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Research Article

Migration's contribution to the urban transition: Direct census estimates from Africa and Asia

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Abstract

BACKGROUND
The components of urbanisation are important to understand, since urbanisation is closely related to development. Internal migration was key in historical urban transitions, while in contemporary transitions the balance of births and deaths has been the main driver of urbanisation. Reclassification of rural areas and international migration also contribute to urbanisation.

OBJECTIVE
Unlike previous work based on indirectly measured net migration estimates, we directly estimate in- and out-migration rates between rural and urban areas across Africa and Asia by age and sex, and evaluate the contribution of the balance of these flows to urbanisation.

METHOD
We use 67 census samples from IPUMS International for 28 countries in Africa and Asia between 1970 and 2014 to estimate in- and out- migration between rural and urban areas, based on available questions of residence. We then model age- and sex-specific migration rates using Poisson regression and estimate net migration through marginal effects.

RESULTS
Results confirm that, in both continents, urbanisation is not generated by rural-to-urban migration but by the urban population itself, be it through natural growth or through expansion to peripheral areas. In Asia, urbanisation reflects internal migration trends and reclassification decisions to a greater extent than in Africa, where natural growth is the key contributor.

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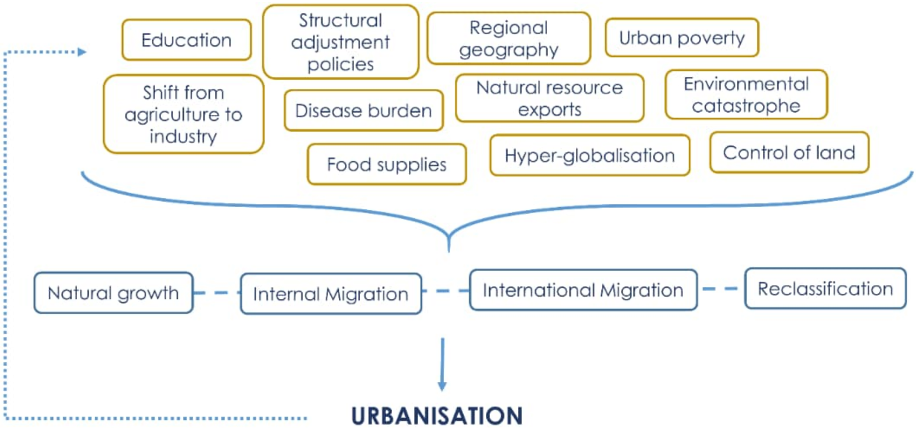
CONTRIBUTION
By using direct estimates, we ascertain the role of inter-regional rural–urban migration in urbanisation. We find that a positive effect of inter-regional migration is counter-balanced by a negative effect of intra-regional migration (combined with reclassification and international migration).

1. Introduction

The proportion of the populations of Africa and Asia living in urban areas is expected to be 58.9% and 66.2% respectively in 2050, despite an anticipated average urbanisation rate [3] of around 1.1% per year in both regions. Looking back, the regions have experienced similar urbanisation paths, with the percentage of the population living in urban areas increasing from 14.3% in Africa and 17.5% in Asia in 1950 to 43.5% and 51.1% respectively in 2020 (United Nations 2018). This is in stark contrast to other regions of the world where the proportion urban currently exceeds 70%, and raises the question of why these regions have been slower to urbanise. Reasons for these differences can be broadly separated into two sets of explanations: the contextual explanation, which includes distal components such as economic growth, and the mostly demographic explanation, which includes four proximate factors such as internal migration (Figure 1). Both sets of explanations can validate the urbanisation trends – that is, the shift in the percentage of the African and Asian populations living in the urban sector. In this article we explore specifically the role of internal migration between the rural and urban sectors in the urban transition, rather than seek to unravel all the root causes of urbanisation. Understanding the role of migration, as opposed to natural increase, is important for governmental policies aimed at spurring or deterring urbanisation. Indeed, urbanisation can be both beneficial, for example by easing access to education and health services, and disadvantageous, for instance by increasing pollution or social inequalities.

[3] Urbanisation refers to an increase in the proportion of the population concentrated in the urban sector, and is the balance between rural growth and urban growth. Urbanisation rate (or the rate of urbanisation) is the average annual rate of change of the percentage urban, reflecting the growth of the proportion urban.

Figure 1: Conceptual depiction of contextual and proximate determinants of urbanisation



Note: The contextual factors depicted here are not exhaustive. The links between the distal factors and urbanisation are two-directional and it is possible, for example, that urbanisation leads to economic growth, or high-density urban settlements allow for specialisation of labour, or close living spaces facilitate faster spread of infectious diseases.

2. The contextual explanation

Perhaps one of the most commonly perceived factors driving urbanisation is economic growth, associated with shifts out of agricultural into industrialisation and tertiarization (Cohen 2006; Davis and Henderson 2003). This is based on the premise that countries work with dual economies (in the rural and urban sectors), and as the urban becomes more attractive, it pulls farmers to cities (Harris and Todaro 1970). A key example of this mechanism is embedded in the Structural Adjustment Programmes (SAP) implemented in sub-Saharan Africa (SSA) which aimed to reduce the employment gap between the rural and urban economies in the 1980s and 1990s. The SAPs led to reductions in formal employment and to the expansion of informal work, making cities less desirable for migrants, and even for urban natives, as urban facilities deteriorated and job opportunities become scarcer (Beauchemin and Bocquier 2004; Jamal and Weeks 1993). They also led to the overall slowing down of rural–urban migration flows and eventual urbanisation, as in Nigeria (Potts 2012).

However, empirical evidence has challenged this close relationship between economic growth and urbanisation. Some scholars argue that in Africa there has been “urbanisation without (economic) growth” (Fay and Opal 2000; Gollin, Jedwab, and Vollrath 2016; Jamal and Weeks 1993; Turok 2013). Others suggest that although urbanisation followed industrialisation in China in earlier years (1950s–1970s), more recently it relies on a land (real estate) economy (Gu, Hu, and Cook 2017). Indeed, other economic factors have been turned to in explaining the urban transition. For instance, exportation of natural resources is positively related to the growth of cities which rely primarily on non-tradable services (Gollin, Jedwab, and Vollrath 2016). By contrast, agricultural trade with improved farm prices seems to have deterred African urbanisation (Henderson, Roberts, and Storeygard 2013). Furthermore, urban poverty, livelihood insecurity, and inequalities have deterred rural-to-urban migrants in India (Kundu 2011) and in Africa, sometimes even leading to counter-urbanisation (Potts 2009).

Beyond economic determinants of urbanisation, political factors such as centripetal state politics or control of land, and geographic–environmental factors such as being landlocked or global warming, are also noted to play significant roles in urban trajectories (Fox and Goodfellow 2021; Potts 2016). Additionally, human development, including health and education, is connected to urbanisation (Njoh 2003). Certainly health, or more specifically a high burden of disease, can impose a natural ceiling on population growth, as was the case in preindustrial urban centres (Fox 2012). Mortality decline is considered a pre-condition for urbanisation to occur (Bandyopadhyay and Green 2018; Dyson 2011), and is intrinsically linked to the proximate determinant of urbanisation, the balance of births and deaths in both rural and urban sectors (natural growth).

3. The demographic explanation

The proximate components of urbanisation include the balance of internal migration flows (between rural and urban areas), the balance of births and deaths (natural population growth) across rural and urban areas, the balance of international migration flows towards the urban sector or from the rural sector, and the re-defining of populations as urban (reclassification). These four components contribute differentially to urbanisation depending on the stage of the demographic and urban transitions (Dyson 2011; Menashe-Oren and Bocquier 2021; de Vries 1990). Historically, internal migration was instrumental to urbanisation within Europe (Bocquier and Brée 2018; Bocquier and Costa 2015; Lerch 2021). By contrast, natural growth has been the driving force behind more recent urbanisation in other regions of the world (Chen, Valente, and Zlotnik 1998; Menashe-Oren and Bocquier 2021; Preston 1979). That said, each country in each continent faces its own urbanisation trajectory, and the end of the urban transition may diverge in different places (Zelinsky 1971).

The greater contribution of natural growth derives from an underlying mechanism that shapes the crude birth and death rates in each sector. Since the bulk of migrants are in the young active age group and contribute to the urban–rural growth differential in the early stage of urbanisation, they also disproportionately contribute at a later stage to natural growth in urban areas. This is because they are of reproductive ages, and also of ages with the lowest mortality. As a consequence, the crude death rate is low in urban areas while the crude birth rate rises, even if the total fertility rate is lower than in rural areas. The situation in rural areas is the mirror opposite: negative net migration in the early stage of urbanisation leads to a smaller reproductive-age population, thus reducing the crude birth rate, while the crude death rate increases as the adults left behind are older on average. In addition, at later stages of urbanisation, urban areas may become less attractive to rural migrants and return migration more frequent, thus balancing migration flows and reducing migration's contribution to urbanisation. The result of these often-under-appreciated age composition dynamics is that the contribution of migration to urbanisation declines over time in favour of natural contribution.

3.1 Urbanisation appears to reflect internal migration trends and reclassification decisions in Asia

Urbanisation trends in Asia are mostly studied in China and India, which are unique not only in their population size, but also in the political hold on population affairs. Radical policies to slow down fertility have been so successful that the falling birth rates and rapid decline in the population growth rate in China,[4] India, and Indonesia (to slightly above replacement level in the latter two countries) indicate that urbanisation is no longer driven as much by natural increase as in the past (Jones 2017). This is especially evident in large cities like Shanghai, where fertility levels are far below the national average and the age structure of the city does not favour population growth (that is, population momentum is not keeping the number of births up). Instead, large migration flows from rural or economically less-developed areas have compensated for falling fertility in urban areas in China, where the one-child policy was strongly enforced (Gu, Hu, and Cook 2007; Jones 2017; Shen and Spence 1996) and the rapid socioeconomic development favoured fertility decline (Cai 2010). This is on par with highly urbanised, low-fertility states in India, which grow more from migration than natural increase (Bhagat and Mohanty 2009). However, estimating the role of internal migration in urbanisation is confounded by the socio-political weight migration can bear, particularly in China. The definition of urban in China is in part determined by the *hukou* system of household registration and the status of seasonal migrants, known as floating populations (Zhang and Zhao 1998). Essentially, the de jure versus de facto definition of urban residents is crucial, because this definition affects so many people in the country.

[4] China's population shrank for the first time in 2022. See: https://www.weforum.org/agenda/2022/07/china-population-shrink-60-years-world/.

Moreover, the definition of what is considered urban has changed relatively frequently in China. In the 1950s an urban area was defined as one with a permanent population of at least 2,000 people, with at least 50% working in non-agricultural activities. In the 1990s the definition of urban became much more complex, with settlements defined as cities at the prefecture level when over 80% of the population belong to non-agricultural *hukou*, with at least 25,000 people. Yet at the county level, multiple combinations of population density, gross domestic product and revenue from industry, proportions in non-agricultural activity, and so on, were used to define areas as urban (Zhang and Zhao 1998). Such reclassification, often driven by the political interests of local authorities, has been instrumental in the definition of urban areas in China (Goldstein 1990), and has even contributed to land speculation and a proliferation of 'ghost cities', when the housing supply is not met by demand (Sorace and Hurst 2016). Similarly in the 1990s in India, based on political interests, small and medium-sized towns at the periphery of economic growth were actually declassified as urban, as government preferred to invest in larger cities (Kundu 2011). It is likely that rural population decline, noted in many Asian countries (Hugo 2020), is actually a reflection of reclassification, rather than negative natural growth in the rural sector.

3.2 Urbanisation in Africa mostly mirrors natural growth

The politics of defining urban settlements is also evident in African countries. For example, in Nigeria, the most populous country of the region, censuses have become controversial, as the data is used to determine electoral districts (Borel-Saladin 2017). The contribution of reclassification to urbanisation in Africa between 1950 and 1980 is estimated at 26.4% (Beauchemin and Bocquier 2004). Despite this relatively substantial role of reclassification, rural–urban migration is often considered the key to urbanisation trends in Africa, evidenced by the literature on the effect of economic growth on urbanisation which refers to migration, e.g., Potts (2016), who shows how migration flows fluctuate according to economic opportunity in Zambia and Zimbabwe. Further evidence from Zambia also suggests that between 1990 and 2010 net migration was the key factor driving urbanisation corresponding to changes in the urban labour market (Crankshaw and Borel-Saladin 2018). And yet, on the whole, it is neither reclassification nor internal migration in Africa that contributes the most to urbanisation. The percentage of urban growth in the continent attributed to natural growth was estimated to be as high as 76% in the 1990s (Stecklov 2008).

However, the continued absence of sufficient and timely data on rural–urban migration flows in many countries makes it hard to conclude that the slow urbanisation in Africa and Asia can be attributed to a single factor, and hard to project future urbanisation trends (Brockerhoff 1999). Indirect estimation of net internal migration has been useful to fill the data gap (Menashe-Oren and Bocquier 2021; Stecklov 2008; United Nations 2001). Yet indirect estimates of net migration are also problematic: they are limited to only net flows (not allowing us to unpack the in- and out-migration flows), internal migration is lumped together with reclassification and international migration (which is assumed to be negligible), and these indirect estimates partly rely on simplifying assumptions (such as rural mortality being 25% higher than urban mortality). Although in this paper we rely on sparse census data, we directly estimate in- and out-migration, based on which we can estimate internal net migration relative to either the urban or the rural population. This allows us to determine the intensity of migration, capturing the potentially significant flows of migration in each direction, even if migration, when balanced out, does not contribute much to urbanisation. Moreover, our direct rural–urban migration estimates exclude reclassification and international migration, providing a more accurate idea of the role of internal migration in urbanisation, albeit with some limitations that we expand on later. This paper has three main aims: (1) identifying in-, out-, and net internal (rural/urban) migration patterns across Asia and Africa; (2) evaluating the contribution of directly estimated net migration to urbanisation; and (3) reconciling these findings with indirect measures of net migration to isolate the roles of the different proximate determinants of migration.

4. Data and methods

This paper uses census data to directly estimate inter-regional migration and analyse the contribution of internal migration to urbanisation. We include a range of African and Asian countries, chosen according to availability of census samples, and required variables. We include countries with a census sample (of at least 1%), available through IPUMS-International, of low- or middle-income countries in Africa and Asia (Minnesota Population Center 2020). IPUMS-International census samples are obtained from national statistics offices, while ensuring representativeness (which can be determined with the provided sample weights).

For each census, we checked for the availability of the following variables, to be able to estimate internal migration rates:

a) Individual demographic characteristics: age, sex, and level of education.
b) Region and rural/urban status of current residence.[5]

[5] Rural/urban current residence was missing in 8 censuses from 7 countries. We therefore imputed rural or urban status from an external data source (mainly from national statistical office publications that include tables of

c) Previous region of residence (with duration in current residence), or region of residence 1 year ago, or region of residence 5 years ago.[6]

Based on these criteria, we initially reviewed 71 censuses from 30 countries, listed in Table A-1.

This methods section outlines the steps we took to estimate migration rates from these censuses, including justification of the choices made. It starts by explaining what is meant by urban and how we chose an urban threshold for defining previous residence as rural/urban. It then details the method used for estimating migration and the modelling strategy taken.

4.1 The definition of urban

In the IPUMS census data the definition of urban is country-specific and is based on various criteria such as a population threshold, administrative classification, or economic activity. The definition of urban for the countries we include in our analysis can be found in Appendix A1 (Table A-2). We use the country-specific definition of urban, and determine the proportions urban of each region within a country, ensuring consistency with the World Urbanisation Prospects (WUP) (United Nations 2018), a reliable source of current proportions urban worldwide. This process is described in detail in Appendix A-1.

We chose an absolute level of urbanisation across countries, 50%, to determine whether each region was rural or urban. 50% is a commonly used and intuitive cut-off (Balk et al. 2018; Eurostat 2021; Hugo 2020). All the same, we tested how changing this threshold would change our results – using a 60% threshold would reduce the number of regions considered urban by only 16% on average across censuses (41 censuses would remain the same), while using a 40% threshold would increase the number of regions considered urban by 50% on average. In over a third of the censuses a 40% threshold would not change the number of regions considered urban, but in Senegal 2002, Benin 2002, 2013, Vietnam 1999, and Indonesia 1990 this threshold would more than double the number of regions defined as urban (see Appendix A-1, Table A-3). Choosing this lower threshold would likely over-estimate rural-to-urban migration flows, and would not be consistent with the share of urban population as estimated by the WUP. In about

the proportion urban by region within each country) based on administrative unit of residence – see Table A-1 for detailed sources.

[6] We do not use censuses which ask about residence 10 years ago since they are less reliable and greatly underestimate return migration, and also because we are unable to reliably determine the urban nature of the area of residence 10 years ago.

60% of the censuses the proportion urban does not differ much whether we consider 40%, 50%, or 60% thresholds, but in some censuses there are noticeable changes in the share of urban population, such as in Malaysia and Benin, leading to deviations from the WUP proportions urban.

According to the 50% threshold definition of rural/urban, the following censuses only have 'rural' regions: Nepal 2001, 2011; Thailand 1970; Rwanda 1991, 2002. We therefore excluded Nepal and Rwanda from our initial 30 countries database, leaving 67 censuses in our analysis. Moreover, some censuses have migration flows between the rural sector and the region of the capital city only. These are Indonesia 1980, 1985, 1990; Kyrgyzstan 1999; Vietnam 1989, 1999; Thailand 1990, 2000; Senegal 2002; Mali 1998; Togo 2010; Uganda 1991, 2002; Burkina Faso 1996; Kenya 1979, 1989, 1999, 2009; and Sudan 2008. In these 19 censuses, 'urban' refers only to the region of the capital city.

In identifying regions within countries as urban, we necessarily consider regions with larger urban settlements – capital cities and main cities. We consider the proportion of the population in urban regions as per our definition, and find that these proportions are very much on a par with the proportion of the population living in cities with over 300,000 people, as defined by the WUP (see Table A-4 in Appendix A-1). On average, we find less than 4 percentage point difference (3.5 in Africa, 3.4 in Asia) between the proportion of the population we consider urban, and the WUP-defined proportion of population living in large cities. This average difference is even lower (1.5 in Africa, 0.8 in Asia) if we remove outliers (South Africa, Malaysia, and Iraq). Outlying countries are likely those with a combination of a few regions and numerous smaller-sized cities and towns. This comparison between the population we consider urban and the WUP proportions living in main cities indicates, first, that our approximation of regions as urban is reasonable at the continental level, and, second, that our migration estimates capture definite rural–urban inter-regional migration flows, and not more intra-regional, short-distance moves, such as from a satellite town to city centre or vice-versa.

Moreover, because we classify entire regions as either urban or rural and only consider inter-regional moves (across administrative boundaries), our internal migration rates underestimate total internal migration between urban and rural sectors. Intra-regional moves, in particular those associated with the expansion of the population out of urban centres and contributing to urban sprawl, or local moves from rural areas to secondary towns, are not taken into account. Our estimates therefore reflect rather inter-regional and mostly long-distance migrations between the urban and rural sectors. The size of regions differs in each country, ranging from roughly 3,600km^2 in Malawi to over 300,000 km^2 in South Africa and Indonesia, the median for all African and Asian countries being 38,500 km^2. Even in countries with smaller regions, inter-regional movement has to cover substantial distance to be considered long-distance. For the migrants, these inter-regional movements represent a change in environment associated with differential investment in infrastructure in each region. This focus on inter-regional migration, as well as the differences in regional size, are important limitations which we consider when we compare direct and indirect migration estimates (see discussion).

Despite relying on only a sample of countries, using a proximate definition of urban areas, and selecting inter-regional migrations, our data match the continental average well in the corresponding decades (Table 1). The average proportion urban (taken from WUP) across all of Asia and Africa between 1970 and 2014 matches very closely the average proportion urban across the Asian and African censuses we use. We also compare internal net migration rates taken from Menashe-Oren and Bocquier (2021) using indirect estimation from an external source (URPAS data: see last section before conclusion), and find that the average urban net migration rates based on our census are remarkably similar to that of all countries in each continent. This indicates that our sample of countries is very close to each continental average, and can be used to generalize our analysis to Africa and Asia, albeit with some caution.

Table 1: Comparison of average proportions urban and net migration rates for entire continents as opposed to our sample

	WUP Mean proportions urban (1970–2014)	Mean urban net migration rates (1980–2015)
All African countries	31.82 (SD= 5.4)	0.0051 (SD=0.012)
African countries (census) included in our analysis	32.50 (SD=11.7)	0.0052 (SD=0.012)
All Asian countries	33.96 (SD=7.2)	0.0048 (SD=0.012)
Asian countries (census) included in our analysis	33.75 (SD=12.1)	0.0045 (SD=0.010)

4.2 Estimation of migration

We calculated the rates of internal migration between rural and urban sectors based on questions about residence 1 year ago (providing 1-year estimates), 5 years ago (providing 5-year estimates), and previous residence (providing 2.5-year estimates). The 2.5-year migration rates refer to the last inter-regional migration identified using the number of years since the last move, and is not representative beyond three years before data collection. The longer the duration of residence, the less representative the migration is of all the migrations that occurred around the year of the last migration. When we select migrations up to 3 years before the census, we implicitly presume that only one inter-regional migration could occur in this 3-year interval, which is reasonable. Last migration up to 3 years before the census is a proxy for residence 2.5 years ago. To sum up, we observe the previous place of residence for three time points, 1, 2.5, and 5 years ago.

The 1-year period is the most reliable to estimate migration, implying more than a six-month duration of residence. The 2.5-year and 5-year periods lead to an underestimation of migration rates, approximately proportional to the duration of the period, since only one migration is accounted for when asking about previous residence or residence 5 years ago. In the latter case there is a greater chance of missing return migration since no migrations are recorded when current residence and residence 5 years ago are the same.[7] Empirical gross difference in the magnitude of rates using these three sources of inter-regional migration estimates (a regression model on all age-, sex-, and education-specific migration rates in our database, using person-years as the exposure variable – Eq. 1) confirms that 1-year estimates are more than five times higher (1/0.18995 = 5.26446) than the 5-year estimates and that the 2.5-year estimates are indeed about 2.5 times lower (1/0.39403 = 2.53787) than the 1-year estimates (Table 2).[8]

Equation 1: Poisson model of internal migration from i to j (M_{ij}), to evaluate magnitude of differences between sources of migration estimates

$$M_{ij} = e^{\ln(PYAR_j)} + e^{\beta_0 + \boldsymbol{\beta}_1 Source + \varepsilon}$$

Table 2: Magnitude of migration rates estimated according to regression model

Migrations	IRR	Std. Err.	P>|z|	95% Confidence Interval
Period (ref=1-year)				
2.5-year	0.3940313	0.0001831	0.000	0.3936726 – 0.3943903
5-year	0.1899535	0.0000838	0.000	0.1897893 – 0.1901179
Constant	0.010485	4.44e-06	0.000	0.0104763 – 0.0104937

Note: Exposure is the natural log of person-years; Model is over all age-sex-education combinations (24,824 observations).

In addition to questions about previous residence, individuals are considered migrants if they crossed a regional border, or in our case crossed a major or minor administrative unit.[9] In the four censuses (see Table A-1) where IPUMS do not have this indicator of migration status, we cannot decipher within-sector migration, such as rural–rural migration, from no migration. Within-sector migration estimates may thus be

[7] Return migration will not affect net migration rates, though it can lead to a slight overestimation of the population at risk at the time of the census.
[8] The differences between the estimated migration rates are also notable in Figure A-2 in the Appendix.
[9] This is determined by an indicator in the data which takes on the values: 'NIU' (not in universe); 'Same major administrative unit'; 'Same major, same minor administrative unit' (denotes non-migrants); 'Same major, different minor administrative unit'; 'Different major administrative unit' (denotes migrants). The category 'Abroad' identifies international migrants.

overestimated. Overall, by considering migration as the crossing of an administrative, inter-regional boundary, our migration rates underestimate total internal migration.

Both in- and out-migration rates are calculated for each census using survival–time analysis. The migration event is assumed to happen at the middle point of the observation window. We calculate the rates as the ratio between the number of migrations and person-years at risk for each direction of migration (urban–rural or rural–urban), by age group and sex. The population at risk is the total population present in the origin (out-migration rate) or destination (in-migration rate) depending on the direction of migration. For in-migration rate computation we employ a reverse-time event history analysis technique (Beguy, Bocquier, and Zulu 2010). International migrants are included in the population at risk. We assume they returned from abroad mid-period. Estimated migration rates are available in the supplementary material, and on Github: https://github.com/ashira-mo/mig_urb2.

4.3 Modelling migration estimates

Based on the estimated inter-regional migration numbers from all the censuses, we model both in- and out-migration for Africa and Asia separately. We use Poisson models, with the dependent variable as a count of migrants, controlling for the person-years at risk as the exposure variable. The model includes a set of covariates: sex, 5-year age group, direction of migration flow (in or out), origin and destination of flow (rural–urban or urban–rural), decade, proportion urban and proportion urban squared (Equation 2).[10]

Equation 2: Poisson model of internal migration from i to j (M_{ij}) from population P_j point of view

$$M_{ij} = e^{\ln(PYAR_j)} + \\ + e^{\beta_0 + \boldsymbol{\beta_1} InOut\#UR\#sex\#age + \boldsymbol{\beta_2} InOut\#UR\#PU + \boldsymbol{\beta_3} InOut\#UR\#PU^2 + \boldsymbol{\beta_4} InOut\#UR\#decade + \boldsymbol{\beta_5} under5 + \varepsilon}$$

where β is a vector of the combinations of all variables in the interactions, and the symbol # is used to signify interactions. *InOut* refers to the direction of flow (in or out of sector), *UR* refers to the origin and destination of the flow (rural-to-urban or urban-to-rural), *PU* indicates the proportion urban, and ε is the error term.

[10] We ran a set of robustness checks, the results of which are presented in Appendix section A-3. Notably, we test (1) an interaction between decade and direction of migration flow and origin–destination, (2) removing 1-year estimates from the Africa model, (3) removing censuses with only capital cities (and no other urban regions), and (4) removing censuses from China in the Asia model, and South Africa in the Africa model.

We exclude education from the model to be able to include children who have no final educational attainment. To simplify the modelling and given that the relatively constant ratio of migration rates for 1, 2.5, and 5 years should not be dependent on other covariates, we divided the 2.5-year migrations by 0.39, and the 5-year migrations by 0.19 (see exact figures in Table 2) in order to standardise rates to 1-year (annual) migration rates. Additionally, we include in the model a covariate that controls for measurement bias for under-5-year-old migration rates for 5-year estimates, since not all of these children were born (rates for this age group are not available for 5-year estimates). To note, even the 1-year estimate for under-5-year-olds is biased downward since under-1-year-old children were not born one year before the census but are counted in the person-years at risk.[11] There are no censuses in Asia with 1-year estimates, so we assume that our adjustment for bias in Africa can also be extended to Asia.

Age is included in the model to account for the age patterns of migration. Migration age profiles almost universally follow a two-peak schedule, while in some places there is an extra smaller peak at retirement ages (Bernard, Bell, and Charles-Edwards 2014; Rogers and Castro 1981). The first peak is within the first five years of life, when children accompany migrant parents from the second peak. The second peak is largest in early adult years as people enter the labour force and marry or form other unions. These age patterns also differ slightly by sex, generally with an earlier peak for adult women associated with union formation in mostly virilocal societies. We use 5-year age groups, which removes any potential bias in the migration age profiles arising from age heaping. All of the above-mentioned covariates are interacted with migration flow (in or out) and direction (urban–rural or rural–urban)[12], so that each age–sex combination may lead to different estimates depending on the origin and destination and the population at risk. In other words, each flow by age and sex can follow its own pattern depending on its direction.

Proportion urban is also included in the model in its quadratic form (PU and PU^2), assuming that level of urbanisation influences the intensity and direction of migration flows between the sectors in a curvilinear way as the urban transition progresses (Bocquier and Mukandila 2011). This also assumes that the effect of migration on the urban transition has the same shape (though possibly with varying intensity) across all countries. This might not reflect historical situations very well; for example, where there was a pause and a rebound in the urban transition before and after a major economic or political disturbance (Bocquier and Brée 2018). Data on proportion urban at the national level are taken from the WUP at the time of the census. As with the age–sex combinations, the effect of PU is interacted with migration flow and direction. We include decades in the model to account for the general historical context in which the

[11] For further details on the estimation of migration of children under age 5, see Appendix section A-3.
[12] Intra-sectorial migration flows, i.e., urban–urban or rural–rural, are not accounted for.

urban transition takes place. The dynamics of the urban transition in the 2010s may not be the same as in the 1980s since the relationship between the countries and the rest of the world may have changed. For instance, the GDP per capita in Côte d'Ivoire rose steadily in the 1980s and 1990s, while in neighbouring countries it stagnated, and only became comparable around 2010. The decades variable may be viewed as a contextual effect, reflecting major historical, political, or economic crises that are not captured by other covariates. This variable is not expected to show much variation but is mainly useful to produce marginal effect estimates along a historical time line.

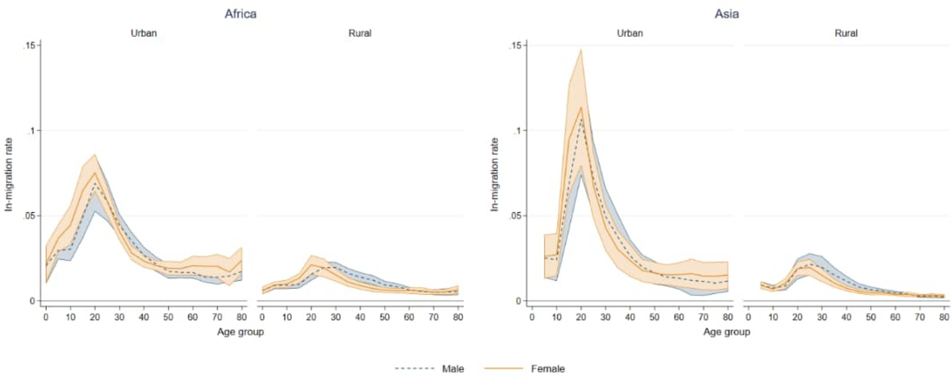
Ideally, we would have included a country variable in the model to control for country fixed effects, covering specificities such as geographical situation, population size, political regime, etc., as well as urban definition and quality of census data. However, our data are not balanced panel data since some countries are represented by only one census. The pooled data can be modelled in a meaningful way only at the expense of explaining the diversity of the historical national situations. Also, the countries in the database are not representative of all countries in Africa and Asia. In particular, countries during periods of conflict or deep economic crisis are badly represented, as censuses are more difficult to conduct under adverse conditions. The modelling should thus be viewed as an attempt to model an average, stable African or Asian country, this average being more an ideal-type country than an actual observed country. The modelling cannot be directly used to reconstruct historical trends in each specific country. Given the different historical contexts of the Asian and African continents, we produce two separate models for Asian and African countries.

To model net migration rates, we do not compute the difference between in- and out-migration rates beforehand. The resulting confidence intervals for these migration rates would not be reliable as there is nothing like a 'net-migrant' to base the computation on (Rogers 1990). However, our modelling strategy (where both in- and out-migration are modelled in the same Poisson model using the person-years at risk either at destination or origin as the exposure variable) enabled us to estimate net migration by computing the marginal effects of the in- minus out-migration rates, using the *dxdy()* option in the suite of *margins* Stata commands. The marginal effect for net migration is provided with a confidence interval. To our knowledge, this is the first time that such confidence intervals are provided for net-migration rates based on in- and out-migration rates. Confidence intervals can be useful for projections or as inputs for other models. To note, these confidence intervals do not reflect data precision, which is reflected upon in Appendix A-2 and Figure A-2, but uncertainties in predictions. Average marginal effects (or average predicted estimates) use model prediction to ease interpretation of the results (in our case, migration rates). They do not measure the reliability of the model estimates themselves (these are obtained from various other parameters like p-value, R^2, etc.), but of the predictions based on the model. In other words, marginal effects help interpretation conditional on believing the model is true. The confidence intervals of the average marginal effects do not reflect precision of the original data or data availability (like the number of available censuses in a given decade), but rather the reliability of the predicted trend of the modelled estimates conditional on the model being correct. All average predicted migration estimates displayed in Figures 2 to 6 are average marginal effects at means of covariates in the model.

5. Results

To start, and to confirm our estimates are reasonable and robust as compared to other sources, we examine the age profile of migrants based on our model (Figure 2). To note, the inter-regional urban in-migration rates are higher than the rural in-migration rates due to larger person-years at risk for rural sectors. We find that in-migration peaks are as expected among young adults (Bernard, Bell, and Charles-Edwards 2014; Rogers and Castro 1981). The peak in the age profile of in-migration to urban areas at around 20 years old is considerably higher in Asia. This is also reflected in the median urban in-migration rates of the raw migration estimates, with a peak of 15.1% rate for ages 20–24 in Asia (inter-quartile range (IQR): 5.7–22.1), and of 7.8% in Africa (IQR: 3.0–15.4). Moreover, for both rural and urban in-migration, female rates are closer to male rates in Asia than in Africa. Indeed, there is a gender difference of 0.6% in Africa (female median: 3.6%; male median: 3.0%), compared to 0.3% in Asia (female median: 2.9%; male median: 2.6%). As previously found, in Africa women migrate at younger ages than men (Menashe-Oren and Stecklov 2018). In-migration rates to rural areas are similar in Africa and Asia and markedly lower than in-migration rates to the cities. In both continents, between ages 30–49, men in-migrate to the rural sector more than women. Although we paid careful attention to the under-5-year-old migration estimates by including a correction for measurement bias (see Appendix A-3), we are still cautious in interpreting the in-migration rates for this age group. We anticipate somewhat higher rates than predicted here for Africa. The estimates are more reliable after age 5.

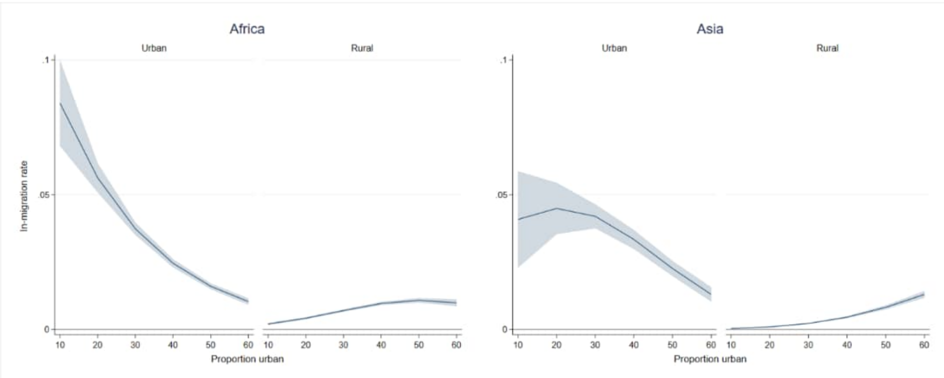
Figure 2: Age pattern of inter-regional migration between rural and urban sectors, based on average predicted annual in-migration rates in urban and rural sectors



Note: The Asia model does not include under-5-year-olds because we do not have 1-year estimates for the region.

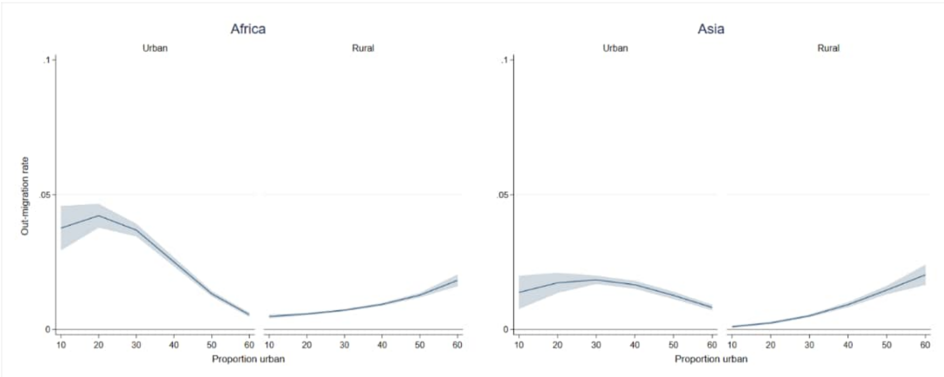
We examine inter-regional (mostly long-distance) migration trends over the urban transition by considering, first, in-migration patterns (Figure 3); second, out-migration patterns (Figure 4); and finally net migration (Figures 5 and 6). Figure 3 presents the predicted annual in-migration rates from the perspective of the urban and rural over the proportion urban, as an indicator of stage in urban transition. Urban in-migration declines in Africa and Asia from around the same rates of 0.04 (4%) to 0.01 (1%) when the proportion urban increases from 30% to 60%. However, when the proportion urban is lower (between 10% and 20%), in-migration is around 4% in Asia but much higher in Africa (in the raw data at this level of urbanisation, median urban in-migration is 6% in Asia (IQR:4–7) and 12% in Africa (IQR:5–16)). In other words, Africa sees a steeper decline in urban in-migration rates as more people live in cities. By contrast, in-migration to the rural sector only increases very slowly on both continents, from almost zero to around 1% as the proportion urban changes from 10% to 60%. In Africa this increase appears to be stable from around 40% urban, while in Asia in-migration rates in the rural sector appear to continue to increase.

Figure 3: Average predicted annual inter-regional in-migration to urban and rural sectors, over the course of urbanisation



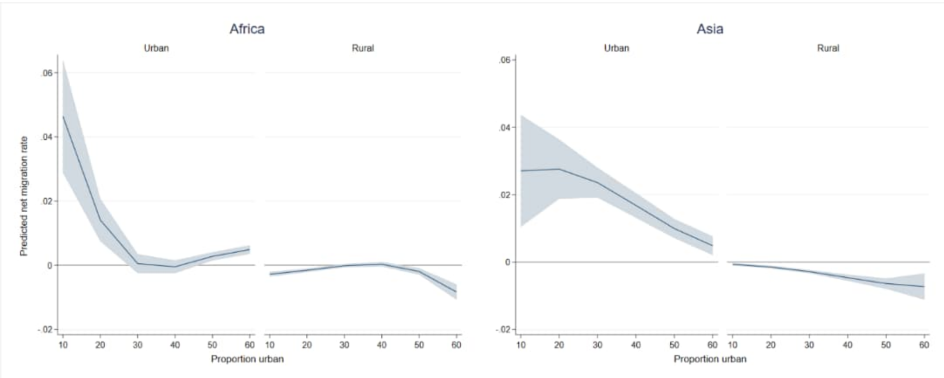
In parallel, Figure 4 illustrates the annual out-migration rates from rural and urban sectors over the urban transition for Africa and Asia. Out-migration rates from the urban sector are lower than in-migration rates, but out-migration from the rural sector reaches 2% when countries are 60% urban, double the in-migration rates to the rural sector. In Africa, out-migration rates decline sharply from 30% urban. In Asia, where urban out-migration rates are lower than in Africa (with medians of 1.4% (IQR:0.6–3.2) and 3.4% (IQR: 1.1–6) respectively), these rates only decline moderately, from a peak of 1.8% at 30% urban to 0.8% at 60% urban. In both continents out-migration from the rural sector is higher in countries that are proportionately more urban. The rising level of rates is expected in the rural sector (as the rural population, or denominator, decreases). Conversely, the declining level of both in- and out-migration rates in the urban sector are expected as the urban sector gains in weight (the denominator increases).

Figure 4: Average predicted annual inter-regional out-migration from urban and rural sectors, over the course of urbanisation



However, the contribution of inter-regional migration to overall growth in either sector is the difference between in- and out-migration rates, i.e., net migration rates, which we examine in Figure 5. The two continents show different migration patterns over the course of the urban transition. In Africa, rural–urban net migration rates from the perspective of the urban sector are very high in the early stages of urbanisation, while they drop quickly to zero when the proportion urban is 30%. From then on, net migration remains close to zero until proportions urban increase to 60%. The story is different in Asian countries. At 10% urban, net migration rates start at a lower 3% level in Asia than in Africa where it is close to 5%; however, in Asia the decline is less steep. Net migration from the rural perspective also differs by continent (right panels of each continent in Figure 5). In Africa, net migration rates in the rural sector are close to zero when the proportion urban is between 30% and 40%, which corresponds to a nearly zero net migration to urban areas, while in Asia the net migration rate in rural areas remained negative over the urbanisation process. The comparison between predicted net migration rates across continents suggests that the contribution of rural–urban migration to urbanisation is heterogeneous. In Africa the contribution of inter-regional net migration to the proportion urban is almost negligible as soon as the proportion urban reaches 30%, while in Asia it is relevant even at advanced stages of urbanisation. However, our results show that even in Asia the net migration rate was too low to account for the rapid urbanisation process there.

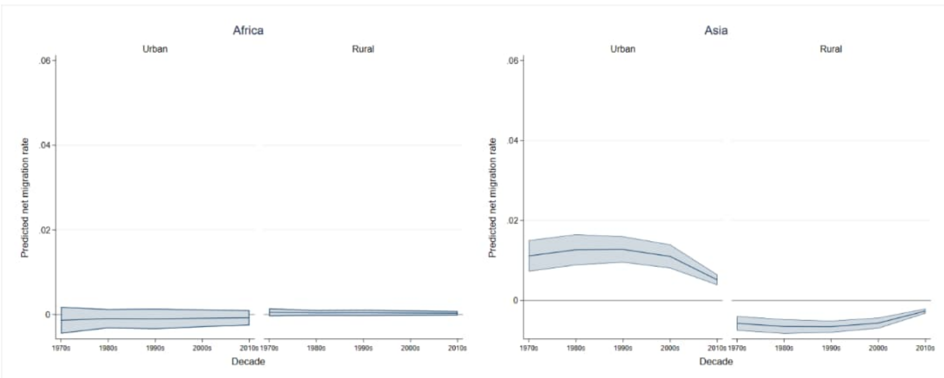
Figure 5: Average predicted annual inter-regional net migration between the rural and urban sectors, over the course of urbanisation



Considering the variation in the migration estimates, we further study Figure 5 according to different model specifications to ensure the robustness of our results. A first source of variance derives from some censuses only including capital cities as the urban sector, as noted above. When we exclude these censuses from the analysis we find results are consistent (see Appendix Figure A-4). We note only slightly lower net migration rates when these censuses are excluded, suggesting that in-migration to capital cities exceeds out-migration to a greater extent than in-migration to other towns or cities. However, we cannot be sure that these lower rates are due to differences in what is considered urban or due to a reduced sample of censuses. A second source of variance derives from the model of Asian countries not including censuses with 1-year migration estimates. It could be that our results for Asia and Africa would be more alike if based on the same source of migration estimates. When we exclude 1-year estimates from the Africa model we find that net migration rates are higher – almost doubled at low proportions urban since the census with 1-year estimates are in countries with low proportions urban – but the trends over proportion urban remain the same (see Appendix Figure A-5). This suggests some selection bias, with countries at low levels of urbanisation (on average 26.6% urban, with standard deviation (SD) of 9.7) associated with 1-year estimates. In comparison, proportions urban in African census with 2.5-year estimates are 35.7 (SD = 13.7) and with 5-year estimates, 45% (SD = 5.6). Thus, we cannot attribute the differences between to Figure 5 and Figure A-5 solely to the source of measurement. A third source of variance could derive from particular countries being included in the model, notably large countries with unique characteristics: China and South Africa. The trend in Asia does not markedly change when excluding China, except below 20% urban where the contribution of migration is higher when China is excluded (see Appendix Figure A-6). When South

Africa is excluded the trend in Africa is different to that seen in Figure 5 at higher proportions urban, declining and with wider confidence intervals (Figure A-7). This is expected, considering South Africa has the highest proportions urban in the continent (63% in 2011). Overall, while these robustness tests confirm the distinct trends in migration over the urban transition in each region of the world, they also call for some caution.

Figure 6: Average predicted annual inter-regional net migration between the rural and urban sectors, over time



While these changes in net migration over the urban transition are dramatic, when we consider the changes in net migration over time we note a very different pattern of relatively stable net migration rates over time (Figure 6). The predicted annual inter-regional net migration rates to urban and rural areas remain close to zero and hardly change between the 1970s and 2010s in Africa, other factors being equal, implying little period effect. Considering the change in the proportion urban over this period (from 21.1% to 41.4% according to WUP), this may be due to balanced migration between sectors (or 'circular migration') and even counter-urbanisation. By contrast, during the entire period in Asia predicted net migration to urban areas is consistently positive, while that to rural areas remains negative. From the point of view of the urban sector, the predicted net migration rate was steady at about 0.015 from 1970s to 2000s and declined slightly in the 2010s. Correspondingly, proportions urban increased in Asia from 1970 (23.7%) to 2010 (44.8%) suggesting that rural–urban migration contributed to urbanisation in Asia.

We further explore the somewhat surprising flat trends of net migration over time in Africa seen in Figure 6 by modifying our model to include an interaction between decade, direction of migration flow (urban–rural or rural–urban) and type of flow (in or out)

(Appendix Figure A-8). We do not use this model in our main results to avoid over-fitting the data, but it does help us test for potential trends over time that may not be captured by our model. Results in Africa based on this model are quite similar – net migration is close to zero for most of the time, but there is a slight downwards trend (from the urban perspective) from the 1970s to the 1980s (see Appendix Figure A-8). By contrast, trends in Asia are markedly different in Figure A-8, with net migration shifting from negative (reducing the urban population) to positive values from the 1990s. The negative net migration in the earlier period likely reflects trends in Indonesia in particular, and suggests some over-fitting of the model. We are therefore cautious in over-interpreting Figure A-8.

The key message from this analysis is that even in altering our model, net migration rates are still relatively flat and close to zero in Africa. These results are consistent with the hypothesis of stagnation in urbanisation in Africa (Potts 2009). Indeed, under Scenario 3 of the Shared Socioeconomic Pathways (SSP), meant to capture future trends of stalled social development and fragmentation (O'Neill et al. 2014), countries in Africa are only expected to reach 50% urban by 2100 (Jiang and O'Neill 2017). It appears that many countries in Africa have reached urban saturation (Bocquier and Mukandila 2011), with the proportion urban not changing over time and not expected to in the near future.

6. Comparing direct and indirect estimates of the migration contribution to urbanisation

The pattern of inter-regional net migration over the urban transition in Figures 5 and 6 can be compared to that presented by Menashe-Oren and Bocquier (2021), which uses data from the United Nations on urban and rural populations by age and sex (URPAS). In an attempt to reconcile direct estimates of inter-regional net migration with indirect estimates of internal migration and reclassification for the same countries and same years, we contrast the two sets of findings. Firstly, Table 3 identifies the potential biases in both migration estimation methods. Of course, both indirect and direct methods are associated with some caveats which may bias migration estimates, making it hard to conclude that one method is preferable over another, or that one method is more accurate for examining the role of internal migration in urbanisation.

Table 3: Potential biases in methods of estimating internal migration

	Direct estimation	Indirect (residual) estimation
Data sources used here	Censuses don't cover all countries for all periods.	URPAS data uses linear interpolation and extrapolation between periods. Where empirical data is missing by rural/urban sector, URPAS population estimates are imputed based on sub-regional proportions urban by age and sex.
Reclassification	Not estimated	Lumped together with migration estimates: where reclassification is high, the migration estimates will be lower.
International migration	Not included in internal migration estimates, but could have an effect on relative contribution of internal migration to urbanisation.	Lumped together with internal migration estimates and reclassification, and could bias estimates, though the proportion of international migrants is small compared to internal migrants.
Under-5-year-olds	Child migration is underestimated since they have not all been exposed to potential migration over the full period covered. However, in our model we correct for this using a factor based on migration in the one year prior to census, as the best estimate.	Because children under 5 are born during the migration period, child migrants are estimated according to the number of female migrants and proportionate age-specific fertility rates, assuming migrant women follow urban fertility rates.
Assumptions made in estimation	Using census data, previous residence is considered urban or rural according to region. Regions are defined as urban or rural based on distribution of population at time of survey. Moreover, regions are assumed to be either totally rural or urban. Internal migration is therefore under-estimated, capturing only inter-regional moves, and not intra-regional.	To estimate the number of migrants the method assumes rural mortality is 25% higher than urban. Sensitivity analysis shows little variation in estimates when changing this assumption to 29% higher rural mortality among children and only 3% higher among adults.[13] This is because fertility is the main source of variation of population growth by sector.

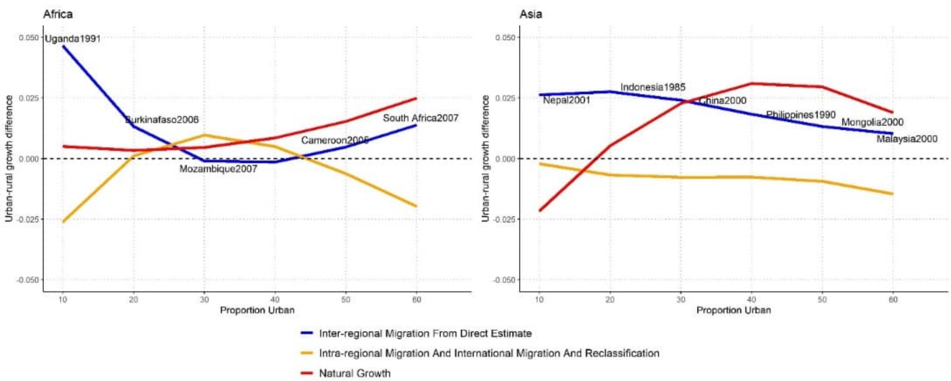
Secondly, we compare the roles of the proximate determinants of urbanisation for the same set of country-years in the census and URPAS data (Figure 7). The indirect estimates used by Menashe-Oren and Bocquier (2021) approximate the combined contribution of internal and international migration, plus reclassification, to urban–rural growth difference. The main feature of the direct method we use here is that it isolates the contribution of inter-regional (long-distance) net migration to urbanisation. Subtracting direct estimates from indirect estimates results in an estimate of essentially intra-regional (short-distance) net migration lumped together with reclassification and international migration (see Appendix A-5). Reclassification generally has a positive effect on urbanisation: it is essentially rural administrative areas that are reclassified as urban, rarely the opposite. The contribution of net international migration is assumed negligible.[14] Therefore, the line in Figure 7 of this residual mainly represents the

[13] This was tested by Menashe-Oren and Stecklov (2018), based on the findings that adult mortality is often higher in the urban sector (see Günther and Harttgen (2012) for example).

[14] The effect of international migration differs according to the urban hierarchy, having a more significant role in urban growth in metropolitan cities (Plane, Henrie, and Perry 2005). As such, a country with numerous metropolises may expect net international migration to contribute to urbanisation. Indeed, international migration to cities contributes to urbanisation in countries of already higher proportions urban (Lerch 2020). For example, in Italy, at 71% urban in 2020 (United Nations 2018), urban agglomerates in the central-north regions of the country grew primarily from international migration (Strozza et al. 2016). Similarly, in the United States of America net international migration has contributed to urban growth, with over 90% of immigrants moving to urban areas, and contributing as much to urban growth as natural growth (Jiang et al. 2022). It

combined effects of intra-regional (short-distance) migration and of reclassification. Negative figures mean that the contribution of intra-regional migration to urbanisation is negative, and is not compensated by (positive) reclassification. In other words, negative figures reflect the dispersal of urban population from city-proper to surrounding rural areas.

Figure 7: Comparison between the indirectly estimated migration estimates and direct estimates of inter-regional internal migration, in Asia and Africa separately



Note: Includes only comparable country-years (60 points), and does not include censuses from before 1985. Sample country names illustrate where some country-years are located in their urban transition.

The role of the different determinants is very different in the two continents, as shown in Figure 7. In Africa, the contribution of inter-regional migration becomes zero at 30%–40% urban and rises after, while the intra-regional and reclassification combined, though slightly positive at 25%–40% urban, declines at higher proportions urban. Remembering that reclassification has most likely a nil or positive effect, this means that intra-regional migration has a very negative effect on urbanisation for countries beyond 45% urban. If not for the positive and increasing contribution of natural growth to the advantage of urban areas, negative intra-regional net migration would translate into counter-urbanisation beyond 45% urban.

In Asia, the negative contribution of intra-regional migration is quite stable till 50% urban, and is largely compensated by the higher inter-regional migration. Although the inter-regional migration contribution is always positive, it declines as proportions urban increase. This is illustrated by highly populated countries like China, Indonesia, and the

remains to be determined if these observations, based on high-income countries, are similarly valid in other settings, including countries in Africa and Asia.

Philippines. In Africa, from 50% urban, negative intra-regional net migration reduces the pace of urbanisation, as it counteracts positive natural growth. At 60% urban in both Africa and Asia we find that natural growth contributes the most to urbanisation, with positive inter- and negative intra-regional net migration, balancing out to a slightly negative contribution to urbanisation. These commonalities suggest that countries like Malaysia and South Africa (in the early 2000s) faced similar patterns of urban transition. By contrast, although at similarly low proportions urban, Malawi (2008) and Nepal (2011) experienced urbanisation differently: In Malawi natural growth contributed to urbanisation, whereas in Nepal natural growth played a negative role, despite high inter-regional migration in both countries. In other words, the differences between Asian and African countries are more important among low-urbanised countries than among high-urbanised countries, suggesting that the first phase of the urban transition does not operate in the same way on both continents.

7. Conclusion

In this paper we estimate internal migration, using census data to evaluate its contribution to the urbanisation process, as opposed to other proximate determinants (natural growth, international migration, and reclassification). Countries in Asia follow somewhat different urban transition trajectories to countries in Africa, leading to different potential urbanisation levels in the future. On both continents, in countries that are over 40% urban, natural growth is the main driver of urbanisation. However, the role of natural growth appears stronger in Asia, where fertility declined earlier (Shapiro and Hinde 2017) and the difference between rural and urban growth is thus more sensitive to population age structures in each region. The age structural effect in Africa is weaker, as fertility decline has been slower (Schoumaker 2019). Indeed, countries in East Africa are at early stages of urban transition (less than 25% urban) and are all still in the middle of a demographic transition, with relatively high fertility and pyramid-shaped age structures (Ezeh, Mberu, and Emina 2009).

Another difference in the urban transitions of Asia and Africa is the diverging role of internal migration in the early stages of the urban transition. Our analysis suggests that the contribution of inter-regional migration to urbanisation in Africa is high at very early stages of the transition, declines, and then regains importance in the later stages. This shift at later stages likely reflects the growth of secondary cities (Zimmer et al. 2020), with regions becoming more urban and captured by our migration estimates. The contribution of inter-regional migration in Asia is higher than in Africa from 20% urban, though it declines as the proportion urban increases. These trends in Asia closely follow urban in-migration patterns over the urban transition, which are not counterbalanced by out-migration trends.

On both continents, the contribution of intra-regional migration is negative when the majority of the country's population is urban. This could be the result of urban sprawl, whereby rural areas surrounding cities expand (centripetal growth), or of reclassification playing a larger role. However, between 20% to 40% urban, inter-regional migration exceeds the negative intra-regional migration in Asia, leading to an overall positive role of internal migration on the continent. At the same stage of urban transition in Africa, positive intra-regional migration is muted by negligible inter-regional migration. However, at later stages of the urban transition, beyond 50% urban, the hierarchy of the components of urbanisation in Asian and African countries is very similar, with natural growth contributing the most, then inter-regional migration ranking second with a positive role, while the contribution of intra-regional migration is negative.

This paper has obvious limitations, mainly due to data constraints. The geographical boundaries of urban areas and of regions are country-specific. The geographical coverage is limited, notably including more stable countries, and the time span is not complete. The measure of migration is not standard across censuses and the urban nature of the previous residence had to be generally approximated. As a consequence, the paper focuses on inter-regional migration only. Although we were careful when testing our models for robustness, given the data limitations the results still depend on a number of methodological choices. Also, country effects could not be controlled for. Therefore, results may be valid at the very macro (continental) level, showing some general trends, but cannot easily be translated to a specific country's situation.

Overall, our analysis is in line with previous studies that have also found that the role of internal migration in the urban transition has been negligible over the last decades, and that natural growth has been the driving force behind recent urbanisation in African and Asian countries, in a context of rapid demographic transition and high population growth (Fox and Goodfellow 2021; Menashe-Oren and Bocquier 2021; zu Selhausen 2022). The main driver of contemporary urbanisation in African and Asian countries is not generated by rural-to-urban migration but by the fast-growing urban population itself, be it through natural growth or through expansion to peripheral areas.

In light of the flat trends in net migration over time, and general stagnation of the urban transition in Africa (Bocquier and Mukandila 2011; Potts 2009), even if sustainability is accomplished, and inequalities reduced (conditions of the first Shared Socioeconomic Pathway – SSP1 (O'Neill et al. 2014)), we do not expect changes in the role of migration, especially considering that urbanisation on the continent does not generally go hand in hand with development (Fay and Opal 2000; Gollin, Jedwab, and Vollrath 2016; Jamal and Weeks 1993; Turok 2013). If current trends continue as they are, in a middle-of-the road scenario (called SSP2) the contribution of migration to urbanisation is expected to remain the same. In Asia, by contrast, we may expect a convergence towards migration contributing little if current trends continue (under SSP2). However, in a scenario of stalled development (as in SSP3), net migration trends may become negative in Asia, even if proportions urban stay relatively low, as cities become less attractive and employment opportunities dwindle.

8. Acknowledgements

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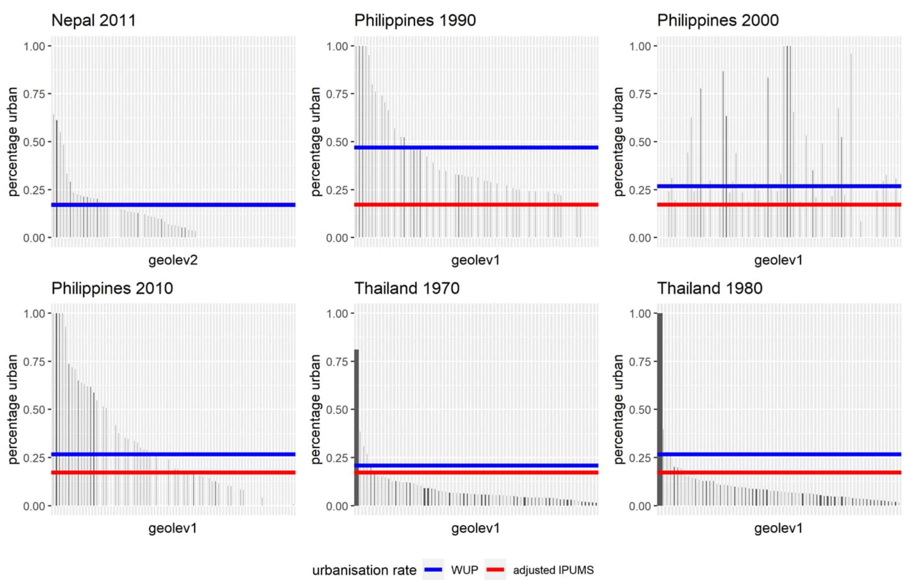
Appendix

A-1 Decisions made in determining rural/urban residence and proportions urban using census data

a) Ensuring consistency in proportions urban

We compare the proportion urban in the census with proportions urban from the 2018 version of UN World Urbanisation Prospects (WUP – https://population.un.org/wup/) to ensure consistency. WUP is a respectable data source on urban populations for all countries, which builds on multiple sources of available data and follows country-specific definitions of urban. If necessary, we adjust the percentage urban in the IPUMS data to that of the WUP, while maintaining the population distribution across regions. This alleviates any sampling error in the census. In Figure A1 we provide examples of the different urban proportions obtained from the two sources, and how the regions are ranked according to these proportions.

Figure A-1: Examples of different proportions urban according to the WUP and IPUMS censuses



Note: WUP 2018 and IPUMS International; each black vertical line represents a region (thickness proportionate to population size).

The 'unadjusted IPUMS urban rate' is calculated as the ratio of the sum of person weights who live in urban areas to the sum of person weights of all people living in the country:

$$Unadjusted\ IPUMS\ \%\ urban = \frac{\sum_{i=urban} \text{perwt}}{\sum_{j=urban,rural} \text{perwt}}$$

where *perwt* is the person-weight, the numerator is the sum of the weighted population residing in urban areas at the time of the census, while the denominator is the weighted population of the country in a specific census year. In Table A-1 we summarise the proportions urban per census according to the IPUMS data, the WUP. The table also indicates the regional level used in the IPUMS data to determine rural and urban residence, and the period the migration estimate covers per census.

Table A-1: Summary of African and Asian censuses covered in the study, including the proportion urban, type of migration rate, and lowest regional level used to determine rural/urban residence

Country	Year	Region	Unadjusted IPUMS	WUP	WUP/ IPUMS	Migration estimation	Geographic level
Burkina Faso (i)	1996	Africa	0.155	0.154	0.99	1-year	geolev2
Burkina Faso	2006	Africa	0.227	0.223	0.98	1-year	geolev2
Botswana	1991	Africa	0.457	0.453	0.99	1-year	geolev1
Benin (iii)	1979	Africa	0.138	0.267	1.93	2.5-year	geolev1
Benin	1992	Africa	0.394	0.358	0.91	2.5-year	geolev1
Benin	2002	Africa	0.389	0.39	1	2.5-year	geolev1
Benin	2013	Africa	0.442	0.446	1	2.5-year	geolev1
Cameroon	1987	Africa	0.381	0.379	1	2.5-year	geolev1
Cameroon	2005	Africa	0.488	0.485	0.99	2.5-year, 5-year	geolev1
China (vi)	1990	Asia	0.264	0.264	1	5-year	geolev1
China	2000	Asia	0.359	0.359	1	5-year	geolev1
Egypt*	1986	Africa	0.535	0.44	0.82	2.5-year	geolev1
Egypt	1996	Africa	0.426	0.427	1	2.5-year	geolev1
Egypt	2006	Africa	0.427	0.431	1	2.5-year	geolev1
Ghana	2000	Africa	0.438	0.439	1	5-year	geolev1
Guinea	1996	Africa	0.299	0.298	1	2.5-year	geolev1
Guinea	2014	Africa	0.347	0.348	1	2.5-year	geolev1

Table A-1: (Continued)

Country	Year	Region	Unadjusted IPUMS	WUP	WUP/ IPUMS	Migration estimation	Geographic level
Indonesia	1971	Asia	0.174	0.173	1	2.5-year	geolev1
Indonesia	1976	Asia	0.185	0.199	1.07	5-year	geolev1
Indonesia	1980	Asia	0.224	0.221	0.988	5-year	geolev1
Indonesia	1985	Asia	0.262	0.261	1	2.5-year	geolev1
Indonesia	1990	Asia	0.309	0.306	0.99	2.5-year	geolev1
Indonesia	1995	Asia	0.373	0.361	0.97	2.5-year	geolev1
Indonesia	2000	Asia	0.424	0.42	0.99	5-year	geolev1
Indonesia	2005	Asia	0.431	0.459	1.07	2.5-year	geolev1
Indonesia	2010	Asia	0.494	0.499	1.01	5-year	geolev1
Iraq	1997	Asia	0.675	0.684	1.01	2.5-year	geolev1
Kenya	1979	Africa	0.128	0.154	1.2	1-year	geolev1
Kenya	1989	Africa	0.165	0.165	1	1-year	geolev1
Kenya	1999	Africa	0.243	0.196	0.81	1-year	geolev1
Kenya	2009	Africa	0.313	0.232	0.74	1-year	geolev1
Kyrgyzstan	1999	Asia	0.35	0.353	1.02	2.5-year	geolev2
Mali	1998	Africa	0.271	0.269	0.99	2.5-year	geolev1
Mali	2009	Africa	0.225	0.352	1.56	2.5-year	geolev1
Mongolia (v)	2000	Asia	0.572	0.571	1	2.5-year	geolev1
Mauritius	1990	Africa	0.393	0.439	1.12	5-year	geolev1
Mauritius	2000	Africa	0.428	0.427	1	5-year	geolev1
Mauritius	2011	Africa	0.401	0.414	1.03	5-year	geolev1
Malawi	1987	Africa	0.107	0.106	0.99	1-year	geo1_mw
Malawi	2008	Africa	0.145	0.153	1.05	2.5-year	geolev1
Malaysia	1991	Asia	0.551	0.506	0.92	5-year	geolev1
Malaysia	2000	Asia	0.659	0.62	0.94	5-year	geolev1
Mozambique	1997	Africa	0.293	0.285	0.97	1-year	geolev1
Mozambique	2007	Africa	0.304	0.304	1	1-year	geolev1
Nepal X	2001	Asia	0.137	0.139	1.02	5-year	geolev1
Nepal X	2011	Asia	0.166	0.171	1.03	5-year	geolev1
Philippines #	1990	Asia	0.486	0.47	0.97	2.5-year	geolev1
Philippines (vii)	2000	Asia	0.469	0.461	0.98	5-year	geolev1
Philippines (viii)	2010	Asia	0.468	0.453	0.97	5-year	geolev1
Rwanda (iv)*+ X	1991	Africa	0.075	0.055	0.74	2.5-year	geolev1
Rwanda* X	2002	Africa	0.172	0.168	0.98	2.5-year	geolev1
Sudan & South Sudan	2008	Africa	0.406	0.329	0.81	1-year	geolev1
Senegal	2002	Africa	0.406	0.406	1	5-year	geolev1
Togo	2010	Africa	0.376	0.375	1	2.5-year	geolev1

Table A-1: (Continued)

Country	Year	Region	Unadjusted IPUMS	WUP	WUP/ IPUMS	Migration estimation	Geographic level
Thailand % #	1970	Asia	0.638	0.209	0.33	2.5-year	geolev1
Thailand #	1980	Asia	0.155	0.268	1.73	2.5-year	geolev1
Thailand	1990	Asia	0.309	0.294	0.95	2.5-year	geolev1
Thailand %	2000	Asia	0.312	0.314	1	2.5-year	geolev1
Uganda	1991	Africa	0.108	0.115	1.06	2.5-year	geolev1
Uganda	2002	Africa	0.123	0.156	1.27	2.5-year	geolev1
Vietnam	1989	Asia	0.197	0.199	1.1	5-year	geolev1
Vietnam	1999	Asia	0.235	0.238	1.01	5-year	geolev1
Vietnam	2009	Asia	0.296	0.298	1.01	5-year	geolev1
South Africa #	2007	Africa	0.6	0.606	1	2.5-year	geolev2
South Africa	2011	Africa	0.59	0.627	1.06	2.5-year	geolev2
South Africa	2001	Africa	0.563	0.574	1.02	5-year	geolev2
Zambia	1990	Africa	0.391	0.394	1	1-year	geolev1
Zambia	2000	Africa	0.352	0.348	0.99	1-year	geolev1
Zambia (ii)	2010	Africa	0.395	0.394	1	1-year	geolev1

Source: Analyse des résultats du Recensement Général de la Population et de L'Habitation de 1996, volume I (Ouagadougou, décembre 2020). Direction de la Démographie, Institut National de la Statistique et de la Démographie, INSD.

i- Source: Zambia 2010 Census of population and Housing. National Analytical Report. Published by Central Statistical Office. December 2012.

ii- Source: Bénin: Recensement général de la population et de l'habitation de 1979 en République Populaire du Bénin. 1979.

iii- Source: The General Census of Population and Housing Rwanda: 16–30 August 2002. National Census Service. Ministry of Finance and Economic Planning. Republic of Rwanda 1991.

iv- Source: Mongolian National Statistical Office.

v- Source: China National Statistical Bureau.

vi- Source: Philippines Census 2000.

vii- Source: Philippines Census 2010.

* *These censuses do not have migration indicators that show the nature of the move; i.e., NIU; same major, same minor administrative unit; same major, different minor administrative unit; different major administrative unit; abroad. The first three types of move are considered non-migrations.*

+ *Education is not available in this census.*

% *In the variable years since last migration ('migyrs1') there is an extra category, of "less than 5 years". For these censuses, people who reported that they changed residence less than 5 years ago are imputed randomly as either 'less than 3 years' or 'more than 3 years' according to the original distribution of this variable. The choice of 3 years corresponds to censuses which include information on previous residence.*

These censuses do not have migration estimates for the under-5-years-old because the question "In what city/municipality did _____ live before moving to this place?" was only asked for persons 5 years old and over.

X *Censuses that are not included in the final analysis*.

To adjust our micro-level direct estimates of IPUMS to that of WUP, we apply the ratio of WUP to unadjusted IPUMS (WUP/IPUMS, see Table A1) to the unadjusted IPUMS. There are two ways of making our estimates consistent with that of WUP, depending on whether the WUP/IPUMS is larger or lower than 1. For both adjustments, we first disaggregate the urban rate by the smallest geographical unit provided by IPUMS: geolev1 is the major administrative geographical level and geolev2 is the minor administrative geographical level, usually more detailed than geolev1. When geolev2 is available and the previous residence is also available at the same level to be matched with, we opted for calculating the urban rate on geolev2; otherwise, we chose the geolev1 as the calculation unit.

i. If WUP/IPUMS is lower than 1, taking Indonesia 1971 as an example (weight=0.99194), we multiply the 'weight' with the urban rate by geolev1 ('urban'), resulting in an adjusted urban rate, i.e., 'adjusted_urban'. The weight is the same for all the districts and is calculated as $WUP / \sum \ pop_d * urban_d$ where d is geolev1.

geolev1	pop	urban	weight	adjusted_urban
360031	0.037617	1	0.99194	0.99193999
360094	0.001274	1	0.99194	0.99193999
360064	0.006199	0.411145	0.99194	0.407831629
360015	0.008502	0.291188	0.99194	0.288840782
360016	0.029103	0.290726	0.99194	0.288382638
360063	0.014359	0.266536	0.99194	0.264387921
360071	0.01452	0.195166	0.99194	0.193592707
360073	0.043851	0.181341	0.99194	0.17987976
360012	0.055969	0.177306	0.99194	0.175876881
360013	0.023605	0.171945	0.99194	0.170559446
360034	0.021065	0.163016	0.99194	0.161701853
360062	0.005912	0.157365	0.99194	0.156096887
360035	0.215722	0.145002	0.99194	0.143832957
360014	0.013873	0.132982	0.99194	0.131910131
360081	0.009203	0.132885	0.99194	0.131814441
360061	0.017071	0.128097	0.99194	0.127064173
360032	0.182763	0.124181	0.99194	0.123180075
360017	0.004389	0.117332	0.99194	0.116385823
360033	0.184874	0.107692	0.99194	0.106824279
360018	0.023469	0.098754	0.99194	0.097957952
360011	0.016977	0.098578	0.99194	0.097783896
360051	0.017919	0.098229	0.99194	0.097436954
360052	0.018612	0.081131	0.99194	0.080477318
360072	0.007721	0.080217	0.99194	0.079570439
360074	0.006035	0.07287	0.99194	0.072282772
360053	0.019395	0.056406	0.99194	0.055951511

ii. If WUP/IPUMS is larger than 1, taking Indonesia 1976 as an example, first we update the urban rate by district ('urban updated') as urban*weight. This results in some districts with urban rate larger than 1, which is not realistic. For these districts we keep the proportion urban as 1, and redistribute the remaining population urban as $dist_d = (urban_d - 1) * total_d$, where $urban_d$ is the urban rate of a district where updated urban rate is larger than 1 and $total_d$ is the percentage of the population of the same district in the total population.

geolev1	pop	urban original	urban updated*	uperc1a*
360031	0.042555	1	1	4.65E-09
360081	0.000704	1	1	7.69E-11
360094	0.000478	1	1	5.22E-11
360064	0.007353	0.474288537	0.521170961	0
360015	0.008748	0.304024615	0.334076808	0
360016	0.030697	0.2720389	0.298929373	0
360061	0.018095	0.242869233	0.266876345	0
360012	0.059216	0.229445337	0.252125526	0
360071	0.015094	0.207519898	0.228032804	0
360073	0.045059	0.206395297	0.226797038	0
360063	0.014635	0.200876903	0.220733162	0
360053	0.003097	0.192054947	0.211039175	0
360013	0.023751	0.180024475	0.197819516	0
360062	0.006438	0.170720802	0.187596194	0
360014	0.014615	0.162651139	0.178728861	0
360034	0.020811	0.161778839	0.177770337	0
360035	0.214906	0.137997574	0.151638344	0
360011	0.017633	0.128205336	0.140878163	0
360032	0.186	0.121669957	0.133696776	0
360017	0.004493	0.113146803	0.124331126	0
360033	0.186843	0.106476	0.117000929	0
360051	0.018186	0.096085572	0.105583429	0
360074	0.006223	0.088778919	0.097554528	0
360018	0.027273	0.08451593	0.092870152	0
360052	0.019052	0.08182594	0.089914262	0
360072	0.008045	0.076618313	0.084191872	0

Note: The columns marked with * are the last updates, after 60 loops, giving an updated urban rate of 0.1989999 as compared to the WUP estimate of 0.199.

iii. We then assign the sum of this deleted population urban to other districts so that their adjusted percentage urban is $urban_a * \left[1 + \sum_d dist_d / (1 - \sum_d total_d)\right]$ where $urban_a$ stands for the urban population in the districts with urban rate smaller than 1. By updating each $urban_a$ with the same multiplier, we make sure to update all adjusted districts to the same extent. However, the redistribution will not be exact and some adjusted districts may find themselves with proportion urban higher than 1. Therefore, we repeat this procedure until the difference between WUP and the weighted sum of updated urban rate is smaller than 0.0000001.

Importantly, the urban definitions used in this analysis are country-specific. Table A-2 outlines these definitions.

Table A-2: Country-specific criteria and definitions of urban as used in the censuses

Country	Population	Administrative	Functional	Detailed urban definition
China		X		In the 2000 administrative organizational system an administrative unit defined as *shiqu* is a city, and as *xian* is a county (or rural, including towns).
Indonesia	X		X	No precise definition – "with urban characteristics". In censuses, enumerators were provided with a list defining if the area they worked in was rural or urban. In the UN Demographic Yearbook, urban is defined as an area which satisfies certain criteria in terms of population density, percentage of agricultural households, and a number of urban facilities such as roads, formal education facilities, and public health services.
Iraq		X		Administratively determined – urban is only within boundaries of the city of Bagdad and two other municipalities (Al-Majlis and Al-Baldei).
Jordan	X			Over 5,000 residents.
Kyrgyz Republic		X		Administratively determined at *kenesh* level, so definition differs depending on number of inhabitants, predominance of agricultural activity, etc.
Malaysia	X			Population over 1,000.
Nepal	X		X	Over 20,000 inhabitants in flatlands, and 10,000 residents in hilly/mountainous areas (combination of population and ecological zone), and based on annual revenue and infrastructure.
Philippines	X		X	Any area fulfilling three criteria: (1) Population size of 5,000 or more, (2) At least one establishment with a minimum of 100 employees, (3) Five or more establishments with a minimum of 10 employees and 5 or more facilities (as of 2003).
Thailand	X	X		Municipal areas of a certain population size and density.
Vietnam	X		X	Population of at least 2,000 with over half working outside agriculture.
Benin	X	X	X	Administrative centres of communes with at least 10,000 residents and one important structural service; e.g., post office, medical centre.
Botswana	X		X	Population of at least 5,000, with at least 75% economic activity not agricultural
Cameroon	X		X	Has an administrative function, or a population of at least 5,000 inhabitants and a primary school, health centre, water supply, electricity, and daily market.
Egypt		X		Settlements in governorates of Cairo, Alexandria, Port Said, and Suez, and capitals of districts.
Ghana	X			Population of 5,000 or more.
Guinea		X		Administratively defined centres of prefectures, and Kamsar and Sangarédi.
Kenya	X			Towns with more than 2,000 people (1969).
Malawi		X		All district centres and townships.
Mali	X	X		5,000 or more inhabitants and district centres (1998).
Mauritius		X		Administratively defined municipal wards.
Mozambique				N/A
Rwanda		X		Administratively determined, including all areas of capital Kigale (2002). In 2012, rural areas are defined as areas mainly characterise by agricultural and livestock activities, and small number of buildings within a cluster of dwellings.
Senegal	X			Agglomerations of 10,000 or more inhabitants.
South Africa			X	Organized and permanent arrangement of dwellings where services such as water, sewage, electricity, and waste removal are provided and controlled by a local/district council.
Sudan and South Sudan	X			5,000 or more inhabitants
Tanzania				Determined by district administration (not uniform).
Togo		X		Capitals of each prefecture.
Uganda	X			More than 1,000 inhabitants (1991) or 2,000 inhabitants (2002, 2014).
Zambia	X		X	Not defined in sample provided to IPUMS, but according to UN Demographic Yearbook a locality of over 5,000 inhabitants where the majority do not depend on agricultural activities.

Source: IPUMS International (Minnesota Population Center 2020).

b) Defining regions as rural or urban

Most of the census datasets do not include information on whether individuals' previous residence was rural or urban, but only the region of previous residence. Therefore, to determine whether a migrant moved from a rural or an urban area, we define regions within each country as rural or urban based on the distribution of the population at the time of the census (i.e., after the migration). This will not be accurate for two reasons:

1. Some regions may have shifted to higher (or lower) proportions urban since the time of previous or last residence.
2. Entire regions are not only rural or only urban. This is especially the case where regions are large. In some countries, such as Rwanda, the capital city may be defined as a region, in which case we can be confident that the region is urban. In other countries, such as Mongolia, the capital city is in a large region and surrounded by rural areas; when this region is defined as urban it will also include rural populations even though the majority of the population in the region may be urban.

Determining whether a region is rural or urban is therefore not straightforward. If we were to say that a region has to have at least 80% of its population in cities to be considered urban, then in Thailand 1970, for instance, the most urbanized region would still not be considered urban, even though it has a large population and includes the capital Bangkok (see Figure A-1). It is possible to consider the fact that in 1970 in Thailand the urban threshold was 60%, and then ten years later 70%. However, this country–year specific definition makes it harder to eventually give the same meaning to migration rates across countries. Moreover, the countries included in our analysis cover a range of urbanisation levels at the national level (though they fall mostly within 20%–50% urban). In order to compare countries, and also censuses within countries over time, we decided on a universal threshold to classify a region as urban, harmonized to match WUP estimates.

We chose a standard threshold, defining each region as urban if it passes 50% urban. In most censuses, changing the threshold to 60% would not reduce the number of regions considered urban, though using a lower threshold (40%) would increase the number of regions considered urban (Table A-3).

Table A-3: Regions defined as urban in each census and the effect of changing the definition of urban (adjusted thresholds)

African Countries	Total number of regions	Number of regions considered urban			Resulting Proportion Urban in the country		
		40% threshold	50% threshold	60% threshold	40% threshold	50% threshold	60% threshold
Benin 1979	6	1	1	1	12.5	12.5	12.5
Benin 1992	12	1	1	1	10.8	10.8	10.8
Benin 2002	12	3	1	1	31.3	9.8	9.8
Benin 2013	12	7	2	1	60.6	17.7	6.8
Botswana 1991	21	8	5	5	44.7	23.3	23.3
Burkina Faso 1996	45	2	1	1	15.7	9.1	9.1
Burkina Faso 2006	45	2	2	1	19.2	19.2	12.3
Cameroon 1987	7	2	1	1	34.9	13.8	13.8
Cameroon 2005	7	4	2	2	53.3	36.0	36.0
Egypt 1986	24	9	8	6	37.7	37.2	36.1
Egypt 1996	24	12	9	5	36.5	29.0	26.9
Egypt 2006	24	11	8	7	31.4	28.2	28.0
Ghana 2000	10	2	1	1	34.5	15.4	15.4
Guinea 1996	33	3	2	1	16.3	15.2	15.2
Guinea 2014	33	6	3	2	34.8	22.3	21.4
Kenya 1979	8	1	1	1	2.7	2.7	2.7
Kenya 1989	8	1	1	1	6.2	6.2	6.2
Kenya 1999	8	1	1	1	7.4	7.4	7.4
Kenya 2009	8	1	1	1	8.1	8.1	8.1
Malawi 1987	26	1	1	0	7.4	7.4	0.0
Malawi 2008	26	1	1	1	7.6	7.6	7.6
Mali 1998	8	1	1	1	10.4	10.4	10.4
Mali 2009	8	2	2	1	16.6	16.6	12.4
Mauritius 1990	10	2	2	2	43.1	43.1	43.1
Mauritius 2000	10	2	2	2	41.3	41.3	41.3
Mauritius 2011	10	3	2	2	44.8	38.6	38.6
Mozambique 1997	11	0	0	0	0.0	0.0	0.0
Mozambique 2007	11	2	2	2	11.4	11.4	11.4
Rwanda 1991 X	8	0	0	0	0	0	0
Rwanda 2002 X	8	0	0	0	0	0	0
Senegal 2002	8	3	1	1	39.6	22.0	22.0
South Africa 2001	25	17	15	13	51.5	35.9	34.3
South Africa 2007	25	18	17	15	51.1	38.2	33.6
South Africa 2011	25	18	16	14	59.1	54.4	37.8
Sudan & South Sudan 2008	25	1	1	1	17.0	17.0	17.0
Tanzania 2002	23	2	2	2	8.5	8.5	8.5
Tanzania 2012	23	2	2	2	11.0	11.0	11.0
Togo 2010	3	1	1	1	41.9	41.9	41.9
Uganda 1991	37	1	1	1	4.4	4.4	4.4
Uganda 2002	36	1	1	1	4.9	4.9	4.9
Zambia 1990	8	2	2	2	32.7	32.7	32.7
Zambia 2000	8	2	2	2	30.2	30.2	30.2
Zambia 2010	8	2	2	2	31.8	31.8	31.8

Table A-3: (Continued)

Asian Countries	Total number of regions	Number of regions considered urban			Resulting Proportion Urban in the country		
		40% threshold	50% threshold	60% threshold	40% threshold	50% threshold	60% threshold
China 1990	30	5	3	1	9.5	2.9	1.2
China 2000	29	4	3	2	6.7	3.3	2.5
Indonesia 1971	26	3	2	2	4.5	3.9	3.9
Indonesia 1976	26	4	3	3	5.3	4.5	4.5
Indonesia 1980	26	1	1	1	4.4	4.4	4.4
Indonesia 1985	27	2	1	1	5.7	4.8	4.8
Indonesia 1990	27	3	1	1	7.3	4.6	4.6
Indonesia 1995	17	3	2	1	30.8	7.2	5.5
Indonesia 2000	26	8	4	1	55.6	28.7	4.2
Indonesia 2005	25	10	5	3	72.7	31.1	7.0
Indonesia 2010	26	12	5	5	73.8	31.1	31.1
Iraq 1997	15	15	11	7	100.0	80.6	61.2
Kyrgyzstan 1999	56	20	17	16	35.6	31.1	28.9
Malaysia 1991	13	7	3	2	59.4	28.9	20.4
Malaysia 2000	13	11	8	5	93.4	69.2	52.4
Mongolia 2000	21	6	5	3	48.4	45.5	39.8
Nepal 2001 X	14	0	0	0	0	0	0
Nepal 2011 X	14	1	0	0	14.1	0	0
Philippines 1990	76	23	16	11	48.3	36.3	26.0
Philippines 2000	76	19	15	12	44.5	37.0	31.6
Philippines 2010	78	21	16	12	49.6	44.1	35.6
Thailand 1970	68	4	2	2	10.0	9.4	9.4
Thailand 1980	68	7	4	4	15.8	12.1	12.1
Thailand 1990	68	3	2	2	12.2	11.9	11.9
Thailand 2000	68	6	5	3	17.2	16.4	13.4
Vietnam 1989	38	2	1	1	7.5	6.2	6.2
Vietnam 1999	38	3	1	1	10.7	6.6	6.6
Vietnam 2009	38	4	2	1	14.5	9.6	8.3

Note: X marks censuses excluded from final analysis.

Table A-4: Proportion of the population living in regions we define as urban, as compared to the proportion of population living in large cities (300k+) according to the WUP

Country	Year	Proportion total urban WUP	Proportion WUP cities (300k+) in total urban pop	Proportion WUP cities (300k+) in total pop (%)	Proportion population in urban regions (%)	Difference between WUP and urban population (%)
Benin	1992	0.358	0.482	17.24	10.74	6.50
Benin	2002	0.390	0.456	17.79	9.71	8.08
Benin	2013	0.446	0.419	18.70	18.07	0.63
Benin	1979	0.267	0.584	15.60	20.20	–4.60
Botswana	1991	0.453	n.a.	n.a.	23.34	n.a.
Burkina Faso	1996	0.154	0.630	9.70	9.05	0.65
Burkina Faso	2006	0.223	0.615	13.73	19.22	–5.49
Cameroon	1987	0.379	0.477	18.08	13.79	4.29
Cameroon	2005	0.485	0.559	27.13	35.45	–8.32
China	1990	0.264	0.537	14.18	12.26	1.92
China	2000	0.359	0.676	24.26	18.46	5.80
Egypt	1986	0.440	0.642	28.23	37.00	–8.77
Egypt	1996	0.427	0.690	29.45	28.88	0.57
Egypt	2006	0.431	0.704	30.36	28.00	2.36
Ghana	2000	0.439	0.403	17.70	34.32	–16.62
Guinea	1996	0.298	0.446	13.29	16.09	–2.80
Guinea	2014	0.348	0.406	14.14	22.06	–7.92
Indonesia	1971	0.173	0.677	11.72	3.74	7.98
Indonesia	1976	0.199	0.641	12.75	5.00	7.75
Indonesia	1980	0.221	0.619	13.68	4.29	9.39
Indonesia	1985	0.261	0.547	14.28	4.73	9.55
Indonesia	1990	0.306	0.496	15.17	4.68	10.49
Indonesia	1995	0.361	0.423	15.29	7.25	8.04
Indonesia	2000	0.420	0.375	15.73	28.55	–12.82
Indonesia	2005	0.459	0.351	16.10	31.01	–14.91
Indonesia	2010	0.499	0.333	16.63	30.91	–14.28
Iraq	1997	0.684	0.745	50.94	80.61	–29.67
Kenya	1979	0.154	0.613	9.44	2.78	6.66
Kenya	1989	0.165	0.601	9.92	5.95	3.97
Kenya	1999	0.196	0.574	11.26	7.11	4.15
Kenya	2009	0.232	0.541	12.55	7.96	4.59
Kyrgyzstan	1999	0.353	0.438	15.44	13.60	1.84
Malawi	1987	0.106	0.635	6.73	7.47	–0.74
Malawi	2008	0.153	0.609	9.31	7.52	1.79
Malaysia	1991	0.506	0.505	25.57	36.21	–10.64
Malaysia	2000	0.620	0.530	32.88	68.97	–36.09
Mali	1998	0.269	0.417	11.21	10.31	0.90
Mali	2009	0.352	0.395	13.91	16.49	–2.58
Mauritius	1990	0.439	n.a.	n.a.	43.12	n.a.
Mauritius	2000	0.427	n.a.	n.a.	41.49	n.a.
Mauritius	2011	0.414	n.a.	n.a.	38.76	n.a.
Mongolia	2000	0.571	0.559	31.90	43.33	–11.43
Mozambique	1997	0.285	0.540	15.38	11.71	3.67
Mozambique	2007	0.304	0.486	14.77	11.40	3.37
Philippines	1990	0.470	0.512	24.06	35.96	–11.90
Philippines	2000	0.461	0.554	25.52	37.04	–11.52
Philippines	2010	0.453	0.594	26.90	43.65	–16.75

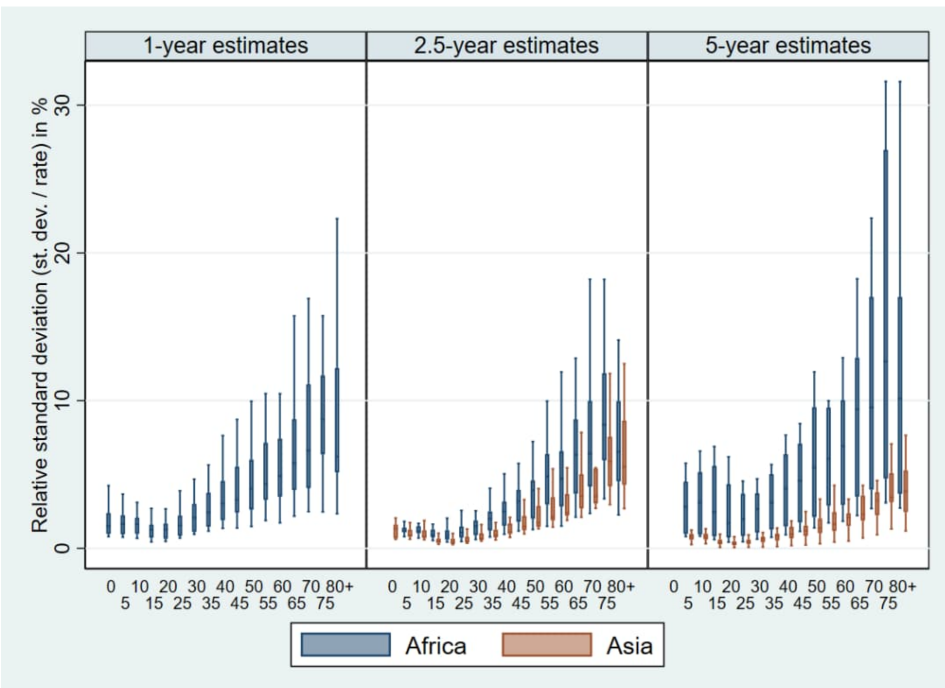
Table A-4: (Continued)

Country	Year	Proportion total urban WUP	Proportion WUP cities (300k+) in total urban pop	Proportion WUP cities (300k+) in total pop (%)	Proportion population in urban regions (%)	Difference between WUP and urban population (%)
Senegal	2002	0.406	0.562	22.81	21.85	0.96
South Africa	2001	0.574	0.635	36.47	64.21	–27.74
South Africa	2007	0.606	0.651	39.45	65.53	–26.08
South Africa	2011	0.627	0.662	41.48	67.02	–25.54
South Sudan	2008	0.176	0.143	2.52	13.48	–10.96
Sudan	2008	0.329	0.589	19.38	13.48	5.90
Tanzania	2002	0.230	0.483	11.10	8.34	2.76
Tanzania	2012	0.295	0.472	13.93	10.90	3.03
Thailand % #	1970	0.209	0.514	10.75	n.a.	n.a.
Thailand	1980	0.268	0.469	12.58	15.52	–2.94
Thailand	1990	0.294	0.534	15.69	11.52	4.17
Thailand	2000	0.314	0.704	22.12	14.83	7.29
Togo	2010	0.375	0.601	22.53	40.98	–18.45
Uganda	1991	0.115	0.386	4.44	4.18	0.26
Uganda	2002	0.156	0.338	5.28	4.65	0.63
Vietnam	1989	0.199	0.459	9.14	6.13	3.01
Vietnam	1999	0.238	0.464	11.03	6.33	4.70
Vietnam	2009	0.298	0.501	14.93	9.11	5.82
Zambia	1990	0.394	0.452	17.80	32.64	–14.84
Zambia	2000	0.348	0.494	17.18	30.29	–13.11
Zambia	2010	0.394	0.490	19.29	31.72	–12.43
Unweighted mean		0.334	0.517	17.31	22.70	–3.59

A-2: Precision of estimates of internal migration rates from census data

Figure A-2 indicates the precision of our estimates of migration, by age, continent, and type of estimate. The measure of the precision is the standard error divided by the estimate of the rate, or relative standard error. Three conclusions can be made from examining the distribution (through box-plots) of this measure of precision in Figure A-2: (1) Estimates are generally well below the 30% threshold, with a few exceptions (all above 75 years old); (2) Estimates of migration below 50 years old are quite precise (below the 10% threshold); and, (3) Estimates for Africa are less precise than those for Asia, especially the 5-year estimates.

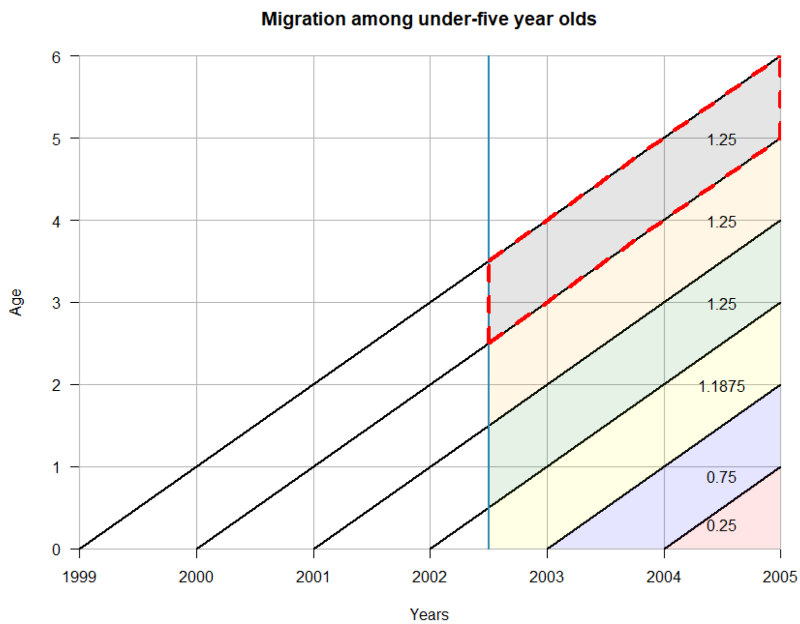
Figure A-2: Distribution of the precision of urban in-migration rates by age group and type of estimates from all IPUMS samples (precision measured by the standard error divided by the rate, in %)



A-3: Estimation of migration among under-5-year-olds

We use a Lexis Diagram for a hypothetical cohort who were born between 2000 and 2005 to demonstrate the estimation of migration exposure among children under 5 years old (Figure A-3). Imagine a census that took place in December 2005 that asks about one's previous residence 2.5 years ago, which was June 2002 (shown as blue vertical line). The shadowed areas show a surface that is the sum of pathways of a hypothetical individual born during anytime a year go through until 2005. For example, the pink lower-right triangle shows all the pathways an individual born between 2004 and 2005 could go in the diagonal direction until the observation time, which is year 2005, and so on. The number noted in the centre of each shadowed surface shows the average number of years at risk of migration for an individual born in a corresponding year. Taking the cohort born in year 2004 as an example, the observation interval is 1 year, i.e., 2004–2005, and the event of migration, if happened, took place on average in June 2004. Plus, the average age for this cohort in 2005 is 0.5 years, so the average risk time of migrating during the observation interval is 0.25 (calculated as 0.5*0.5).

Figure A-3: Lexis diagram of hypothetical cohort, demonstrating the exposure of under-5-year-old children to migration



When estimating the person-years at risk of migration for the under-5-year-olds during the past 2.5 years, one obvious concern is that some children have a shorter risk time than others born later in the age group. If we do not correct for this, the exposure time will be longer for younger children and shorter for older children. We correct the person-years at risk for each 1-year age group according to the factors noted in the Lexis in Figure A-3. For example, the risk time for an individual aged 4 in 2005 is the size of the surface of the red-dashed parallelogram, and the person years at risk are multiplied by a factor of 1.25.

A-4: Model robustness checks

Figure A-4: Model of predicted annual inter-regional net migration between rural and urban sectors, over the course of urbanisation, excluding censuses with migration flows between the rural sector and the region of the capital city only

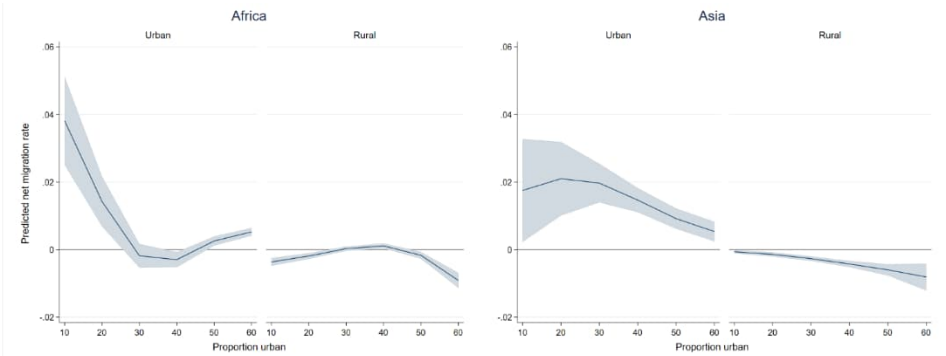


Figure A-5: Model of predicted annual inter-regional net migration between rural and urban sectors, over the course of urbanisation, excluding censuses with 1-year migration estimates in Africa

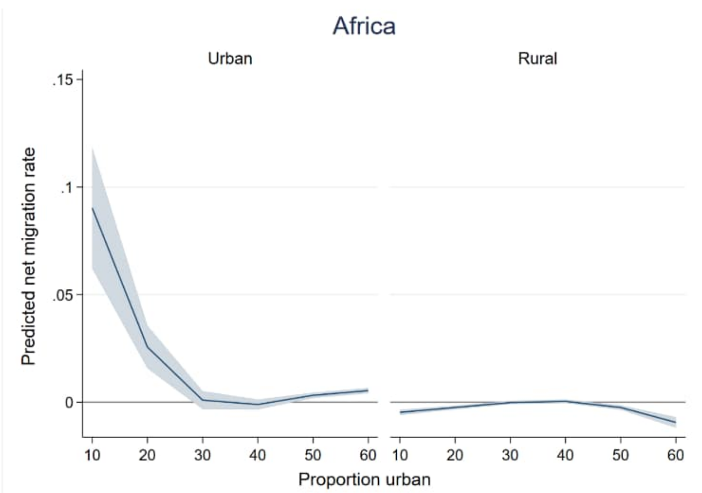


Figure A-6: Model of predicted annual inter-regional net migration between rural and urban sectors, over the course of urbanisation, excluding China censuses

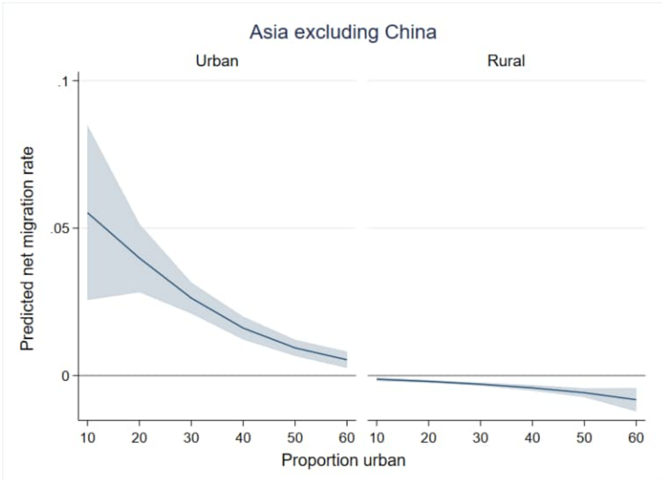


Figure A-7: Model of predicted annual inter-regional net migration between rural and urban sectors, over the course of urbanisation, excluding South Africa censuses

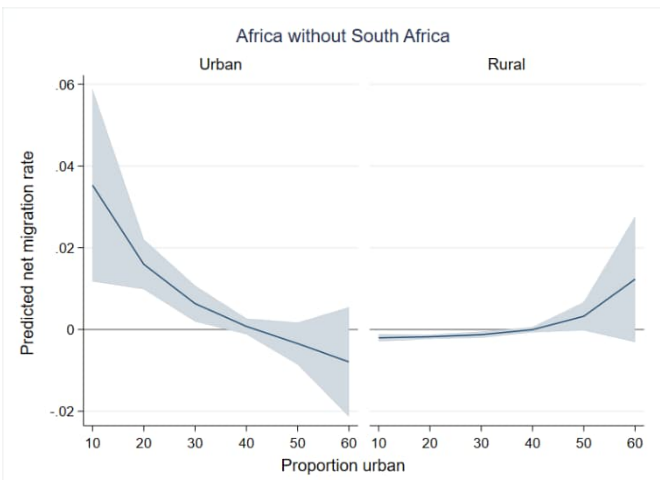
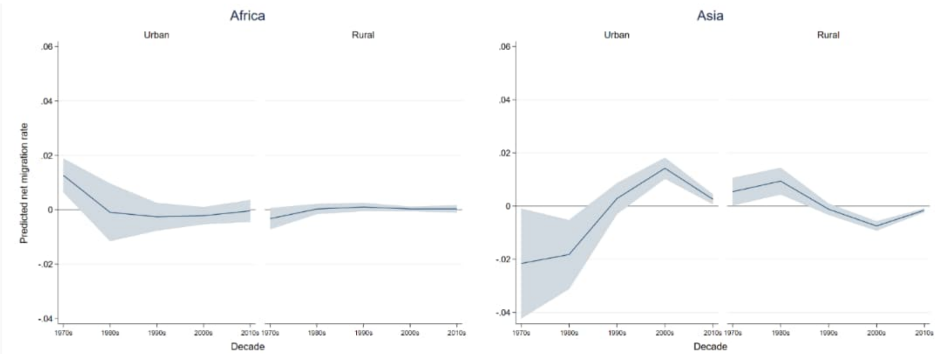


Figure A-8: Model of predicted annual inter-regional net migration between rural and urban sectors, over time, including a decade-migration flow interaction in model



A-5: The components of urban–rural growth difference

In Table A-5 we provide estimates of urbanisation components using URPAS and census sources for Africa and Asia at different levels of proportions urban. Figure 7 is based on this table.

Table A-5: Components of urban–rural growth difference for Asia and Africa separately using URPAS (indirect estimates) and census (direct estimates)

	Direct measurement of migration			**Indirect estimates of migration**			**Difference between indirect and direct**
	1. Inter-regional net-migration urban	2. Inter-regional net-migration rural	3. Urban–rural interregional migration growth difference	4. Urban–rural migration and reclassification growth difference	5. Urban–rural natural growth difference	6. Urban–rural total growth difference	7. Urban–rural intra-regional, international migration and reclassification growth difference
% urban			(Column 1 – 2)			(Column 4 + 5)	(Column 4 – 3)
Africa							
10	0.0439	–0.0028	0.0466	0.0204	0.0050	0.0254	–0.0262
20	0.0118	–0.0015	0.0132	0.0144	0.0034	0.0178	0.0011
30	–0.0010	0.0000	–0.0010	0.0087	0.0046	0.0133	0.0097
40	–0.0010	0.0005	–0.0014	0.0034	0.0086	0.0120	0.0049
50	0.0029	–0.0019	0.0048	–0.0015	0.0153	0.0139	–0.0062
60	0.0051	–0.0088	0.0139	–0.0059	0.0249	0.0190	–0.0198
Asia							
10	0.0255	–0.0007	0.0263	0.0241	–0.0217	0.0025	–0.0021
20	0.0261	–0.0015	0.0276	0.0209	0.0053	0.0261	–0.0068
30	0.0215	–0.0026	0.0241	0.0164	0.0228	0.0392	–0.0077
40	0.0145	–0.0038	0.0183	0.0107	0.0310	0.0417	–0.0076
50	0.0082	–0.0051	0.0132	0.0038	0.0296	0.0335	–0.0094
60	0.0041	–0.0063	0.0103	–0.0042	0.0189	0.0146	–0.0146

Note: Includes only comparable country-years (60 points), and does not include censuses from before 1985.