km. If these were causal estimate, a household moving from a density of 550 to 8100, would experience and increase in net income of about 1.4 log points, about a 4-fold increase. While the LSMS reports respondents at densities nearing 20,000, such respondents are rare and so our estimates of income at these high densities are imprecise. The corresponding plots for hourly wages (not shown) are similar but with a less steep slope and modestly wider confidence bands. In all, these estimations indicate that African wages and income are sensitive to density, and suggest that moving to denser locations can have a high return for African families.

5.2 Utilities and schooling: public goods strongly influenced by policy

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[10] We note the similarity between results presented here and those in Henderson et al. (2020), which examines how outcomes differ across the discrete urban-rural classifications given in the GHS Settlement Model (Florczyk et al. 2019).

DHS questions about water and sanitation are tailored to allow an evaluation of whether the UN's sustainable development goals are attained. This has led to nuanced questions. Safe water can be quite different than piped water. For example, in places that the GHS defines as cities in Sub-Saharan Africa and in South Asia about 40 and 80% of people have access to safe water, but only about 8 and 25% respectively have water piped into their dwelling unit (Henderson et al., 2019). Toilets flushing into a central sewer system are rare. We will return to this point below,

The DHS household panel of Table 3b looks at the relationship between indicator variables for the availability of electricity, safe drinking water and improved sanitation and our log density measure. As for the LSMS variables, for each of these household indicators, Table 3b reports the results of regressions without controls, and with the controls listed at the bottom of the panel. In each case, increasing density by one log point, i.e., a factor of 2.7, leads on average to an increase in the share of households with access to electricity, safe drinking water and improved sanitation of about 0.08. Controlling for household characteristics reduces this effect by 25-45% and increases the relevant R-square's dramatically. On the basis of estimates that include demographic controls, a one standard deviation increase in log density is associated with increases in the share of survey respondents with an electricity connection, safe water or improved sanitation of about 0.074, 0.097, and 0.11 respectively, where sample means are 0.69, 0.50 and 0.57.

Figure 6 presents a binscatter plot similar to that of Figure 5, but where the outcome variable is the indicator for improved sanitation. Even after controlling for household demographic characteristics, we see a rapid and precisely estimated increase in access to improved sanitation with density. Comparing panel a and b, we see that introducing controls reduces the estimated marginal effect of density, but does not change the tight relationship between density and access to improved sanitation. Household access to utilities and schooling depend in greater part on public sector provision, for example, of water mains, reservoirs, schools and teachers, than other outcomes we will see below. As for net income in Figure 5, in Figure 6 we see a slow increase in access to improved sanitation below log density of about 6, and more rapid increase at higher densities. There is also evidence of a downturn at very high densities This may reflect a decline in services to high density slums, but our small sample of high density respondents does permit much confidence in this finding. This is an important area for future work.

A figure for safe water corresponding to Figure 6 looks similar, including the non-linearity at high densities. For electricity, the fit with controls is very tight, although the rise is more linear. We think these differences are supply driven and reflect lower costs of service provision in dense areas and, perhaps, political considerations. Denser areas may be more favoured in the political arena as in the classic urban bias literature (e.g., Ades and Glaeser, 1995 and Davis and Henderson, 2003).

The DHS school panel of Table 3b estimates the relationship between educational attainment of household children and log density. In particular, the schooling outcome is an indicator variable that takes the value one in the event that a household 16 year old has completed at least 8 years of schooling, and zero otherwise. Increasing density by one log point increases the share of 16 year olds completing 8 years of schooling by about 0.05. Controls reduce this effect by 2/3. In the corresponding binscatter plot (not shown) the confidence bands are modestly wider than for improved sanitation.

In all, our results suggest that schooling is strongly affected by socio-economic composition of the population served, but better supply conditions in denser areas also seem important. This raises two questions that merit further research. First, as we will see, women's' lives seem better at higher density. It is natural to wonder how this is related to education. Is the increase in education attainment we note gender neutral? Second, how much of the increases in incomes and wages can be ascribed to increases in education that are caused by density. To the extent that dense developing world cities cause human capital accumulation, this ought to accounted as part of the benefit of density, not as a sorting effect that should be subtracted from urban increases in labor productivity.

5.3 Female, child, and birth outcomes.

The DHS female panel of Table 3a reports on four outcomes related to the status and wellbeing of women. There are indicator variables for: the use of modern contraception for sexually active women ages 20-40 who are not pregnant and do not want to have a child in the next 2 years; reporting an affirmative response by females to the question `is wife beating justified for any reason?'; and if a woman reports having ever experienced spousal household violence. Finally, there is the total number of births in last 3 years to each women age 15-49. The DHS birth panel of Table 3a reports on an indicator for whether each child born from 3 months to 3 years ago survived at least three months. The DHS children panel of Table 3b reports on outcomes for household children. We report on three outcomes recorded for each household child. First is an indicator variable reporting whether the child has had the 3rd and final DPT3 shot by 2 years of age. Second is an indicator variable for whether the child has had diarrhoea in the last 2 weeks. Finally is an indicator variable reporting whether each child age five and under has had a cough in the last two weeks.

While the many coefficients on the relationship between density and the female, infant and child outcomes are often small, so are incidence rates for these outcomes. Second, unconditional outcomes ‘improve’ as density rises, so that domestic violence, diarrhoea, and infant deaths all decline with density. However sorting matters a lot; in a number of cases demographic controls reduce density coefficients by well over 50%. Moreover, in four cases, effects are actually reversed once controls are added. After controlling for demographic characteristics*, domestic violence, diarrhoea, cough and infant mortality rise significantly with density*. A one standard deviation increase in density is associated with an increase in domestic violence, diarrhea, cough, and infant mortality of 0.013, 0.005, 0.0065, and 0.0013, given means of 0.28, 0.12, 0.19 and 0.035, all 3.5 - 5% increase relative to the mean. These are not huge but neither are they negligible. More work is needed, especially in looking at very high densities and better controlling for sorting.

That diarrhoea may rise modestly with density may seem at odds with the fact that safe water and improved sanitation both improve with density. There are two related interpretations. One is that, as density rises, the increased access to safe water and improved sanitation is not enough to offset the effect of increased crowding on contamination of food and water. The other is that the UN sustainable development goals are setting too low a bar: safely managed water and improved sanitation just are not clean enough.

Figure 7 presents a binscatter plot of the relationship between the incidence of childhood diarrhea, the indicator from the DHS children section of table 3b, and log density. This figure differs from Figures 5 and 6 in two important ways. First, as we have already noted, the sign of the relationship between the incidence of childhood diarrhea and population density changes when we add controls. This change is also visible in Figure 7. Second, with the addition of controls, the confidence bands for in this figure expand dramatically. This huge widening of confidence bands once controls are added applies to all the outcomes in this sub-section, except fertility and wife beating being justified.

This means that we can have less confidence in the precision and appropriateness of our linear specification for density effects for most outcomes in this sub-section. This is broadly consistent with the results in Table 3b. The R-squared in the regressions without controls for many outcomes are particularly low compared to income, schooling, or utilities. Adding controls results in some cases in a relatively small increase in the regression R-squared compared to utilities or income. In all, this suggests that the relationship among density, demographic controls, and these outcomes need much more investigation and may be more subject to unobserved features of the local environment, not by density a simple density measure.

5.4 Adult health outcomes: lifestyle

The DHS lifestyle panel of Table 3b reports on the relationship between log density and four lifestyle diseases for adults age 20-49. These lifestyle diseases are reported as a series of indicator variables. These are obesity, i.e., BMI $\geq$ 30, which is reported for the entire DHS universe of countries. For India alone, DHS reports indicator variables for the incidence of high blood pressure (mean systolic measure $\geq$ 140) and self-reported reported asthma and diabetes. The incidence of obesity, high blood pressure and diabetes all increase with density and, while controls matter, they reduce the density effects by only about 25% on average.

These diseases are `lifestyle diseases'. They reflect changes in diet, exercise, work intensity and stress, which may come with higher density. We can imagine that stress might come from long commutes or hours of work, smaller social networks, changed family circumstances, and crowding. In Table 3 all of these negative outcomes rise with density. While people may not make migration decisions anticipating some of these effects, they are strong in some cases. A one standard deviation increase in density raises the likelihood of measured high blood pressure and obesity by 0.010 and 0.017 respectively with mean overall incidence of 0.24 and 0.06. However, we caution confidence bands on a non-linear plot of these relationships after adding controls are wide as in Figure 7, except for obesity which is pretty tight.

Asthma alone does not respond to density. This is particularly striking given that this estimation relies entirely on DHS data for India, where air quality is notoriously bad. This surprising result would seem to be consistent with results in Aldeco, Barrage and Turner (2019). Using global data, this paper finds that the relationship between population density and the concentration of airborne particulates is unambiguously positive, but quite small. That is, air pollution is worse in cities than in rural areas, but not much worse.

5.5 Safety

The Afrobarometer panel of Table 3a presents estimates of the relationship between log density and four indicator variables describing perceptions of crime. The first of these indicators reflects whether the survey respondent reported being fearful while walking outside. The second, whether he or she reported being fearful at home. The third reports whether the survey respondent's home has been robbed in the past year. The final indicator variable reports whether the survey respondent or a household member has been attacked in the past year. All outcomes rise with density, although the relationship for being attacked is weak. With controls, effects are little diminished. In general it appears that exposure to crime increases with density.

Conclusion

The developed world and parts of the developing world have largely completed the urbanization process. They are highly urban and their shares of urban residents are growing slowly. This is not true in SSA and South and South East Asia. Here, rates of urbanization are lower and growth rates are higher. This is where the world is building cities.

The development path for SSA and parts of South and South East Asia also seems to be different from what we have seen in the rest of the world. Much of the rest of the world has followed the trajectory that inspired the dual sector model of urbanization. That is, rural farmers moved to the cities to work in progressively more productive factories. This does not seem to be the path that many recently urbanizing countries are taking. Their shares of manufacturing employment can be low and stagnant or declining. In SSA in particular, there are far more farmers living in cities than we would guess from looking at other places in the world. This suggests that the mechanism that seems to have driven urbanization in much of the rest of the world, the decline of labor productivity in agriculture relative to manufacturing, may not be at work in South Asia and SSA. This invites us to ask why these regions are urbanizing.

Patterns of population density in South and South East Asia and SSA are also much different than what we observe in developed countries. Significant fractions of the population in these regions live at densities that are practically non-existent in the developed world. At the same time, there are important differences across regions in land use. Notably, in spite of the high proportion of people living at high densities, South and South East Asia have high proportions of people living at low densities, while in SSA this proportion is very low. Again, these are important regional differences that invite us to ask what is different about the different regions, and whether the same economic fundamentals motivate urbanization in all regions.

Finally, in some regions of the developing world, and in SSA in particular, people are moving to cities when they are poorer and less productive than were their 19th and 20th century counterparts in developed countries. SSA became 40% urbanized with a per capita income about half that of Europe in 1900. This means that cities in these regions lack the resources to provide basic services that people in developed world cities take for granted; clean water and functioning sanitation, land registries, paved roads, police and fire protection. In spite of this, these cities are growing.

We discussed a variant of the Roback model of spatial equilibrium. This model provides the foundation for most theoretical models in urban economics. Its basic intuition is that people will move to exploit utility differences across space. Starting from this intuition, it is hard to reconcile the facts listed above with the rapid urbanization we observe in parts of the world. Migrants from rural regions cannot move into urban manufacturing jobs when no such jobs exist, and at the same time, the cities to which they move often lack rudimentary public services. This would lead us to wonder why people in SSA, in particular, are urbanizing so fast.

In fact, the recent literature and results that we present here, suggest that this is not the correct question. Manufacturing jobs or not, incomes and wages increase rapidly with density. We use the LSMS to establish this for SSA, and the literature suggests that it is true more broadly in the developing world. Moreover, in spite of the `earliness' of developed world urbanization, many important aspects of life improve rapidly with density; access to electricity, safe water, modern sanitation, schooling and inoculations for children. The lives of women seem to also be better in a number of dimensions in denser places.

These benefits of urbanization seem large both economically and econometrically. Against these, benefits, the costs of density may seem more modest. There are increases in the incidence of lifestyle diseases and poorer child health outcomes; and crime, fear of crime and domestic violence seem to increase with density. However in many cases the increases are modest and noisy. In total, this suggests that we could ask the opposite question: Could the increases in the incidence of lifestyle diseases, poorer child health outcomes and crime that comes with density possibly outweigh the very large increases in income and access to modern conveniences? If not, then why don't people moving to cities even more rapidly? Resolving this question seems like an obvious question for further research, as would verifying our results in more convincing research designs.

Finally, our results suggest that reductions in urban crime and public health interventions that target lifestyle diseases, child health outcomes, and crime are important for policy makers who would like to facilitate rural to urban migration.

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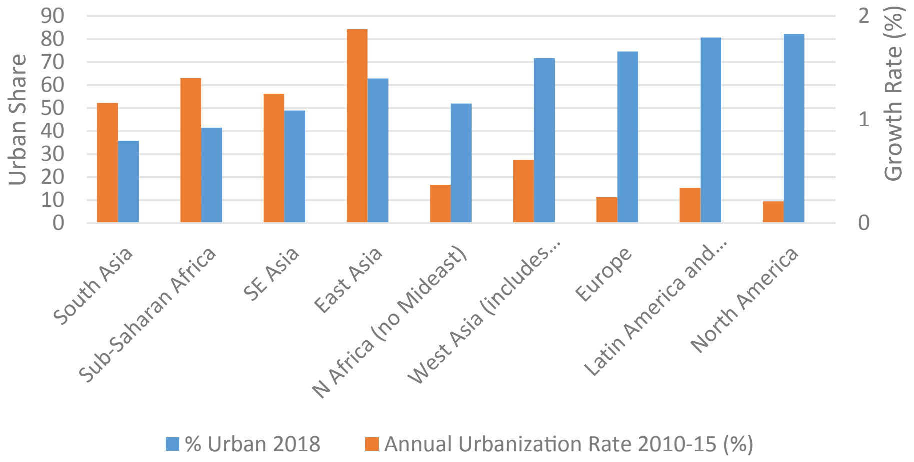
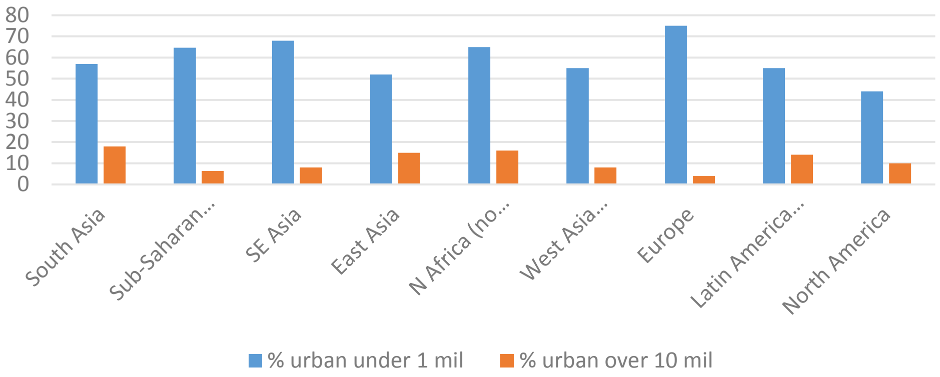
Figure 1: On-going urbanization rates by region.



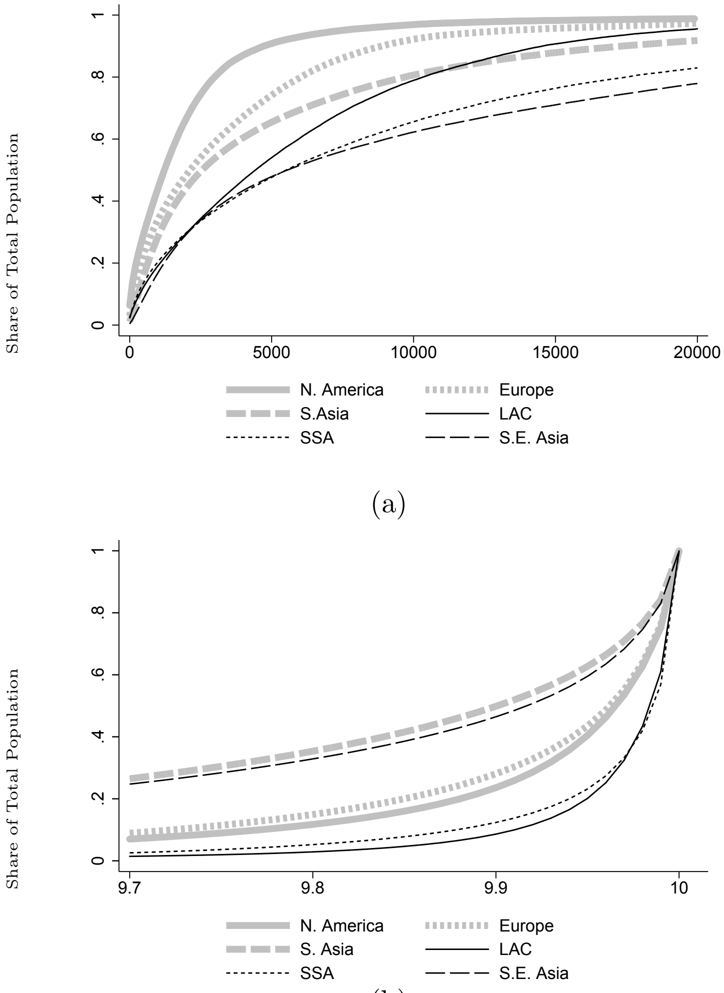
Note: *Regions are UN regions. Data are from United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision, Online Edition. The Middle East is part of West Asia (not North Africa) and Latin America includes the Caribbean. Oceania is excluded.*

Figure 2: Share of urban population by city size and region.



Note: *From World Urbanization Prospects, UN 2018. Citation: United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision, Online Edition. The Middle East is part of West Asia (not North Africa) and Latin America includes the Caribbean. Oceania is excluded.*

Figure 3: Population density gradients by region

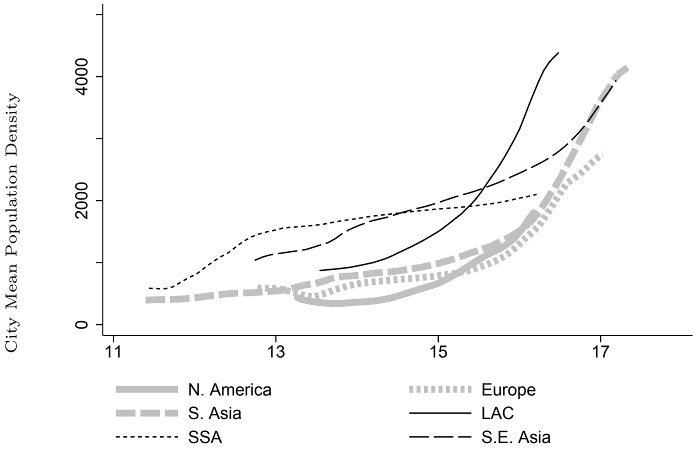


(a)

(b)

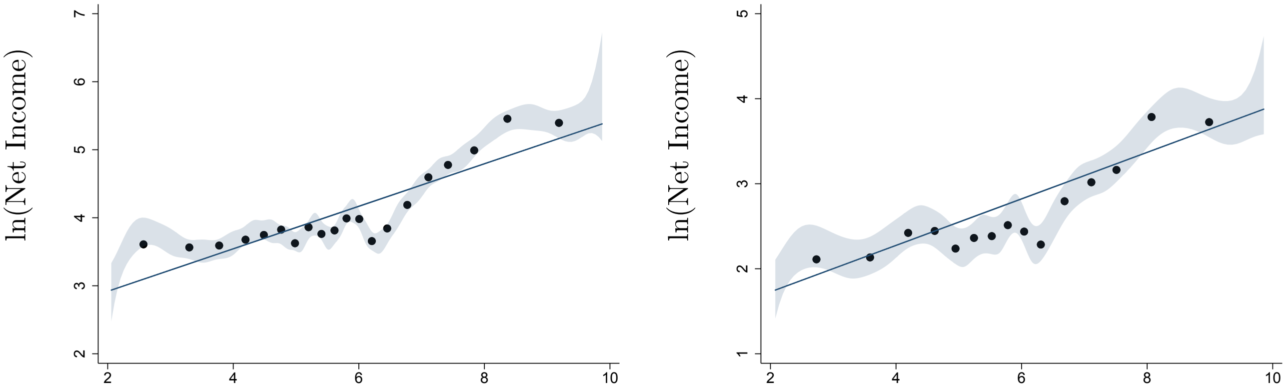
Note: *(a) Cumulative share of population by density. (b) Cumulative share of population by land area in the region. Based on population data from GHS.*

Figure 4: City population density by log(City Pop.)



Notes: *Vertical axis is mean population density from GHS in a 50km radius disk centered on the centroid of each of the 657 UN world cities. Horizontal axis is total population in the same disk, also from GHS.*

Figure 5: Log net income versus log population density/km^2 within a 5k radius.

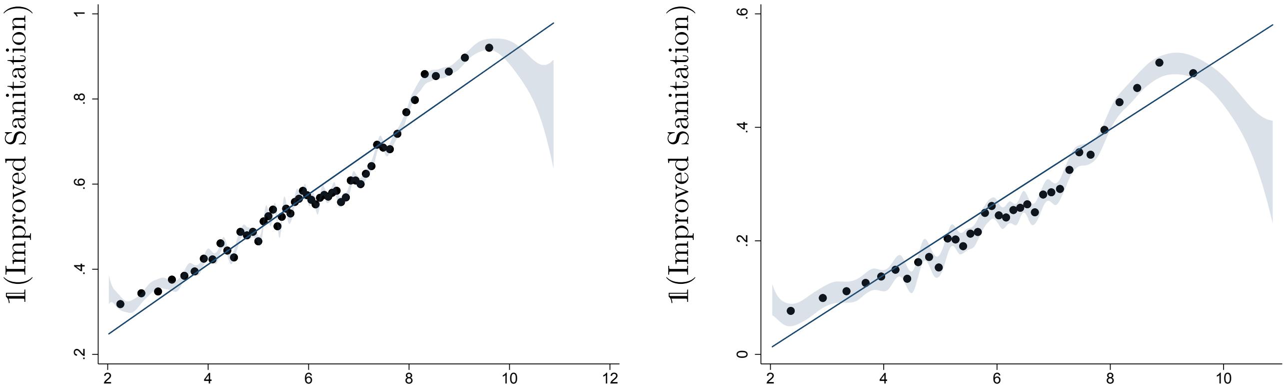


(a) No Controls

(b) Demographic controls

Note: *Binscatter plots of LSMS net income of respondent household against the log of GHS population density in a 5km disk around the survey respondent. Log population density is censored below 2. Left panel has no controls. Right panel includes demographic controls and country fixed effects. Shading indicates 95% confidence band. Income includes wage income, net farm income and net business income. For a small number of observations expenses exceed (monthly) incomes. We drop these observations to permit logarithmic scaling. LSMS survey countries are listed in table 4. Linear regression based on results in table 3a, which provides more details about the sample.*

Figure 6: Access to improved sanitation versus log population density/km^2 within a 5k radius.

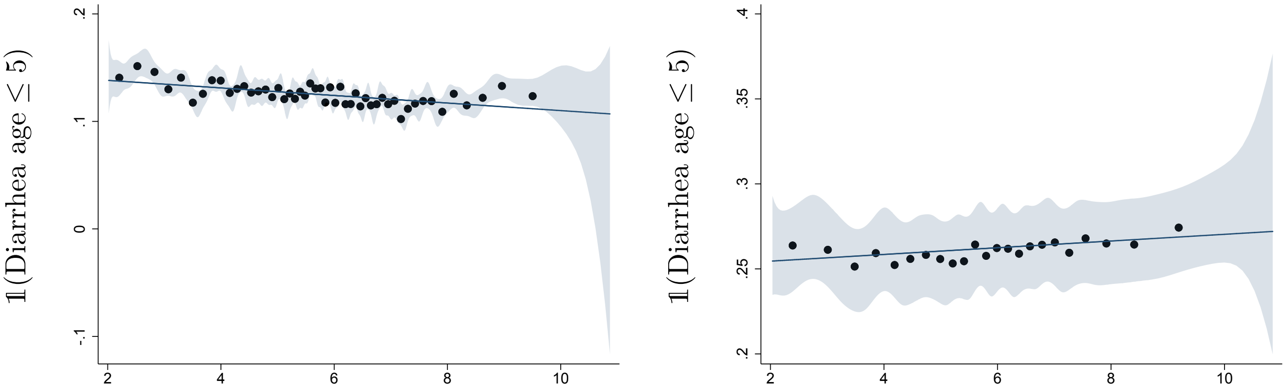


(a) No Controls

(b) Demographic controls

Note: *Binscatter plots of a DHS indicator variable that is one if a respondent household has access to improved sanitation. Log population density is censored below 2. Left panel is unconditional. Right panel includes demographic controls and country fixed effects. Shading indicates 95% confidence band. DHS survey countries are listed in table 4. Linear regression based on results in table 3a, which provides more details about the sample.*

Figure 7: Diarrhea last two weeks for children five and under versus log population density/km^2 within a 5k radius.



(a) No Controls

(b) Demographic controls

Note: *Binscatter plots of a DHS indicator that is one if a child five or under had diarrhea in the past two weeks against the log of GHS population density in a 5km disk around the survey respondent. Log population density is censored below 2. Left panel is unconditional. Right panel includes demographic controls and country fixed effects. Shading indicates 95% confidence band. DHS survey countries are listed in table 4. Linear regression based on results in table 3a, which provides more details about the sample.*

Table 1: Share of manufacturing in GDP by region and year.

Region	1990	2000	2010	2017
E. Asia	24.6	25.2	27.6	27.4
S.E. Asia	22	24.8	22.6	20.9
L. America and Caribbean	20.7	17.9	15.7	15.2
N. Africa	17.6	17.9	16	16
Europe	17.5	15.3	11.9	11.8
S. Asia	15.9	15.6	16.1	14.4
W. Asia	14.4	13.2	12.1	13.8
S.S.A.	13.8	11.6	8	9

Notes: *Data from the World Development Indicators 2018 are organized by UN regions. The table reports regional weighted averages using weights based on country share of regional GDP in 2017. Data cover 126 countries in a consistent sample over time. The Middle East is part of West Asia (not North Africa). Oceania is excluded*

Table 2: Farmers in African cities by city size.

African countries	All urban	All rural	Primate city	Secondary cities (top 25%)	Tertiary cities (50-75%)	All others
% reporting agriculture as main industry	20.5	88	8.5	23.8	38.6	41.3
% reporting manufacturing as main industry	10.6	<2	12.4	10	8.3	7.3

Notes: *Dased on authors' calculations and Kriticos and Henderson (2018). The data are from IPUMS for the most recent census for Ethiopia, Tanzania, Uganda, Mozambique, Ghana, Cameroon, Mali, Malawi, Zambia, Sierra Leone, Liberia, and Botswana. Small cities are in the bottom 50% of cities by size and tertiary cities are in the 50-75th percentiles. Cities are defined by night-light boundaries to which population is assigned. Details are reported in Henderson and Kriticos (2018).*

Table 3a: Density gradients for Afrobarometer, LSMS and DHS outcomes.

	No controls		Controls						
Outcome	β *s.e.*	R^2	β *s.e.*	R^2	$\overline{y}$ *s.e.*	$\overline{x}$ *s.e.*	N	Clusters	Countries
Data: *LSMS*									
ln(Income)	$.3126^a$	0.067	$.3170^a$	0.856	4.097	5.77	35,231	2,118	6
	(.0161)		(.0141)		(2.014)	(1.67)			
ln(Wage)	$.1177^a$	0.019	$.0488^a$	0.553	1.191	6.38	18,806	1,704	6
	(.0152)		(.0094)		(1.435)	(1.69)			
Controls: $\mathbb{1}$(*Kindergarten*), $\mathbb{1}$(*Some prim. sch.*), $\mathbb{1}$(*Some high sch.*), *age O(2)*, $\mathbb{1}$(*fem.*).									
Data: *DHS household*									
Electricity	$.0797^a$	0.084	$.0444^a$	0.827	.691	5.96	987,081	28,088	39
	(.0012)		(.0010)		(.462)	(1.68)			
Safe Water	$.0853^a$	0.083	$.0576^a$	0.655	.510	5.95	1,005,468	28,604	40
	(.0013)		(.001)		(.500)	(1.69)			
Imp. Sanitation	$.0825^a$	0.079	$.0630^a$	0.662	.572	5.95	1,005,283	28,604	40
	(.0010)		(.0010)		(.495)	(1.69)			
Controls: *H.H. size O(2)*, $\mathbb{1}$(*fem. HoH*),*age HoH O(2)*, $\mathbb{1}$(*Some prim. sch. HoH*), $\mathbb{1}$(*Some sec. sch. HoH*), $\mathbb{1}$(> *sec. sch. HoH*).									
Data: *DHS school*									
School≥8yr	$.0497^a$	0.029	$.0158^a$	0.719	.611	5.94	95,687	25,529	40
	(.0014)		(.0011)		(.488)	(1.67)			
Controls: $\mathbb{1}$(*fem.*), $\mathbb{1}$(*fem. HoH*), *age HoH O(2)*, $\mathbb{1}$(*Some prim. sch. HoH*), $\mathbb{1}$(*Some sec. sch. HoH*), $\mathbb{1}$(> *sec. sch. HoH*).									
Data: *DHS female*									
Contraception	$.0297^a$	0.011	$.0122^a$	0.595	.496	5.9	183,273	19,294	37
	(.0016)		(.0009)		(.500)	(1.76)			
Justified Beating	$-.0361^a$	0.017	$-.0120^a$	0.499	.384	5.87	575,495	20,129	40
	(.0016)		(.0009)		(.486)	(1.76)			
Victim	.0001	0.000	$.0074^a$	0.320	.277	5.8	194,157	17,951	32
	(.0010)		(.0009)		(.448)	(1.77)			
Tot. # births	$-.0278^a$	0.008	$-.0109^a$	0.370	.298	6.01	1,110,331	28,604	40
	(.0007)		(.0004)		(.531)	(1.68)			
Controls: *age O(2)*, $\mathbb{1}$(*Some prim. sch.*), $\mathbb{1}$(*Some sec. sch.*), $\mathbb{1}$(> *sec. sch.*), $\mathbb{1}$(*fem. HoH*),*age HoH O(2)*, $\mathbb{1}$(*Some prim. sch. HoH*), $\mathbb{1}$(*Some sec. sch. HoH*), $\mathbb{1}$(> *sec. sch. HoH*).									
Data: *DHS birth*									
Infant Death	$-.0006^a$	0.000	$.0008^a$	0.038	.035	5.75	294,385	28,205	40
	(.0002)		(.0002)		(.184)	(1.71)			
Controls: $\mathbb{1}$(*fem.*), *age (mother) O(2)*, $\mathbb{1}$(*Some prim. sch.(mother)*), $\mathbb{1}$(*Some sec. sch.(mother)*), $\mathbb{1}$(> *sec. sch.(mother)*), $\mathbb{1}$(*fem. HoH*), *age HoH O(2)*, $\mathbb{1}$(*Some prim. sch. HoH*), $\mathbb{1}$(*Some sec. sch. HoH*), $\mathbb{1}$(> *sec. sch. HoH*).									

Note: *Regressions of respondent level 'outcome' on log population density in a 5km disk. Standard errors are clustered by 'survey cluster'. Each row reports results from two regressions, one without demographic controls and one with;* $^a = 1\%$, $^b = 5\%$, $^c = 10\%$, *all two-tailed tests. Relevant demographic controls are listed at the bottom of each panel.* $\overline{y}$ *and* $\overline{x}$ *are mean of outcome and* ln(*pop. density*) *in the 'no-controls' sample. Except for the LSMS panel, we lose only a tiny number of observations when we add controls.*

Table 3b: Density gradients for Afrobarometer, LSMS and DHS outcomes.

	No controls		Controls						
Outcome	β	R^2	β	R^2	$\overline{y}$	$\overline{x}$	N	Clusters	Countries
	s.e.		*s.e.*		*s.e.*	*s.e.*			
Data: *DHS children*									
Diarrhea	-.0035^a	0.000	.0030^a	0.160	.125	5.76	512,855	28,507	40
	(.0005)		(.0004)		(.331)	(1.71)			
DPT3	.0209^a	0.007	.0123^a	0.798	.763	5.76	95,334	24,914	40
	(.0013)		(.0011)		(.425)	(1.71)			
Cough	-.0001	0.000	.0038^a	0.255	.188	5.76	513,082	28,507	40
	(.0008)		(.0006)		(.391)	(1.71)			
Controls: *age O(2)*, $\mathbb{1}$(*Some prim. sch.(mother)*), $\mathbb{1}$(*Some sec. sch.(mother)*), $\mathbb{1}$(> *sec. sch.(mother)*), $\mathbb{1}$(*fem. HoH*),*age HoH O(2)*, $\mathbb{1}$(*Some prim. sch. HoH*), $\mathbb{1}$(*Some sec. sch. HoH*), $\mathbb{1}$(> *sec. sch. HoH*).									
Data: *DHS lifestyle*									
High B.P.	.0076^a	0.001	.0108^a	0.260	.244	6.17	475,157	15,838	2
	(.0008)		(.0008)		(.430)	(1.57)			
Asthma	0.00002	0.000	.00012	0.019	.015	6.18	712,978	15,546	1
	(.00012)		(.00012)		(.122)	(1.57)			
Diabetes	.0019^a	0.001	.0015^a	0.028	.014	6.19	677,232	15,545	1
	(.0001)		(.0001)		(.117)	(1.57)			
Obese	.0128^a	0.006	.0100^a	0.154	.077	6.07	851,767	28,330	39
	(.0005)		(.0003)		(.267)	(1.67)			
Controls: *age O(2)*, $\mathbb{1}$(*Some prim. sch.*), $\mathbb{1}$(*Some sec. sch.*), $\mathbb{1}$(> *sec. sch.*), $\mathbb{1}$(*fem. HoH*),*age HoH O(2)*, $\mathbb{1}$(*Some prim. sch. HoH*), $\mathbb{1}$(*Some sec. sch. HoH*), $\mathbb{1}$(> *sec. sch. HoH*).									
Data: *Afrobarometer*									
Fear Walking	.0157^a	0.003	.0155^a	0.430	.381	5.65	26,437	2,210	24
	(.0037)		(.0034)		(.486)	(1.76)			
Fear at Home	.0094^a	0.001	.0102^a	0.386	.334	5.65	26,437	2,210	24
	(.0037)		(.0036)		(.472)	(1.76)			
Theft at Home	.0042	0.000	.0059^b	0.320	.288	5.65	26,476	2,210	24
	(.0028)		(.0026)		(.453)	(1.76)			
Attacked	.0026	0.000	.0024	0.147	.103	5.65	26,468	2,210	23
	(.0019)		(.0019)		(.303)	(1.76)			
Controls: $\mathbb{1}$(< *Primary sch.*), $\mathbb{1}$(*Some sec. sch.*), $\mathbb{1}$(> *high sch.*), *age O(2)*, $\mathbb{1}$(*fem.*), *H.H. size*									

Note: *Regressions of respondent level 'outcome' on log population density in a 5km disk. Standard errors are clustered by 'survey cluster'. Each row reports results from two regressions, one without demographic controls and one with;* $^a = 1\%$, $^b = 5\%$, $^c = 10\%$, *all two-tailed tests. Relevant demographic controls are listed at the bottom of each panel.* $\overline{y}$ *and* $\overline{x}$ *are mean of outcome and* ln(*pop. density*) *in the 'no-controls' sample. Except for the LSMS panel, we lose only a tiny number of observations when we add controls.*

Table 4: Country lists for Afrobarometer, LSMS and DHS outcomes.

Data: *LSMS*
Ethiopia, Ghana, Malawi, Nigeria, Tanzania, Uganda.
Data: *Afrobarometer*
Algeria, Angola, Benin, Eswatini, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Sudan, Togo, Tunisia, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.
Data: *DHS*
Angola 2015-16, Bangladesh 2014, Benin 2011-12, Burkina Faso 2010, Burundi 2010, Cambodia 2014, Cameroon 2011, Chad 2014-15, Colombia 2010, Comoros 2012, Congo Democratic Republic 2013-14, Cote d'Ivoire 2011-12, Dominican Republic 2013, Ethiopia 2016, Gabon 2012, Ghana 2014, Guatemala 2014-15, Guinea 2012, Haiti 2012, Honduras 2011-12, India 2015-16, Kenya 2014, Lesotho 2014, Liberia 2013, Malawi 2015-16, Mali 2012-13, Mozambique 2011, Myanmar 2015-16, Namibia 2013, Nepal 2016, Nigeria 2013, Rwanda 2014-15, Senegal 2010-11, Sierra Leone 2013, Tanzania 2015-16, Timor-Leste 2016, Togo 2013-14, Uganda 2016, Zambia 2013-14, Zimbabwe 2015.