The Impact of Internal Migration on Population Redistribution: An International Comparison

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Abstract
We know that internal migration shapes human settlement patterns but few attempts have been made to measure systematically the extent of population redistribution or make comparisons between countries. Robust comparisons are hampered by limited data access, different space-time frameworks and inadequate summary statistics. We use new analysis software (IMAGE Studio) to assess the effects of differences in the number and configuration of geographic zones and implement new measures to make comparisons between a large sample of countries, representing 80% of global population. We construct a new *Index of Net Migration Impact (INMI)* to measure system-wide population redistribution and examine the relative contributions of migration intensity and effectiveness to cross-national variations. We compare spatial patterns using the slope of a regression between migration and population density across zones in each country to indicate the direction and pace of population concentration. We report correlations between measures of population redistribution and national development and propose a general theoretical model suggesting how internal migration redistributes population across settlement systems during the development process.

1. Introduction

It has been possible to compare fertility and mortality in national populations across the world since 1950 using comparable indices such as total fertility rate or life expectancy (UN 2014a). In recent years, progress has also been made in harmonising international migration statistics (Poulain *et al.* 2006; Raymer and Willekens 2008; UN 1998) and in the development of global estimates of international migration flows (Abel and Sander 2014). In the case of internal migration, movements from place to place within a single country, cross-national comparisons remain a challenge. Bell *et al.* (2002) proposed a suite of 15 measures designed to capture four discrete dimensions of internal migration for comparisons between countries. Until recently, implementation has been constrained by the lack of readily accessible data for a global sample of countries.

A repository of internal migration data assembled under the IMAGE project (*Internal Migration Around the GlobE)* has now established the foundation of internal migration and population statistics needed to advance this agenda[1]. Building on an inventory of migration data collections for 193 UN member states (Bell *et al.* 2015a), an international team of researchers has assembled internal migration data covering 135 countries (Bell *et al.* 2014) and built a bespoke software platform, the IMAGE Studio, to compute multiple migration indicators using flexible geographies (Stillwell *et al.* 2014; Daras 2014). Various papers have explored methodological issues (Bell *et al.* 2013a) and made cross-national comparisons of overall internal migration intensities (Bell *et al.* 2013b, 2015b) and migration age profiles (Bernard *et al.* 2014a, 2014b; Bernard and Bell 2015), globally as well as for selected regions and group of countries (Bell *et al.*, 2012; Charles-Edwards *et al.* forthcoming).

The current paper focuses on the spatial impact of internal migration on population redistribution, arguably the most visible and significant aspect of human population movement. The aim of the paper is to explore both the substantive and methodological dimensions of this phenomenon. The key substantive question concerns the role of internal migration in transforming settlement systems, particularly in terms of population concentration and de-concentration, and the way the transformation varies over space and time. Key methodological issues are how to select appropriate measures of internal migration that capture the impact of population shifts, how urban and rural populations are defined, and how to handle the spatial frameworks on which the analysis is based. As with all geographical problems, the analysis of migration data for different zonal systems is affected by the modifiable areal unit problem (MAUP) (Openshaw 1984). When different numbers, sizes and shapes of zones are chosen for analysis of internal migration in any country, different results are generated.

We focus on samples drawn from 91 countries covering all continents, representing 80 per cent of the world's population. In *section two,* we review relevant previous literature and outline a theoretical framework for understanding the role of migration in population redistribution within countries. In *section three,* we discuss the difficulties for cross-national comparison arising from differences in data types, observation intervals and territorial geographies, and the problems of access to data. In *section four*, we use the flexible geographies available through the IMAGE Studio to examine the effects of scale and zone design on measures of migration impact. Building on the work of Bell *et al.* (2002), we then propose a new summary measure, the Index of Net Migration Impact (*INMI*), to capture the system-wide impact of migration on population redistribution. We apply the *INMI* to compare migration impacts across 71 countries, distinguishing the relative contributions of migration intensity and effectiveness, and explore the links to various measures of national development. *Sections five* and *six* examine the patterns of redistribution, focusing first on the role of internal migration in urbanization. Few countries collect data in a form that clearly allows rigorous measurement and comparison of rural-urban movements so we turn attention to finer levels of spatial scale, focusing on the links between net migration and population density. For selected countries, we also explore temporal trends. *Section seven* discusses our findings in the context of national development and the urban transition.

2. The role of internal migration in population redistribution

Perhaps the single most significant aspect of internal migration is the way it alters the spatial distribution of population. Internal migration sits alongside births, deaths and international migration in shaping population change, but as the first demographic transition runs its course and as spatial differentials in vital rates diminish, internal migration plays an increasingly important role. Analysis of the drivers and dynamics of internal migration is critical to understanding the progressive shifts in the pattern of human settlement across the globe and its likely future trajectory. International migration also plays an important role in adding to populations in metropolises in the developed world but makes a minor contribution to population redistribution in less developed countries. There are important linkages between internal and international migration in global cities (Sassen-Koob 1984) through substitution of domestic labour and migration to other parts of the national settlement system (Frey 1979, 2015). The population accounts needed to distinguish the roles of internal and international migration have been created for European regions (De Beer *et al.* 2010) but they are unavailable for most countries of the world.

The role of internal migration in population redistribution was studied by Ravenstein (1885), who explored the flows of lifetime migrants recorded in the 1871 and 1881 censuses of Great Britain and Ireland. He showed how internal migration from rural areas was essential to the growth of industrial cities and towns in Britain, where mortality was high. The lifetime migration measures used by Ravenstein cumulate migration experience over many decades in the 19th century which saw rapid industrialization and urbanization. Equivalent processes have subsequently occurred in countries across the world, so that, by 2011, half of the world's population lived in cities (UN 2014b). Dyson (2010) argues that urbanisation, like fertility decline, is an inevitable consequence of the fall in mortality that triggered the demographic transition. Keyfitz (1980) demonstrates that city growth is mediated by a complex interplay between natural increase and net migration, but rural to urban migration remains the pivotal process in many countries. For example, in China rural outmigration has underpinned the massive growth of coastal cities since the 1980s, compensating for falling fertility in urban areas (Shen and Spence 1996).

There is also a longstanding pattern of migration outwards from city cores to the urban peripheries and beyond, driven by new household formation and facilitated by the development of rail and road transport for commuting. This process of suburbanization continues in most countries though in some cities, central re-urbanisation is occurring. In some advanced economies, suburbanization has spilled over into counter-urbanization (Champion 1989), triggered in the 1970s by retirement migrants seeking coastal and countryside locations away from urban congestion but later expanding to the working ages and families in the 1980s. Fielding (1989) described the transition to counter-urbanisation in Western Europe and identified a systematic shift in the 1970s. Net migration gains changed from a positive to a negative association with settlement size, reversing a longstanding pattern. Courgeau (1992) showed the trend was sustained into the 1980s using data at the *département* level in France. Rees and Kupiszewski (1999) distinguished the contributions of internal migration, international migration and natural change to population redistribution in 12 European countries, and explored the relationship between internal migration and population density in the 1980s and 1990s. They found that counter-urbanization featured only in Western Europe (United Kingdom, the Netherlands, France) and that urbanization remained dominant elsewhere. In Eastern Europe, rural depopulation, migration to capital cities and other countries continued in the 1990s after the transition from Communism. In Western Europe the hollowing out of cities through outward migration created new opportunities for city centre revival, led by the service, knowledge and cultural industries. This growth was driven primarily by international immigration and was counter-balanced by net internal losses (Rees *et al.* 2010).

Geyer (1996) painted a picture of the changing relationships between internal migration and population re-distribution across national settlement systems in graphical form as the theory of differential urbanization. This built on earlier contributions by Berry (1978, 1988), Richardson (1980), Klassen and Scimeni (1981), Long (1985), Champion (1989, 1992) and Geyer and Kontuly (1993). Geyer and colleagues conceived urbanization as a process occurring in seven stages, each of which exhibited distinctive flows between layers of the settlement system. The schema starts with a primate city stage where lower settlement layers send migrants to the largest city, the economy of which is growing vigorously. Growth then spreads down the settlement system and smaller cities attract migrants. At this stage the smallest settlements lose internal migrants and the largest settlements gain. When advanced urbanization has been achieved a reversal occurs as migration cascades down the urban hierarchy leading in some countries and some areas to counter-urbanization. Smaller places (including rural areas accessible to cities) experience positive net migration while larger places experience negative net migration. This relationship, however, may end and be replaced by renewed gains from migration in primate cities, losses in intermediate (de-industrialising) cities and continued gains in accessible rural places.

Geyer (1996) reviews the explanations put forward for the migration patterns of each stage and the factors responsible for transition to new stages. The urbanization and counter-urbanization processes are driven by multiple factors linked to broad economic trends, to waves of technical innovation in production and consumption and to individual, family and household preferences and circumstances, related strongly to the life course. Geyer and colleagues tested their theory through a set of empirical case studies which ranged from high income (Britain, Western Germany) to low income countries (India, South Africa) (Kontuly and Geyer 2003a, 2003b). Their theoretical predictions fitted reality in eight of nine cases.

Global forces may impact on internal migration in other ways. As manufacturing in many industrial economies becomes more labour efficient or less competitive compared with emerging economies, then smaller or more peripheral cities may undergo population decline. Oswalt and Rieniets (2006) report that, between 1990 and 2000, a quarter of cities in the world were losing population, mainly through internal migration outflows driven by economic, political and environmental forces. Internal migration is also motivated by other forces including the desire to settle new lands for farming, as occurred in North America (Zelinsky 1971), and is still important for resource frontier exploitation in regions as diverse as north-western Australia (iron ore mining) and Kalimantan (oil palm plantations). In parts of east and southeast Asia resource exploitation combines with political and defence motives to encourage migration to settlement frontiers.

Despite these complexities, most countries of the world have experienced long running urbanization through rural to urban migration, and this process continues at a rapid pace in the developing world, especially where high fertility generates labour supply in excess of economic opportunities. But, in a small number of countries, this process is being superseded by more subtle migration streams, driving cycles or sequences of suburbanization, counter-urbanization or re-urbanization. Interregional population flows underpin a shifting mosaic of growth and decline as individual regions compete in the national, and increasingly in the international, space economy. While these forces inevitably play out in complex ways in individual countries depending on their history and context, internal migration invariably plays a pivotal role. In the final part of our paper we build on the work outlined here in offering a schematic framework of change in the relationship between net migration and population density over the development transition in countries across the world. If common patterns in regard to the role of internal migration are to be identified, however, what is first required is the application of rigorous measures across a large sample of countries spanning the entire development spectrum.

3. Data on internal migration

Cross-national comparisons of internal migration face impediments in regard to the types of data collected, the intervals over which migration is measured, and the spatial frameworks employed (Bell *et al.* 2002). An allied problem is the limited availability of migration data, as data collection does not guarantee dissemination (Bell *et al.* 2015a). These issues have been explored in detail elsewhere (Bell *et al.* 2002, 2014, 2015a), so this section confines attention to the way measurement differences bear on cross-national comparisons of migration impact. It then describes the migration data assembled for analysis in the present paper.

Migration data are collected in several ways. The main distinction is between data capturing migration events, associated with population registers, and data on migration transitions, derived by comparing place of residence at two points in time, which are generated from population censuses. Events count migrations while transitions count migrants. Over short intervals, the number of migrants closely matches the number of migrations but as the observation interval lengthens, transitions increase more slowly because a rising proportion of migrations are made by return or repeat movers. While this difference is important for computation of migration intensities, its effects cancel out when calculating area-specific net migration (Rees 1985), and are negligible when migration is measured over a single year (Long and Boertlein 1990). As a result, event and transition data reveal the same spatial pattern of net population redistribution, provided there are no differences in population coverage and reporting. Because population registers are common in Europe and Asia, but rare in Latin America and Oceania (Bell *et al.* 2014), we draw migration data from both population registers and censuses in order to maximise geographic coverage.

Migration events are usually measured over a single year, while migration transitions can be measured over any time interval, although the most common are one and five years (Bell *et al.* 2015a). The longer the transition interval, the greater the potential effect of repeat and return migration, so care is needed comparing migration intensities measured over intervals of different length. While migration flows covering different measurement intervals cannot be compared reliably, the effects cancel out for net migration so that measures can be converted to common intervals (Long and Boertlein 1990). In practice, size and composition of the population at risk alter over time and the contextual forces driving migration also change, so that migration over any single year interval is unlikely to be representative of the longer interval. It can be argued, therefore, that five-year transition data provide a more realistic picture of the underlying flows and net redistribution of population than can data for any single year. However, the five-year data are collected and made available by only a minority of statistical agencies. We therefore compare countries separately with respect to the impact of the measurement interval. Many censuses around the world also collect data on duration of residence, usually in association with a question on previous place of residence (Bell *et al.* 2015a). By filtering migration data for a given duration of residence, it is possible to derive migration flows broadly comparable to conventional migration transitions. To maximise the number of case study countries, we also draw on last residence data, coupled with residence duration. Censuses also commonly collect data on lifetime migration by comparing region of current residence against region of birth (Bell *et al.* 2015a). Lifetime migration, however, inherits the cumulative impact of moves aggregated over a miscellany of ages which prejudices comparability and offers a poor picture of contemporary patterns and trends. We therefore restrict attention to migration over one- and five-year intervals.

Even where countries collect the same type of data over equivalent observation intervals, comparisons are made difficult by differences in the number and pattern of spatial units into which countries are divided (the MAUP). Comparing migration intensities among 96 countries, Bell *et al.* (2015b) explored and addressed the effects of the MAUP by harnessing the IMAGE Studio, a software algorithm designed to generate multiple random aggregations of geographic units at a range of spatial scales (Stillwell *et al.* 2014). Issues of scale and zonation loom equally large in comparison of countries with respect to the spatial impact of internal migration. In Nepal, for example, the census collects data on migration between 74 districts, whereas in the UK, census data are available for movements between more than 10,000 wards. In this paper we take as our starting point the migration data for basic spatial units that are available and manageable in each country[2]. We examine the effect of the MAUP by generating system-wide measures of migration impact at a range of spatial scales using the IMAGE Studio. We focus in particular on the Aggregate Net Migration Rate, Migration Effectiveness Index and Crude Migration Intensity, which are defined below.

Although these system-wide measures provide summary indices of migration impact, they contain no information as to its spatial form so we then consider spatial patterns of net internal migration. Particular interest attaches to the role of migration in the process of urbanization, so we examine the scale and intensity of rural-urban migration in countries around the world. Such comparisons are seriously prejudiced by cross-national differences in the definition of urban and rural areas, but an equally intractable problem is that few countries classify both the origin and destination of migrants by rural/urban status. Urban and rural areas are, in any event, coarse spatial categories so, following Rees and Kupiszewski (1999), we also utilise the more detailed geographies of migration available in each country to examine the relationship between net migration and population density.

Differences in data collection practice are complicated by issues of data availability, as countries rarely make migration statistics readily available. To address this deficit, the IMAGE project has assembled a global repository of internal migration data (Bell *et al.* 2014). The IMAGE Repository houses internal migration data for 135 countries and includes a variety of data types (event, transition, duration), measured over intervals of different lengths (one year, five years, duration of residence) and held in varied formats (counts of migrants by type of flow, aggregate inflows and outflows, and origin-destination flow matrices), with the precise nature of the holdings determined by the nature of the data collected and made available in each country. The Repository also incorporates data for each country on populations at risk and digital boundaries of the spatial units. For many countries flow matrices are available at multiple spatial scales corresponding to particular levels of administrative or statistical geography. For the purposes of this paper we draw on the most finely grained geography available in each country, but we also utilise information on flows between rural and urban areas where these are available (Table 1). The principal dataset takes the form of migration flow data for 88 countries of which 37 measure migration over a one-year interval and 57 over a five-year interval. Six countries collect data for both intervals so we have 94 flow matrices. Together these countries account for almost half of all UN member states and nearly 80 per cent of the world’s population. Our sample covers more than two thirds of countries in Europe, Latin American and North America, but only one quarter of countries in Africa and Oceania and about 43 per cent of those in Asia. Bell *et al.* (2014) set out in detail the data available in each country, indicating the collection year, number of spatial units, data type, interval of observation and data format.

Table 1 here

4. System-wide indicators of migration impact

Across any system of sub-national regions, the overall impact of net migration on the pattern of settlement is most effectively captured in the Aggregate Net Migration Rate (*ANMR*), defined as half the sum of the absolute net changes aggregated across all regions, divided by the population at risk (Bell *et al.* 2002):

$$ANMR = 100 \times 0.5 \sum_i |D_i - O_i| / P \qquad (1)$$

where D_i and O_i are inflows to and outflows from region i and P is the population summed across all regions. The *ANMR* thus measures the impact of migration on population redistribution: it identifies the net shift of population between regions per hundred persons resident in the country. The *ANMR*, in turn, is a product of the Crude Migration Intensity (*CMI*) and the Migration Effectiveness Index (*MEI*) such that

$$ANMR = CMI \times MEI / 100 \qquad (2)$$

where

$$CMI = 100 \times M / P \qquad (3)$$

$$MEI = 100 \times 0.5 \sum_i |D_i - O_i| / M \qquad (4)$$

and $$M = \sum_i (D_i) = \sum_i (O_i) \qquad (5).$$

The *CMI* represents the overall incidence, or level of internal migration within a country, indicating the propensity to move. The MEI indicates the effectiveness (or efficiency) of migration as a mechanism for population redistribution by comparing net migration to migration turnover; it quantifies the spatial imbalance between migration flows and counter-flows. Low values of *MEI* are found when migration streams and counter-streams are closely balanced, while high values indicate asymmetry across the system, with some regions gaining population at the expense of others (Shryock *et al.* 1976).

It follows from equation 2 that the same impact of migration on population redistribution, as measured by the *ANMR*, may be achieved either through high *MEI* combined with low *CMI* or *vice versa*. Data for Canada and Australia provide a case in point. Based on five-year migration data, Canada (2006, 288 regions) and Australia (2011, 333 regions) both returned *ANMR*s of 1.8 per cent, but the *MEI* for Canada (15.0) was almost twice that of Australia (8.6), while for *CMI* values for the two countries were 11.8 for Canada and 21.2 for Australia.

Observed *CMI* is dependent on spatial scale: the larger the number of zones over which migration is measured, the higher the apparent intensity. Courgeau (1973) demonstrated that the *CMI* is a log-linear function of the number of regions into which a territory is divided, and Courgeau *et al*. (2012) show it is also a log-linear function of the average number of households per region. Bell *et al*. (2015b) used the latter relationship to generate estimates of the aggregate *CMI*, representing all changes of address, for 96 UN member states which collectively house 80 per cent of the world's population. The authors utilised the IMAGE studio (Stillwell *et al.* 2014) to generate *CMI*s for a cascading sequence of zonal aggregations, beginning with the finest level of geography, termed Basic Spatial Units (BSUs), available in the country-specific origin-destination flow matrix, and progressively aggregating upwards in user-defined increments. At each spatial level, the algorithm creates a series of spatial configurations by stepwise aggregation of BSUs into Aggregate Spatial Regions (ASRs) of varying shapes and sizes. Multiple iterations at each spatial level provide a range of random spatial configurations. A suite of migration indicators proposed by Bell *et al.* (2002) are then computed for each configuration at a given level, and the results are averaged before repeating the process at the next level of aggregation. The result is a sequence of migration indicators estimated for the selected levels of spatial aggregation—for example, 200, 190, 180, … , 40, 30, 20 ASRs. The change in the mean value of the indicator indicates the scale effect of the MAUP, while the variation around the mean reveals the zonation effect. Bell *et al.* (2015b) used the IMAGE Studio to examine the effects of the MAUP on the *CMI*, and Stillwell *et al.* (2015) explore its impacts on the frictional effects of distance. Here we utilise the IMAGE Studio to examine the relationship between the *CMI*, *MEI* and *ANMR* in different countries at various levels of scale.

In Figure 1, values are plotted for the three indicators at various spatial scales for selected countries which measure migration over five-year intervals, plotting the number of regions on the horizontal axis in the top graph and the common logarithms of the number of regions on the bottom graph. Moving from right to left along each graph reveals the effect on the indicator of progressive aggregation into fewer, larger spatial units. The different starting points on the right of the graph reflect variations between countries in the finest level of geography for which migration data were available, but have been truncated to facilitate readability for countries with very large matrices such as the USA and Ecuador. The points at the left end of each graph indicate the final level of aggregation in the IMAGE Studio computation for each country.

Figure 1 here

The most striking feature of the graphs is the relatively small degree of variation in the *MEI* with changes of geographic scale. The level of the *MEI* differs markedly between countries, but for most it is largely invariant with spatial scale, at least when computed for 20 regions or more. At higher levels of aggregation (fewer than 20 regions), this stability appears to break down for some countries, but beyond this point the slope is either flat or rises gently. This result has two important implications. First, it suggests that, for a given volume of migration, the extent of population redistribution within a country tends to be similar at a range of geographic scales: countries in which significant redistribution is occurring between regions tend also to record high levels of population redistribution at the sub-regional and local level. Only at the level of very large regions, such as states and provinces, does this relationship falter. Processes of population redistribution within countries, it therefore appears, tend to be echoed across the geographic spectrum. A second, and equally significant consequence of this stability in the *MEI*, is that reliable comparisons can be made between countries even when migration data are recorded at different levels of spatial scale. In this respect, findings for the *MEI* match those reported by Stillwell *et al.* (2015) for distance decay, which also appears largely invariant with spatial scale, and contrast sharply with those for the *CMI* which varies systematically with scale, as Figure 1 clearly shows.

Figure 2 ranks countries on the median *MEI,* computed for an incremental sequence of scale steps, starting from a minimum of 20 ASRs. Disregarding those countries, for which data are available only for fewer than 20 regions, leaves 47 countries which collect data over a five-year interval, and 24 which collect one-year data. The boxplots reveal the remarkable degree of consistency in the *MEI* across spatial scale in the majority of countries. Only a small number have extensive whiskers (indicating a wide spread of possible values). Even countries such as El Salvador, Mexico and Burkina Faso, which display a relatively large interquartile range, can be reliably positioned in the international league table with respect to migration effectiveness. For one-year intervals, the *MEI* varies from 3.5 in Sweden to 33.7 in Kenya. For five-year transitions, the range is even larger: from 4.6 in Japan to 61.0 in China. The results show a distinctive geographic distribution with low values of *MEI* in North America, Australasia, northern and western Europe, grading to moderate values in eastern Europe, southwest Asia and the Russian

Federation, and rising to a peak in South and East Asia. Africa displays a patchwork of moderate to high values, whereas in Latin America, there is a clear upwards gradient moving northwards from Chile and Argentina into Central America.

Figure 2 here

The *MEI* itself provides useful insights into the role of migration in population redistribution because it measures the extent to which inter-regional flows are balanced by counterflows, but it is the *ANMR* that captures the overall impact of migration on the settlement system. The *ANMR* cannot be used to make cross-national comparisons directly because it is affected by the *CMI*, which varies with spatial scale. As the number of spatial units increases, there is a parallel rise in migration intensity, and hence the *ANMR*, since the division into finer spatial frameworks progressively captures more short distance moves. However, by capturing the functional forms depicted in Figure 1, it is possible to develop a generalised version of equation 2 to deliver a composite index that enables systematic comparisons of overall migration impact to be made.

Following Courgeau, we know that log transformation of the x axis delivers a linear relationship with the *CMI*, and this holds whether spatial scale is expressed in terms of number of units (Courgeau 1973) or mean household density (Courgeau *et al*. 2012) The foregoing has also established that the *MEI* is broadly constant as BSUs are aggregated into ASRs with higher numbers of regions. We can fit the following regression models to the indicators[3]:

$$CMI = a_1 + b_1 log_{10} n \quad (6)$$

$$MEI = a_2 + b_2 log_{10} n \quad (7)$$

$$ANMR = a_3 + b_3 log_{10} n \quad (8)$$

where *n* is the number of spatial units. The task is to establish the relationship between the parameters of these three models. Substituting into equation 2, we obtain:

$$a_3 + b_3 log_{10} n = (a_1 + b_1 log_{10} n) \times (a_2 + b_2 log_{10} n) \quad (9).$$

Since internal migration is zero when only one spatial unit is used, the intercepts for equations 6 and 8 by definition are zero, that is $a_1 = 0$ and $a_3 = 0$. Accepting that the *MEI* is largely invariant with scale, above a threshold of *circa* 20 regions, allows us to adopt the approximation that b_2 = zero, so that:

$$b_3 log_{10} S = (b_1 log_{10} n) \times (a_2) \qquad (10)$$

and dividing through by $log_{10}n$ on both sides, simplifies to:

$$b_3 = a_2 b_1 \qquad (11)$$

Thus, the slope of the *ANMR* against $log_{10}n$ (b_3) is a product of the average *MEI* (a_2) and the slope of the *CMI* (b_1). We cross-checked results for the value of b_3 calculated as a product of a_2b_1 against the measured slope of b_3 and found a correlation coefficient (Pearson r) of 0.99986 across 70 countries. Cross-national comparisons of migration impact that incorporate the effects of both migration intensity and effectiveness can therefore be made using the slope of the *ANMR*, and this in turn can be estimated directly from the slope of the *CMI* and from the *MEI* computed for any number of regions. As with Courgeau's original (1973) contribution to comparisons of migration intensity, the resulting measure, b_3 (the modelled slope of the ANMR) is directly scalable and decomposable into contributions from *CMI* and *MEI*. This is therefore eminently suited to comparisons of migration impact between countries or over time.

To facilitate comparisons, it is useful to adopt a benchmark to serve as a point of reference. While any single country might serve this purpose, we adopt the mean across our sample of countries as the point of reference, computed separately for one-year and five-year data. We calculate the ratio of CMI slope for a country to the average slope for all countries, where number of areas used, n, is equal to or greater than 20. We compute the ratio of mean CMI for a country to the average of mean MEIs over all countries in the sample.We then multiple these two ratios to generate an Index of Net Migration Impact *(INMI)*. This is defined formally as:

$$INMI = \left[\frac{CMI\ slope\ for\ a\ country}{Average\ \ CMI\ slope\ for\ all\ countries}\right] \times \left[\frac{Mean\ MEI\ for\ a\ country}{Average\ MEI\ for\ all\ countries}\right] \qquad (12)$$

INMI is computed for all countries where ASRs are >20. Values for countries with 1 year and 5 year data are given in the Appendix.

Because the INMI is the product of two ratios (as was the modelled ANMR), we are able to make robust comparisons between countries in regard to aggregate population redistribution, distinguishing the relative contributions of migration intensity and migration effectiveness. Figure 3 (A and B) displays the results in a simple scatterplot, setting the ratio of the *MEI* against the ratio of the *CMI* slope. The surface of the plot therefore represents the *INMI* for each country and the contour lines (0.5, 1.0, 1.5 and 2.0) link points of equal migration impact. Values of *INMI* above one indicate that the effect of migration in redistributing population is above the average, while values below unity denote an effect below the average. The radial lines emanating from the origin help to divide the plot and signify the relative contributions of the *MEI* and the *CMI*, with the principal diagonal dividing the plot at a point where the two factors exert an equal effect on population redistribution. Thus, in the graph of five-year migration countries (Figure 3B), it can be seen that Mongolia records the highest migration impact, driven equally by above average *MEI* and *CMI*. For both Cameroon and Vietnam, the impact is somewhat lower, at a little under 1.5 times the sample mean, but the sources are quite different. For Cameroon, population redistribution is due to high intensity, whereas in Viet Nam, lower intensity is compensated by high migration effectiveness. The underlying data, together with constituent values for the mean *MEI* (a_2) and slope of the *CMI* (b_1) are available in the Appendix. We note that the Figure 3 plots are based on overall modelled empirical relationships for all countries in the sample rather than precise accounting relationships for a particular country.

Figure 3 here

In countries which record migration over a single-year interval, Kenya and Sudan[4] stand out with the highest levels of population redistribution, followed by Ireland, Canada, Turkey and Australia, while Japan, Italy and Romania have the lowest. The remaining countries are less strongly differentiated in terms of the *INMI*, but the plot reveals that this masks two distinctive clusters with quite different drivers. On the one hand there is a cluster of southern and eastern European countries, together with Burkina Faso, where migration effectiveness is above the mean but the impact on population redistribution is offset by comparatively low levels of migration intensity. In these countries, the radial grid indicates that intensity contributed less than one quarter of the aggregate *INMI*. On the other hand, there is an extended cluster of countries from northern and western Europe, together with Japan and the USA, in which relatively high levels of migration intensity are absorbed in reciprocal exchanges, resulting in low migration effectiveness which constrains the extent of population redistribution.

The five-year data encompass a broader geographic spectrum of countries but some spatial patterns are still clearly apparent. Most distinctive here is that the low levels of migration intensity which are found across much of Asia (see Bell *et al.* 2015b) are generally compensated by high levels of migration effectiveness (China, Vietnam, Nepal, India). Thus, although the propensity to migrate is low, the movements which do take place are more likely to result in a net shift of population between areas within the country. Latin America displays greater diversity, with low effectiveness offsetting high intensity in Chile, Costa Rica, Bolivia and Paraguay, a cluster of countries a little below the mean on both drivers (Peru, Ecuador, Columbia, Brazil) generating below average *INMI*, and a group in Central America (El Salvador, Dominican Republic, Cuba, Honduras, Mexico) where it is low intensities that constrain redistribution. Data for Africa are sparse, but reveal relatively low levels of migration impact in Egypt, Mali and Ghana, but more substantial redistribution in Guinea, Senegal, Tunisia, Uganda and Cameroon. What is common to both the one- and five-year datasets is a general tendency for high migration effectiveness to be offset by low migration intensity (the Russian Federation, 1 year; China, 5 year) or *vice versa* (Australia, 1 year; New Zealand, 5 year). It is only a minority of countries in which both drivers are either well below (Argentina, 5 year; Mali, 5 year) or well above (Kenya, 1 year; Mongolia, 5 year) the mean.

Bell *et al*. (2015b) reported a moderate association between migration intensity and a range of development indicators across a large sample of countries. Table 2 reveals more modest correlations for the countries examined here, especially for countries which collect data over a single year[5]. However, both datasets deliver strong correlations with the two measures of migration impact: the mean *MEI* and *INMI*. Computed across the 24 countries which collect one year migration data and the 47 countries for which we have five-year data, there is a significant inverse association with the level of urbanization, the Human Development Index (HDI), and GDP per capita. The associations are consistently stronger across the one-year sample and stronger with the *MEI* than with the *INMI*. The five-year sample also shows a modest, significant negative correlation with the international migration rate, suggesting that international migration tends to substitute for internal migration and therefore reduce the impact of internal migration within this group of countries.

Table 2 here

In practice, there are theoretical reasons to doubt that the relationship between migration impact and development is linear, and Figure 4 confirms that many functions might fit equally well.

Following the ideas outlined by Geyer (1996) and Geyer and Kontuly (1993), one possibility is an inverted U-shaped curve, reflecting a relationship similar to that identified by Kuznets (1955) where income inequality rises and then falls with development. In the case of migration, it is likely that population movement responds to regional economic differentials, triggering a rise in migration intensity and a growing imbalance in inter-regional flows as economic development proceeds at an uneven pace, followed eventually by a return to more symmetrical flows as the urban transition comes to a close and regional disparities erode. The third order polynomial fitted to data for the 47 countries that collect five year migration statistics (Figure 4) traces the theoretical relationship between the *MEI* and the HDI.

Figure 4 here

5. Rural-urban migration

The aggregate measures discussed in the previous section provide summary indicators of the strength of migration impact on overall population redistribution, but provide no information as to their spatial manifestation. In this section we focus on the role of migration in urbanization, arguably the most visible, widespread and significant form of population redistribution within countries. Despite its widely recognised significance, the IMAGE Inventory revealed that few countries measure urban-rural migration directly (Bell *et al.* 2015a). Few censuses ask respondents to indicate whether their place of previous residence was rural or urban, and *post hoc* classifications are unreliable because the geographic zones used by statistical agencies seldom provide a clear distinction between rural and urban areas. Rural-urban migration is also commonly collected in national sample surveys, such as USAID's Demographic and Health Survey (DHS) and the World Bank's Living Standards Measurement Study (LSMS), but cross-national comparisons are prejudiced by sample sizes, definitional differences and population coverage. The DHS, for example, is confined to women aged 15-49. The analysis in this section is based on data for 25 countries which provide complete two by two matrices of flows between urban and rural areas, delimited according to official national definitions.

The direction and magnitude of the flow between rural and urban areas is most readily captured by the migration effectiveness ratio (MER_{RU}), computed as:

$$MER_{RU} = 100 \times (M_{RU} - M_{UR})/(M_{RU} + M_{UR}) \qquad (12)$$

where M_{RU} denotes the migration flow from urban to rural areas and M_{UR} is the migration flow in the reverse direction. MER_{RU} represents the net shift of migrants towards or away from urban areas per hundred migrants crossing the urban/rural boundary and is positive when urban areas gain and negative otherwise. The ratio has limits of + and – 100, with smaller absolute values indicating that flows to and from urban areas are closely balanced. Countries with high positive values of MER_{RU}, signifying ongoing urbanization, are located principally in South and Southeast Asia. Counter-urbanization processes, signified by negative values of MER_{RU} are most prominent in European post-Soviet countries.

Figure 5 presents the shares of each of the four flows: urban-urban, rural-urban, urban-rural and rural-rural, sorted by the direction and magnitude of the net flow from rural to urban areas, as measured by the rural-urban migration effectiveness ratio. Countries differ widely in the mix of flows. In most countries, urban to urban flows dominate, which is not surprising given that urban dwellers now represent a majority of the world population. In New Zealand, 80 per cent of migration is within the urban subsystem, whereas rural-rural migration dominates in Timor, India, Cambodia and Swaziland. In 15 of the 25 countries, migration results in the net transfer of population from rural to urban areas, but in the remaining ten the rural areas gain.

Figure 5 here

Figure 6 reveals a moderate negative correlation ($r = -0.66$) between MER_{RU} and the level of urbanization across the 25 countries, suggesting that rural to urban migration is closely linked to the urban transition. Countries at an earlier stage in the transition, such as India and Indonesia are undergoing rapid urbanization through rural to urban migration, while those with high proportions resident in urban areas, such as Estonia and Poland, are registering net losses, indicating a predominance of counter-urban migration. Nevertheless, it is clear that marked variations exist between countries throughout the settlement spectrum. Across eastern Europe and western Asia, for example, levels of urbanization lie in a relatively narrow band around 65-75 per cent, but the MER_{RU} varies widely between plus and minus 20 per cent, signifying continued urbanization in some countries, but counter-urbanization in others.

Figure 6 here

Urbanization, growth in the size and share of the population living in urban places, results from the interplay of natural increase, domestic and international migration, and is also affected by changes in definition and reclassification as expanding cities absorb rural settlements on their peripheries. The strength of these processes varies widely between countries and few, if any, maintain the detailed population accounts that are needed to distinguish their relative contributions to changes in their settlement geography. Cross-national comparisons are further impeded by differences in the way that "rural" and "urban" areas are defined, and the criteria that are used which variously include population thresholds, administrative status, morphology, accessibility and functionality. As a result, rural-urban migration in Mali has a meaning quite different from that which is implied by the same term in China. It follows that, the urban-rural dichotomy is too simplistic as a framework for comparing the spatial impacts of internal migration in different countries. While a number of attempts have been made to define settlement hierarchies and classifications that have more universal application (Champion *et al*. 2003), none have been adopted by countries worldwide.

6 Net internal migration and population density

One solution is to use population density as a proxy for urban/rural classification and to analyse cross-national differences in the impact of internal migration on sub-national zones according to their various levels of density. Rees and Kupiszewski (1999) applied this approach to 12 European countries using data for various administrative zones classified into selected density bands. Courgeau (1992) adopted a similar approach but calibrated the relationship between the net migration rate (NMR) and the logarithm of population density for individual zones by fitting a linear regression model. This was implemented using observations for 190 zones of metropolitan France (95 *départements* split into rural and urban components) for four inter-census periods. Figure 7A reproduces Courgeau's results and Figure 7B adds results for subsequent inter-census intervals for 95 *départements*, maintaining the same vertical scale to facilitate comparison. The regression line for the period 1975-1982 appears in both graphs and the similarity of the slopes gives confidence to estimate regression in countries where the spatial units are not classified into rural and urban parts.

Figure 7 here

A clear progression is apparent in the slope of the regression lines over the sequence of intercensal periods. For 1954-62, the slope is strongly positive, denoting losses from sparsely populated areas and corresponding gains in the more densely populated parts of the country. For

1962-68 and 1968-75, the slope moderates as the strength of this rural to urban movement weakens, and by the second half of the 1970s, the relationship has reversed, with a negative slope denoting a shift to counter-urbanization. Net movements to less populated areas continued at a diminished rate in the 1980s, but strengthened marginally in the 1990s and early 2000s. Of course, individual *départements* at various levels of density may have continued to variously register gains or losses, in each period, but the overall shift in the settlement pattern was clear.

We can apply this approach to countries in the IMAGE database for which net migration rates (*NMR*s) and population densities for individual zones are available, but first we need to check that the regression slopes are not unduly affected by the number of zones used. We used the aggregation routines in the IMAGE Studio to compute net migration rates and population densities across 95 countries. Population-weighted regressions were computed using bespoke routines in R, setting *NMR*s against the log of population density for each scale (number of zones. In general, we found the scale effect to be small above a minimum threshold of around 30 zones. Figure 8 illustrates this finding for migration over a one-year period measured at the Australian 2011 Census. Median slope values are relatively stable at successive levels of aggregation above 30 zones, inter-quartile ranges are compact and outliers are rare, but this pattern breaks down as the number of regions falls below 30. Underpinning the slope-scale relationship is a combination of different redistribution processes, with a varying mix by scale. When only a few regions are used, economic factors drive migration and the regression slopes are sensitive to the spatial configuration of zones. When many regions are used, housing markets, residential mobility and other local factors come to the fore, which tend to reduce biasing effects.

Figure 8 here

Excluding countries for which the IMAGE database contains less than 30 regions leaves a sample of 67 countries for which we computed the slopes of population-weighted *NMR* regressed against the logarithm of population density at BSU level. Figure 9B plots the results against the HDI for the 40 of these countries which collect five-year migration data. Where the slope is above 0, net internal migration is concentrating the population in higher density areas, associated with urbanization, whereas slope values below zero signify population deconcentration. We have fitted a polynomial function to the two plots that correspond with that employed for the *MEI* in Figure 4. The relationship is suggestive rather than definitive: high HDI countries generally have negative (USA, Canada) or modestly positive (Japan) slopes, while countries with low HDI display strong positive slopes (Kenya in the one year plot, Guinea and Uganda in the five year plot). However, countries in the middle HDI bands have wide range of slopes, ranging from moderately positive (China, Vietnam) to marginally negative (Indonesia). Data for countries which collect data over a single-year (Figure 9A) are drawn primarily from Europe and display much more modest variation in slopes, all under 1 and generally under 0.5, denoting modest tendencies towards concentration (Denmark, Belarus, Bulgaria) or dispersal (Spain, Belgium). Note that in this plot there are low outliers (Kenya, Burkina Faso) with low HDI which influence the fitted function and high outliers (USA).

Figure 9 here

The results in Figure 9 complement and extend the system-wide indices plotted in Figure 3. For example, Kyrgyzstan and Panama both registered high values of *INMI* (Figure 3B), and Figure 9B shows that in both countries this was associated with strong urbanization. Indonesia and Thailand, on the other hand, both recorded *INMI* values below the sample mean, and in each case this was due to low intensity coupled with above average effectiveness. In Indonesia, however, this underpinned moderate deconcentration (associated with policies that encourage migration out of densely settled Java to othe less densely populated islands). By contrast, in Thailand the dominant trend was urbanization. Comparison of Switzerland and the USA on the chart for five-year data reveals a similar picture, in this case with high levels of migration intensity but low effectiveness in both countries, underpinned by urbanization in the former and counter-urbanization in the latter.

How do we synthesize these diverse levels, causes and patterns of spatial redistribution through internal migration? Figure 10 is a theoretical schematic framework that attempts to do this by tracing the relationship between net internal migration and population density as a country undergoes development (vertical axis) through a series of five phases (the horizontal axis). As the country urbanizes, as both a cause and consequence of development, the first phase involves net internal migration from low density areas (rural settlements) to high density areas (urban settlements), and in the second phase, the process of urbanization accelerates. In the third phase it slows and may reverse into counter-urbanization, with a negative slope in the net internal migration-density relationship in phase 4. The final phase recognises three alternative outcomes: (a) counter-urbanization, (b) re-urbanization or (c) dynamic equilibrium. In a few countries (Australia, USA) where there is a strong preference for low density living, counter-urbanization may continue or be associated with shrinking cities. Re-urbanization may occur as the centres of cities are redeveloped after being emptied through de-industrialization. Or migration flows between urban, suburban and rural may be balanced with little population redistribution, a state of dynamic equilibrium.

Figure 10 here

Underpinning these shifts in spatial patterns, the overall impact of internal migration in terms of system-wide distribution first rises then falls as the settlement system shifts from predominantly rural to urban, then settles into dynamic equilibrium. Migration effectiveness declines as most movement is absorbed in reciprocal flows and counter-flows. The evidence suggests that migration intensities, too, tend to fall after peaking at high levels of development (Bell *et al.* 2012). Thus, countries may experience migration flows between urban areas which involve high mobility but low effectiveness, leading to minimal population redistribution. What complicates interpretation is the wide national variation in levels of migration intensity and efficiency, and their complex interplay. This variability, in turn, is a product of cross-national differences in the nature of housing markets, economic structures, policy frameworks and cultural forces, and the way these interact with the existing geographies of human settlement.

7. Conclusion

With the progressive convergence of birth and death rates between countries and regions, internal migration, together with international migration, now represents the principal source of change in the pattern of human settlement within countries. Despite its acknowledged significance, remarkably little progress has been made in understanding the spatio-temporal dynamics of internal migration and measuring its impacts on population redistribution. We have sought to address the issue by harnessing a unique international dataset of country-specific internal migration flow matrices, assembled as part of the IMAGE Project, to bespoke software designed to compute a suite of migration indicators and simultaneously explore the effects of the modifiable areal unit problem (MAUP) on cross-national comparisons of migration. We examined migration flows at various levels of spatial scale drawn from population censuses, registers and administrative sources covering 91 countries, and explored the redistributive effects of internal migration in terms of both system wide indicators and spatial patterns.

Using the random agglomeration facilities of the IMAGE Studio, we demonstrated that two key measures of population redistribution, the *MEI* and the slope of the *NMR*/population density gradient, are stable and largely independent of scale and zonation effects above a threshold of around 30 zones. That is, very similar results are obtained irrespective of the number of zones into which a country is divided to make the calculations, or their spatial configuration. The consequence is that reliable comparisons can be made between countries on these two measures, even though they are calculated using differing numbers of spatial units. We also demonstrated that there are marked variations between countries on both these measures.

We have proposed a new system-wide measure, the *Index of Net Migration Impact* (*INMI*) which is a generalised form of the *Aggregate Net Migration Rate* (Bell *et al.* 2002), and shown how this can be decomposed into its constituent elements, the *mean MEI* and the *slope of the CMI* (the latter as proposed by Courgeau, 1973). Like its constituents, the *INMI* is independent of spatial scale and can therefore be used to compute the overall redistributive effects of internal migration and make comparisons between any countries for which suitable flow matrices are available. Because the *INMI* is a product of the *mean MEI* and the *CMI slope*, it is also possible to determine the relative influence of migration intensity (the *CMI slope*) and migration effectiveness (the *mean MEI*) on the resulting *INMI*. We identified marked variations between countries in the extent of population redistribution, as measured by the *INMI*, and showed how the role of intensity and effectiveness varied around the globe. In Asia we found that low levels of migration intensity were largely offset by moderate to high effectiveness, whereas most Latin American countries displayed a more balanced profile with low scores on each component. Africa showed greater diversity with some of the highest and lowest levels of redistribution. Europe, on the other hand, was characterised by relatively low levels of redistribution but with two distinctive clusters, marked by low intensity and high effectiveness in the south and east, reversing to higher intensities but lower effectiveness in countries to the north and west. Moderate linear correlations were identified with selected development indicators but we suggested a third order polynomial offered a more theoretically justifiable fit between population redistribution and national development.

Few countries collect data on rural-urban migration directly so we compared the spatial patterns of redistribution between countries using the slopes from regression equations computed by setting the *NMR* against the log of population density for basic spatial units in each country. Countries with lower HDI generally delivered steep, positive slopes, indicating that internal migration was serving to increase levels of population concentration, whereas slopes were shallow or negative for higher HDI countries, pointing to weak concentration or counter-urbanization. Combining this space-rich but time-poor empirical evidence with earlier time-rich but space-poor analyses by Courgeau (1992) and by Kontuly and Geyer (2003b), we outlined a general conceptual model suggesting how internal migration redistributes population across settlement systems during stylised phases of development.

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[1] http://www.gpem.uq.edu.au/image
[2] While the IMAGE Studio can theoretically accommodate a flow matrix of any size, run times increase rapidly for large matrices. In practice the largest matrix used for the work reported here was the county to county matrix for the US which comprises 3143×3143 counties.
[3] In these equations we drop the 100 constant in equations 1 to 4 for clarity in exposition.
[4] Data for Sudan are drawn from the 2008 Census, before the country was divided.
[5] The one-year data are drawn mainly from Europe but include three African countries, Kenya, Sudan and Burkina Faso. When these together with Turkey are removed from the analysis (as in Bell *et al.* 2015b), the correlation with migration intensity is significantly strengthened, but associations with the *MEI* and *INMI* are reduced.

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TABLE 1 Number of countries by data types and region

Region	Urban-rural migration	Regional OD matrices or aggregate inflows and outflows		Coverage (countries with one or more data sets)	Coverage of UN countries
		1 year interval	5 year interval		
Africa	3	3	11	15	28%
Asia	11	3	13	18	43%
Europe	9	28	5	30	67%
Latin America	1	0	21	21	69%
North America	0	2	3	3	100%
Oceania	1	1	4	4	29%
Total	25	37	57	91	48%

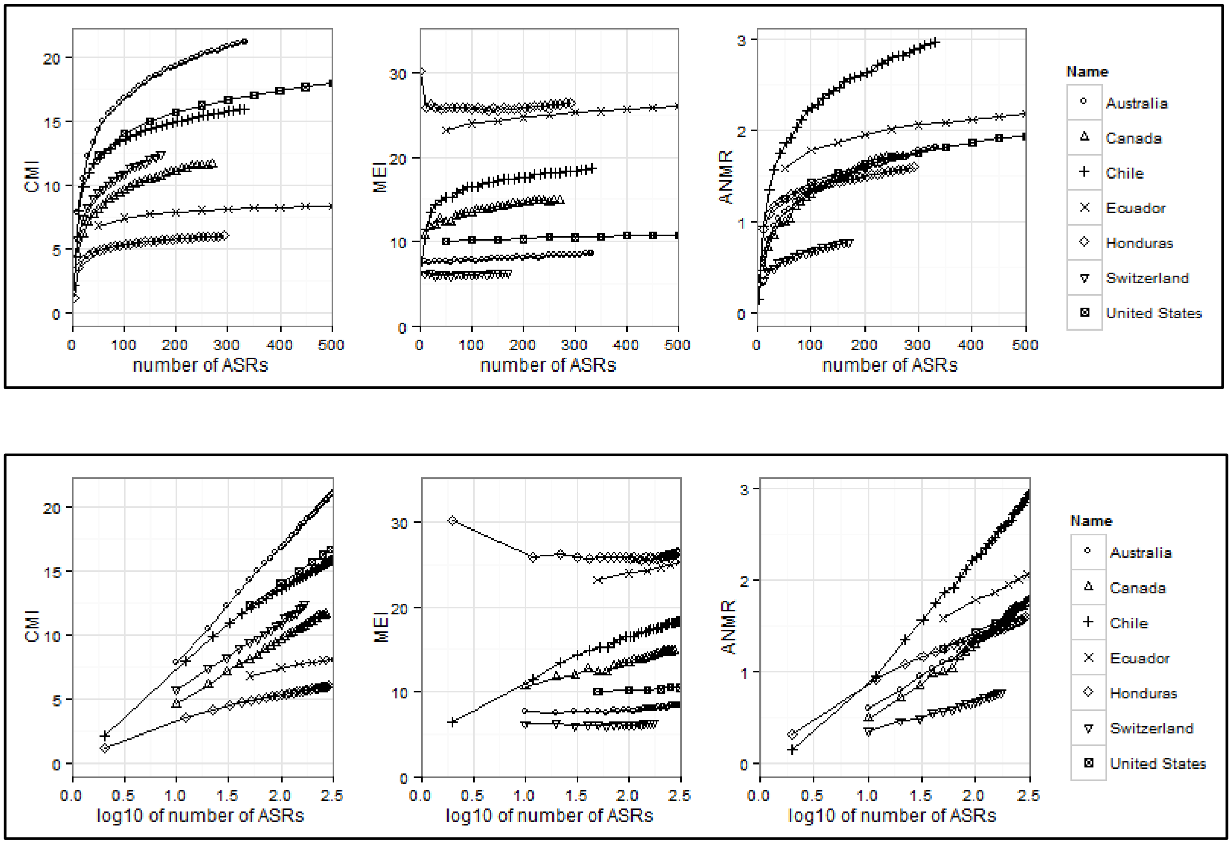
Source: IMAGE Repository (Bell *et al.* 2014, 2015a)

TABLE 2 Correlation (Pearson r) between measures of migration impact and selected development indicators

	One-year data			Five-year data		
Development indicator	*CMI* Slope (b_1)	*MEI* Mean (a_2)	*INMI* (b_3)	*CMI* Slope (b_1)	*MEI* Mean (a_2)	*INMI* (b_3)
Urbanization	0.133	-0.773***	-0.648***	0.273*	-0.609***	-0.290**
HDI	0.087	-0.738***	-0.577***	0.370**	-0.570***	-0.243*
International Migration Rate	-0.061	-0.217	-0.214	-0.054	-0.358**	-0.322**
GDP per capita	0.282	-0.743***	-0.461**	0.328**	-0.595***	-0.365**

Notes:
CMI is Crude Migration Intensity; *MEI* is Migration Effectiveness Index; *INMI* is Index of Net Migration Impact; HDI is Human Development Index; GDP is Gross Domestic Product.
One-year data, n=24 countries; five-year data, n=47 countries.
Significance *** p<.001, **p<0.05; *p<0.1
Source: Authors' computations using the IMAGE database (Bell *et al.* 2014).

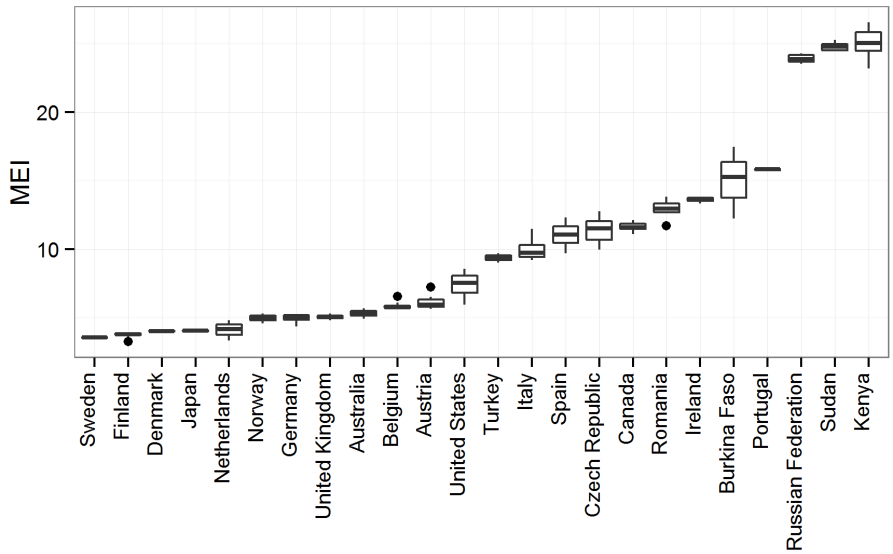
FIGURE 1 Migration intensity, migration effectiveness and the aggregate net migration rate, as a function of the number of spatial units, selected countries which measure migration over a five year interval



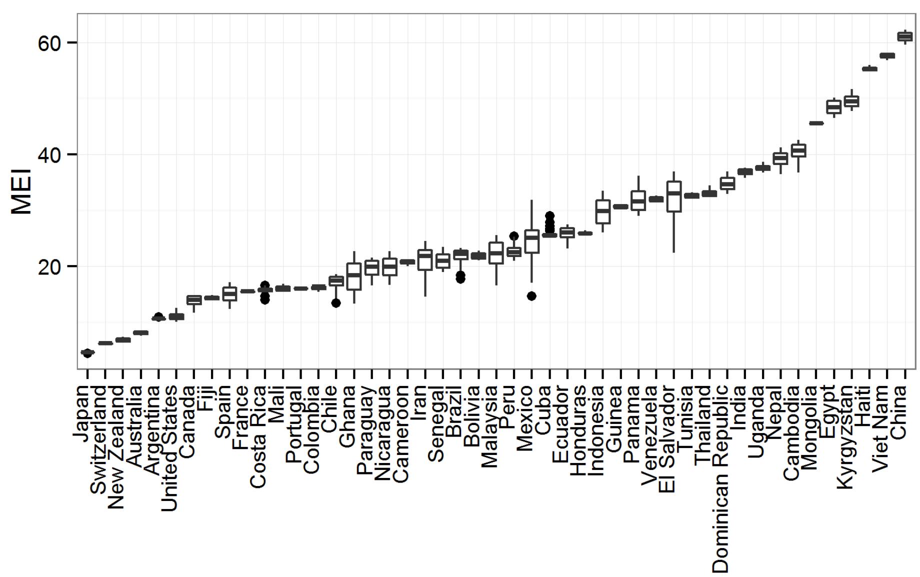
Notes: *CMI* = Crude Migration Intensity, *MEI* = Migration Effectiveness Index, *ANMR* = Aggregate Net Migration Rate, ASR = Aggregated Spatial Regions
Source: IMAGE database (Bell *et al.* 2014), processed using the IMAGE Studio (Stillwell *et al.* 2014).

FIGURE 2 Boxplots of Migration Effectiveness

A: Countries with one-year interval migration data



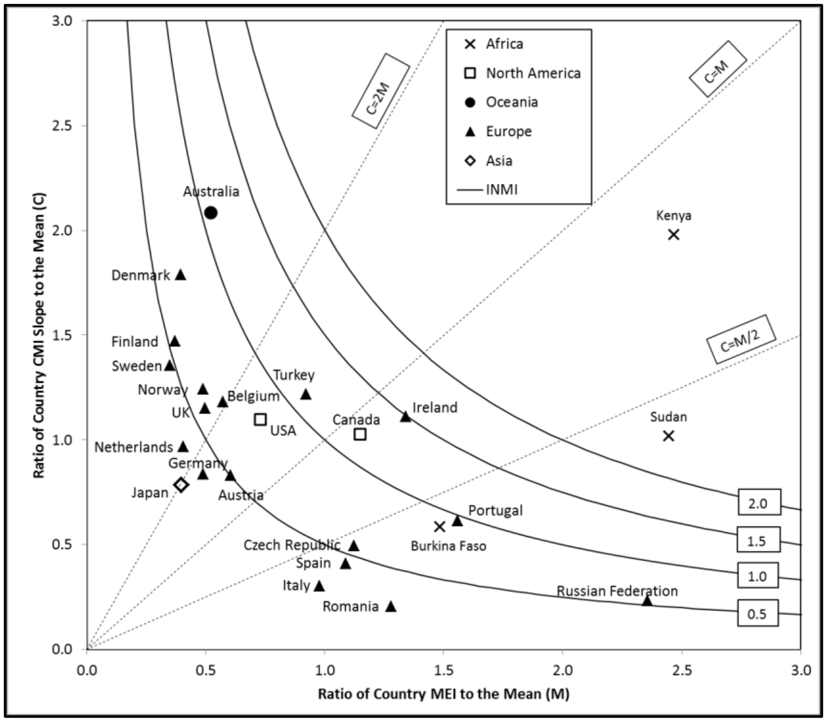
B: Countries with five-year interval migration data



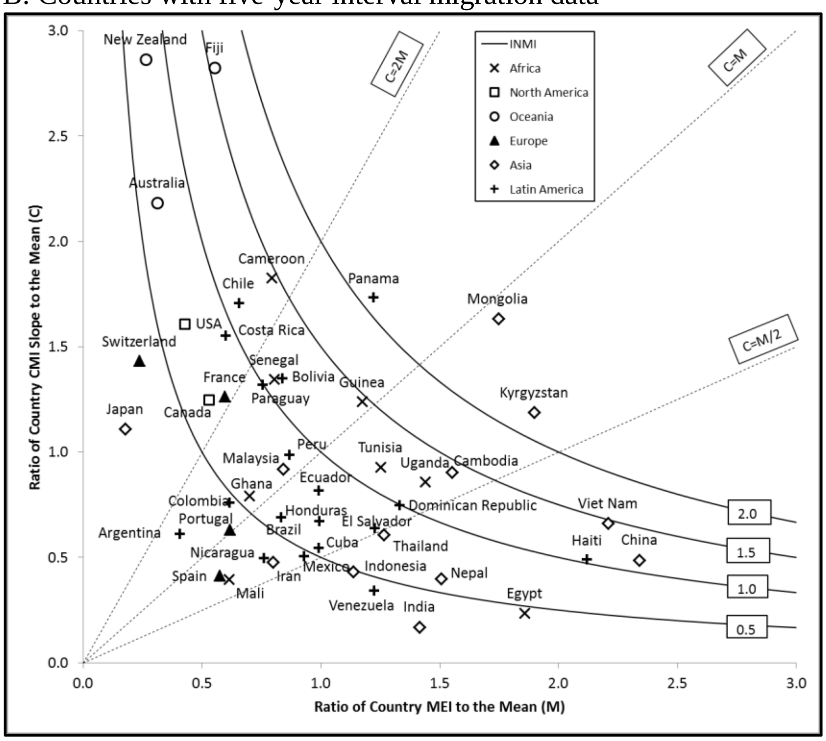
Notes:
The box plots show the distribution of values produced by random draws from possible contiguous combinations of basic spatial units (BSUs) for each country. The plots show the median, upper and low quartiles of the distribution, so that 50 per cent of observations fall within the box. The whisker lines extend 1.5 times the inter-quartile range above or below the upper and lower quartiles or to maximum or minimum of the distribution if these fall within the whisker extents. The dots represent outlier observations which fall beyond the ends of the whiskers.
Source: IMAGE database (Bell *et al.* 2014) with zonation solutions computed using the IMAGE Studio (Stillwell *et al.* 2014).

FIGURE 3 Index of Net Migration Impact

A: Countries with one-year interval migration data

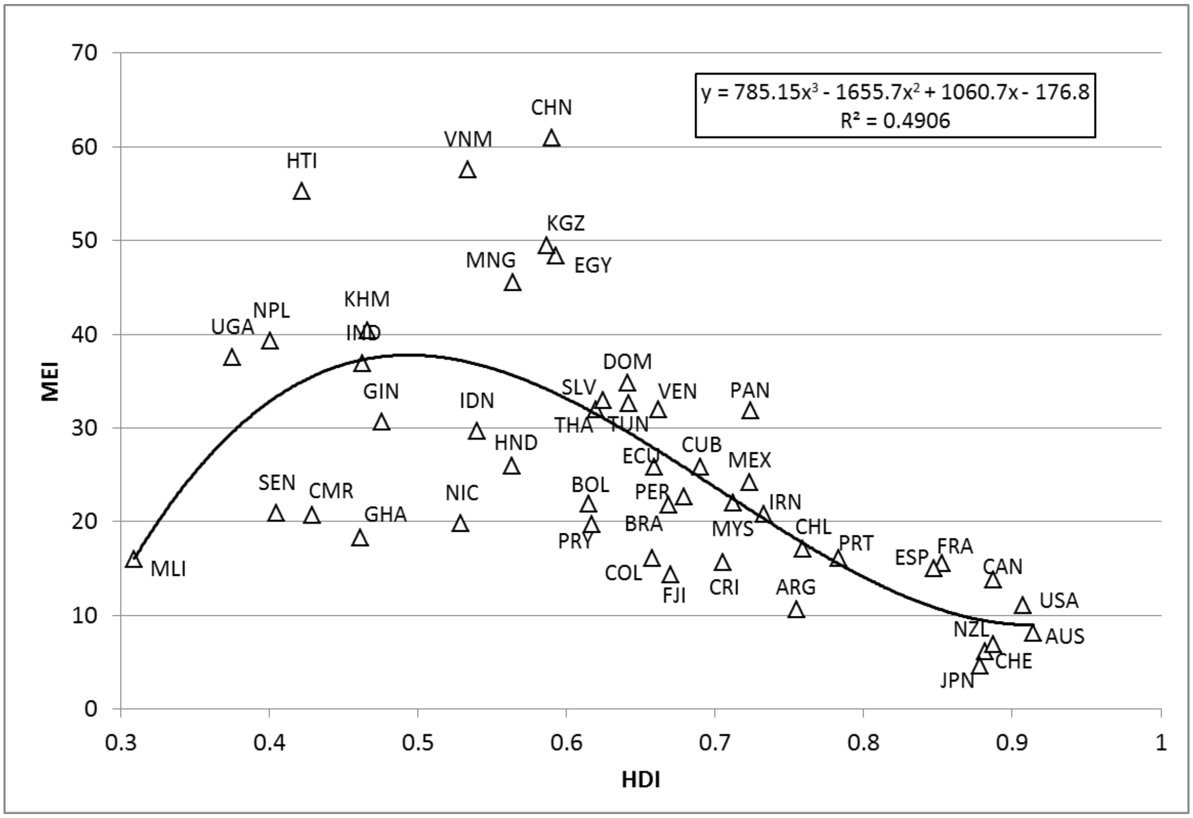


B: Countries with five-year interval migration data



Notes: *CMI* = Crude Migration Intensity, *MEI* = Migration Effectiveness Index, *INMI* = Index of Net Migration Impact. Plotted *CMI* and *MEI* values are ratios to the mean of countries on the graph. The product of the mean *MEI* and *CMI* slope generates the *INMI* which can be read as a ratio to the average INMI from the curvilinear surface.
Source: Authors' calculations using the IMAGE database (Bell *et al.* 2014), processed using the IMAGE Studio (Stillwell *et al.* 2014).

FIGURE 4 Migration Effectiveness Index (MEI) and the Human Development Index (HDI), countries with five-year interval **migration data**



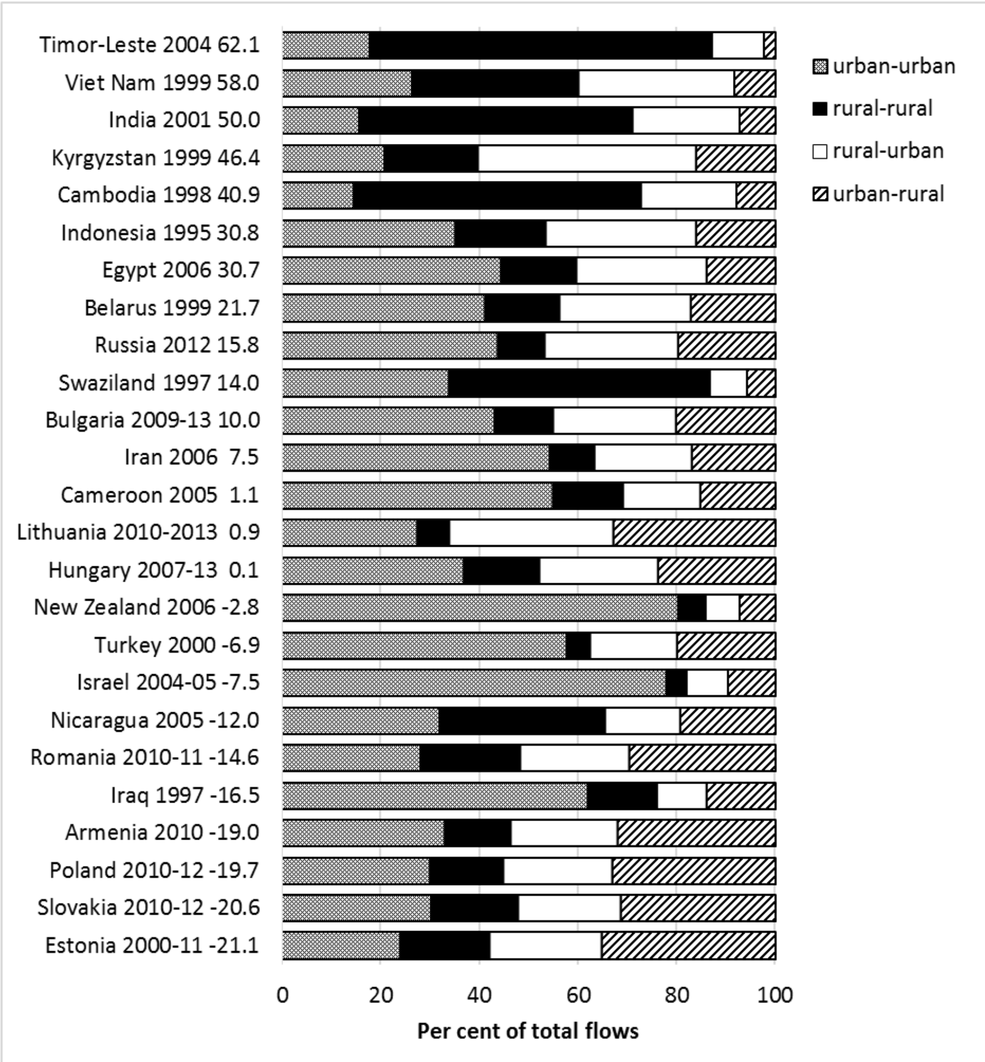
Key to the countries

ARG	Argentina	CUB	Cuba	HTI	Haiti	MYS	Malaysia	THA	Thailand
AUS	Australia	DOM	Dominican Rep.	IDN	Indonesia	NIC	Nicaragua	TUN	Tunisia
BOL	Bolivia	ECU	Ecuador	IND	India	NPL	Nepal	UGA	Uganda
BRA	Brazil	EGY	Egypt	IRN	Iran	NZL	New Zealand	URY	Uruguay
CAN	Canada	ESP	Spain	JPN	Japan	PAN	Panama	USA	United States of America
CHL	Chile	FJI	Fiji	KGZ	Kyrgyzstan	PER	Peru	VEN	Venezuela
CHN	China	FRA	France	KHM	Cambodia	PRT	Portugal	VNM	Viet Nam
CMR	Cameroon	GHA	Ghana	MEX	Mexico	PRY	Paraguay		
COL	Colombia	GIN	Guinea	MLI	Mali	SEN	Senegal		
CRI	Costa Rica	HND	Honduras	MNG	Mongolia	SLV	El Salvador		

Note: The countries are listed in alphabetical order of their three letter codes.

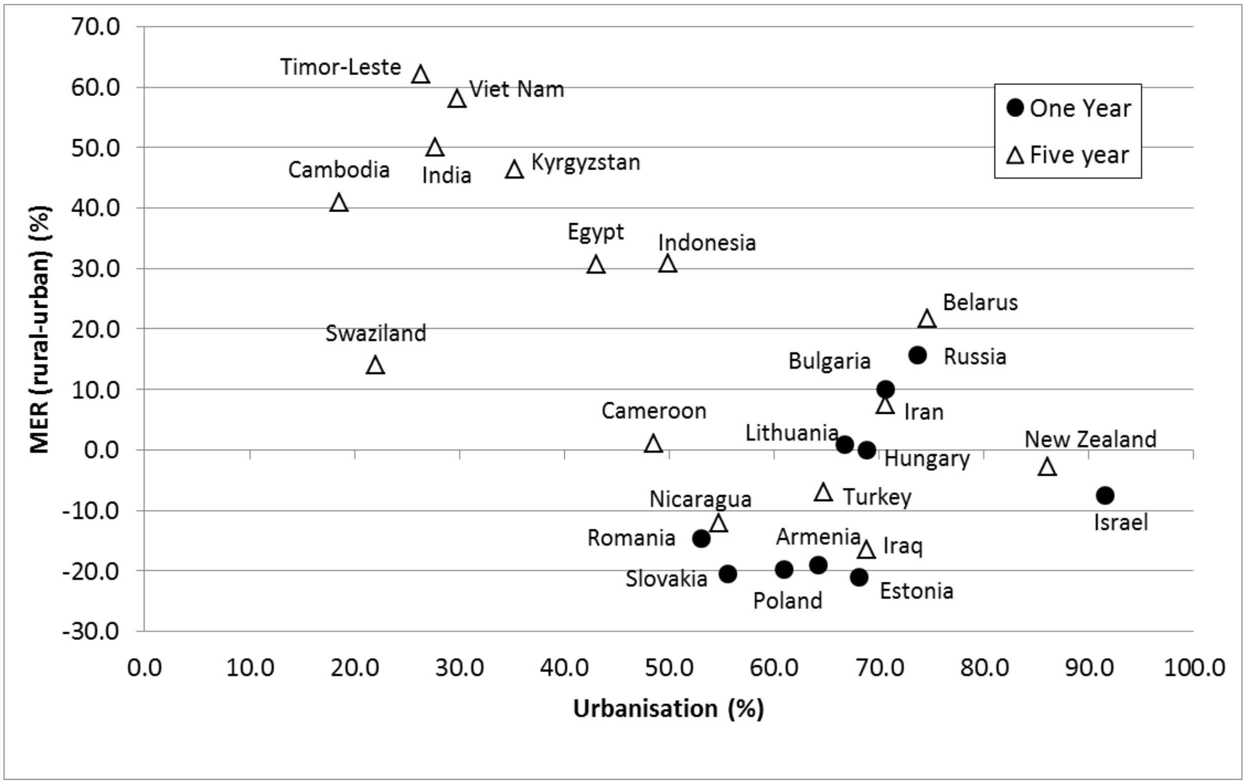
Source: Authors' calculations using the IMAGE database (Bell *et al.* 2014), processed using the IMAGE Studio (Stillwell *et al.* 2014).

FIGURE 5 Shares of migration between rural and urban areas for selected countries ranked by migration effectiveness



Notes: The values of the Migration Effectiveness Ratio for rural-urban migration (MER_{RU}) are shown next to the country names.
Source: Authors' calculations using the IMAGE database (Bell *et al.* 2014)

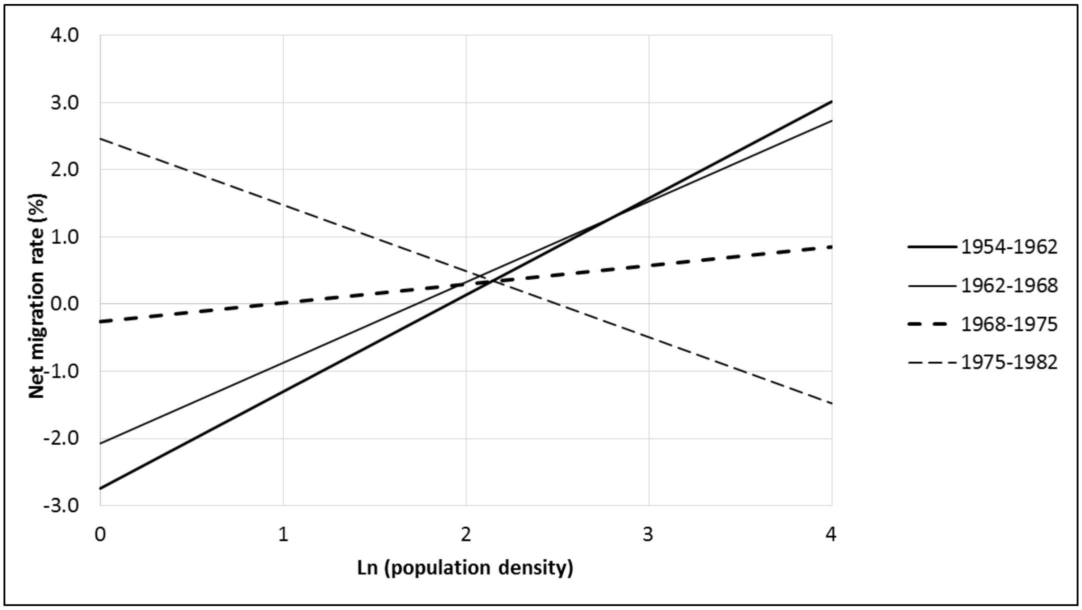
FIGURE 6 Rural to urban-migration effectiveness and level of urbanization



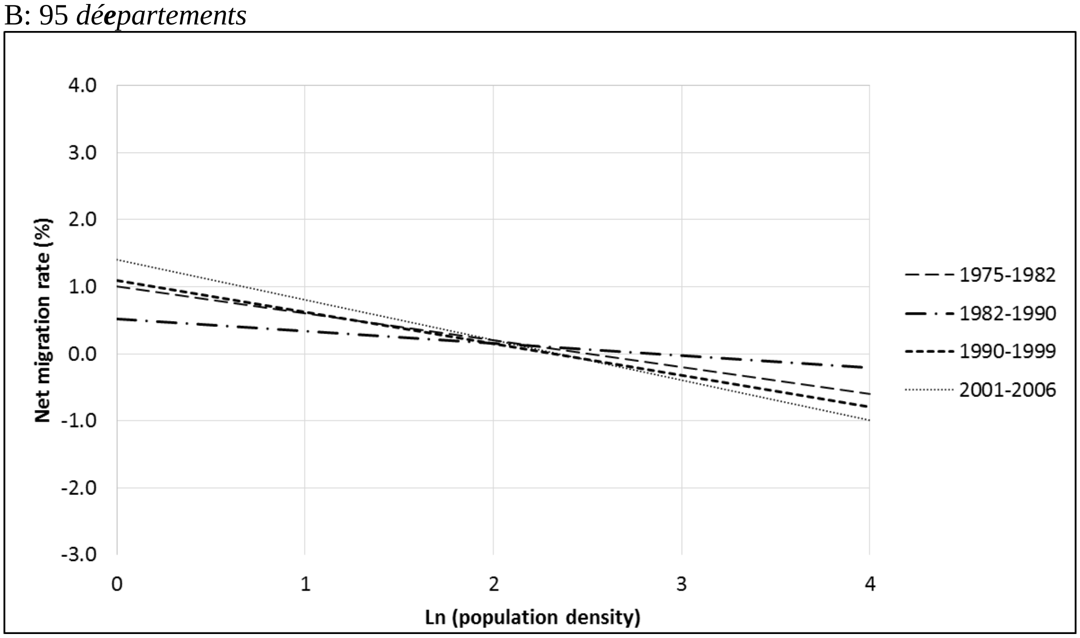
Source: Authors' calculations based on the IMAGE database (Bell *et al.* 2014).

FIGURE 7 The relationship between annual rates of net internal migration and the logarithm of population density for the *départements* of France

A: 95 *départements* split into rural and urban areas



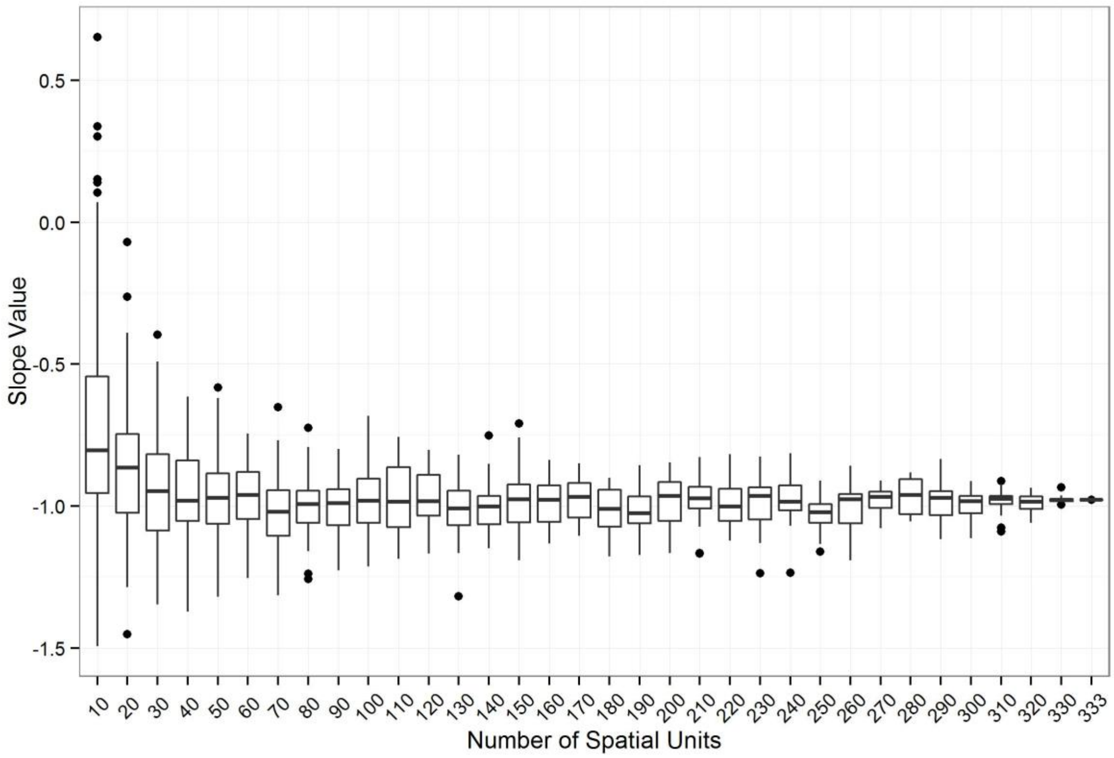
B: 95 *déepartements*



Notes: Figure 7a: Based on net migration rates for *départements* decomposed into rural and urban parts for 1954-1962, 1962-1968, 1968-1975 and 1975-1982. Figure 7b: Based on net migration rates for whole *départements* for 1978-1982, 1982-1990, 1990-1999 and 2001-2006. Population density = population per square kilometre.

Source: Adapted from Courgeau (1992) with additional computations by the authors for 1982-1990, 1990-1999 and 2001-2006 using data in the IMAGE database (Bell *et al.* 2014) from the Institut National de la Statistiques et des Études Économiques (INSEE).

FIGURE 8 Slope of internal net migration rates as a function of log population density plotted against the number of zones at selected scales, one-year migration data, 2011 Census, Australia



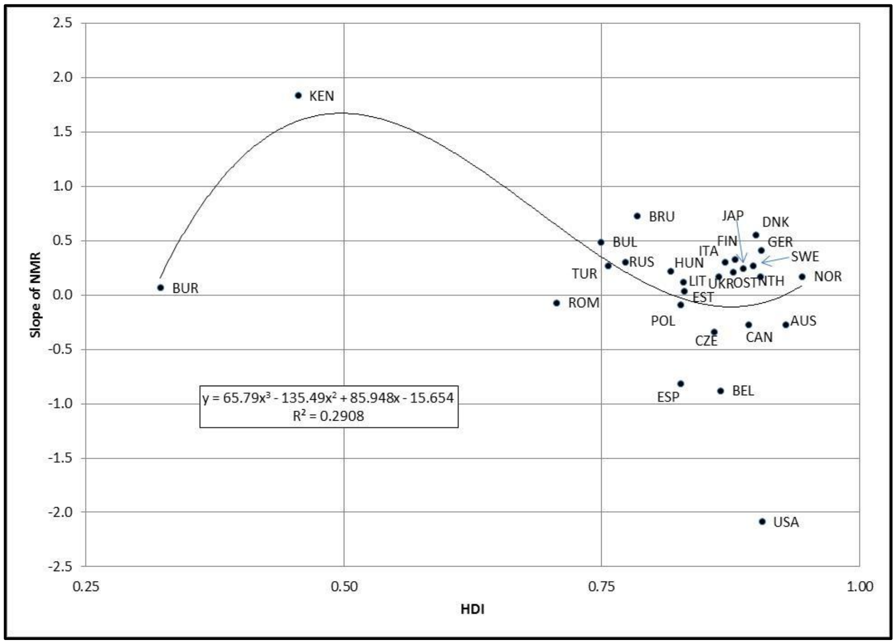
Notes:

1. The box plots show the distribution of values produced by random draws from the universe of possible contiguous combinations of 333 basic spatial units for the number of zones indicated on the horizontal axis.
2. The box plots show the median, upper and low quartiles of the distribution, so that 50 per cent of observations fall within the box. The whisker lines indicate the ranges of observations above the upper quartile or below the lower quartile. The dots indicate outliers.
3. The zonation solutions were computed using the IMAGE Studio. The regression slopes were computed using R. The number of random draws for each set of zones was 100.

Source: Authors' calculations based on the IMAGE database (Bell *et al.* 2014), processed using the IMAGE Studio (Stillwell *et al.* 2014).

FIGURE 9 Slope of the Net Migration Rate (*NMR*) against the Human Development Index (HDI)

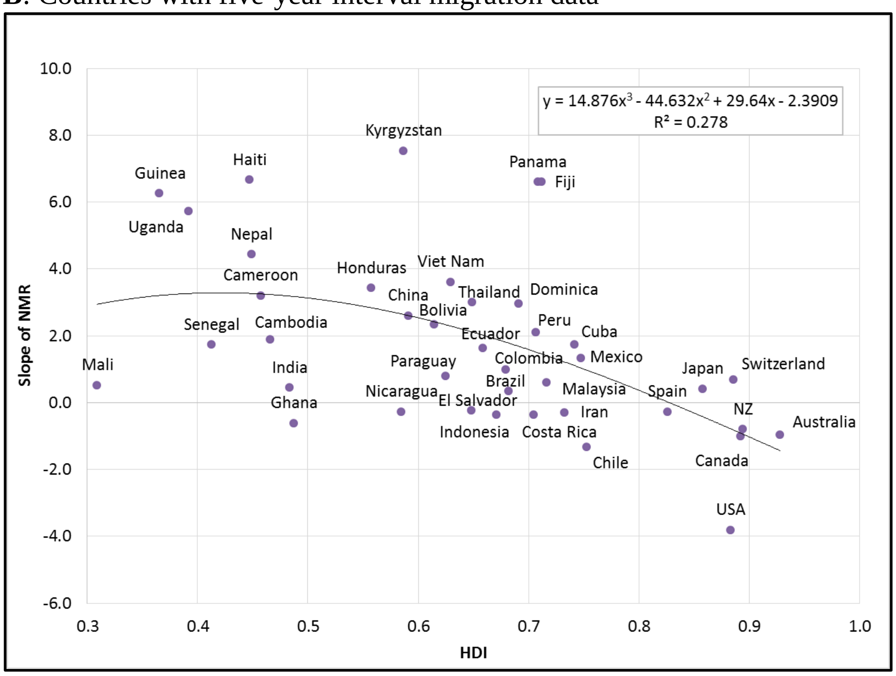
A: Countries with one-year interval migration data



Key to countries

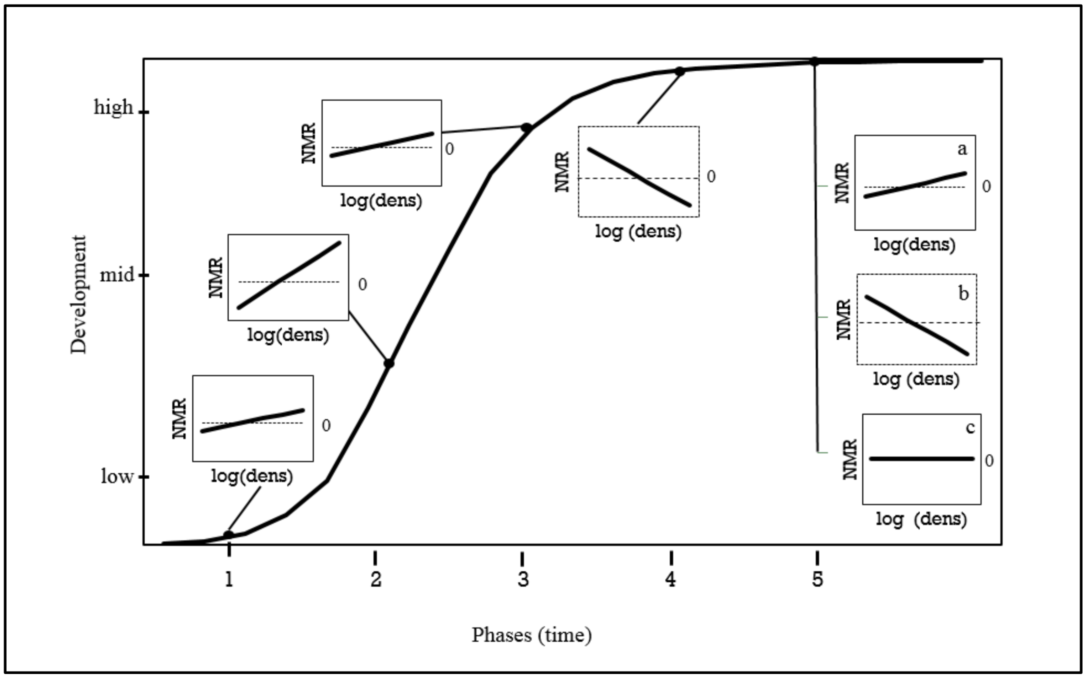
AUS	Australia	CZE	Czech	HUN	Hungary	NTH	Netherlands	TUR	Turkey
BEL	Belgium	DNK	Denmark	ITA	Italy	OST	Austria	UKR	Ukraine
BRU	Belarus	ESP	Spain	JAP	Japan	POL	Poland	USA	USA
BUL	Bulgaria	EST	Estonia	KEN	Kenya	ROM	Romania		
BUR	Burkina Faso	FIN	Finland	LIT	Lithuania	RUS	Russia		
CAN	Canada	GER	Germany	NOR	Norway	SWE	Sweden		

B: Countries with five-year interval migration data



Source: Authors' calculations based on the IMAGE database (Bell *et al.* 2014), processed using the IMAGE Studio (Stillwell *et al.* 2014).

FIGURE 10 A theoretical framework linking development to population redistribution through net internal migration



Notes:
Phases in population redistribution
1 - Early urbanization
2 - Mature urbanization
3 - Late urbanization
4 - Counter-urbanization
5 - After the transitions: (a) Re-urbanization, (b) Counter-urbanization, (c) Dynamic equilibrium

Source: Authors' schematic based on ideas from Zelinsky (1971), Courgeau (1992), Geyer (1996), Kontuly and Geyer (2003a, 2003b) and evidence presented in the paper.

Appendix: Mean *MEI*, *CMI* slope and *INMI*, various countries

One-year data

Country	Year[1]	No of BSUs	*CMI* Slope	Mean *MEI/100*	Modelled *ANMR* Slope	Ratio of *CMI* Slope to Average *CMI* Slope	Ratio of Mean *MEI* to Average	*Index of Net Migration Impact INMI*
Romania	2002	42	0.29	0.1297	0.0376	0.20	1.28	0.26
Italy	2009	107	0.43	0.0991	0.0426	0.30	0.98	0.30
Japan	2011	47	1.12	0.0402	0.0450	0.79	0.40	0.31
Netherlands	2010	431	1.38	0.0411	0.0567	0.97	0.41	0.39
Germany	2009	412	1.19	0.0497	0.0591	0.84	0.49	0.41
Spain	2001	52	0.58	0.1105	0.0641	0.41	1.09	0.44
Sweden	2012	290	1.93	0.0354	0.0683	1.36	0.35	0.47
Austria	2010	99	1.18	0.0613	0.0723	0.83	0.60	0.50
Finland	2011	336	2.09	0.0375	0.0784	1.47	0.37	0.54
Russian Federation	2010	80	0.33	0.2389	0.0788	0.23	2.35	0.55
Czech Republic	2010	77	0.71	0.1139	0.0809	0.50	1.12	0.56
United Kingdom	2001	426	1.64	0.0504	0.0827	1.15	0.50	0.57
Norway	2013	428	1.77	0.0496	0.0878	1.24	0.49	0.61
Belgium	2005	589	1.68	0.0580	0.0974	1.18	0.57	0.68
Denmark	2011	99	2.54	0.0401	0.1019	1.79	0.40	0.71
USA	2008	3143	1.56	0.0739	0.1153	1.10	0.73	0.80
Burkina Faso	2006	45	0.84	0.1504	0.1263	0.59	1.48	0.88
Portugal	2001	22	0.87	0.1581	0.1375	0.61	1.56	0.95
Australia	2011	333	2.97	0.0530	0.1574	2.09	0.52	1.09
Turkey	2012	81	1.73	0.0935	0.1618	1.22	0.92	1.12
Canada	2006	288	1.46	0.1162	0.1697	1.03	1.15	1.18
Ireland	2006	26	1.58	0.1360	0.2149	1.11	1.34	1.49
Sudan	2008	25	1.45	0.2480	0.3596	1.02	2.44	2.49
Kenya	1999	69	2.82	0.2503	0.7058	1.98	2.47	4.89
Mean			*1.42*	*0.1015*	*0.1334*	*1.00*	*1.00*	*1.00*

Notes:

1. In the second column we provide a year of reference. For register (movement) data, the year is the calendar year indicated. For census (transition) data, the year is when the census was taken, The date for the start of the measurement year for the census question falls in the previous year. For example, the UK census date was 27 March 2011, so that one-year ago was 27 March 2010.

Five-year data

Country	**Year[1]**	**No of BSUs**	***CMI* Slope**	**Mean *MEI/100***	**Modelled *ANMR* Slope**	**Ratio of *CMI Slope* to Average *CMI* Slope**	**Ratio of Mean *MEI* to Average**	***Index of Net Migration Impact INMI***
Japan	2000	47	4.27	0.0463	0.1973	1.11	0.18	0.20
Spain	2001	52	1.59	0.1498	0.2387	0.41	0.57	0.24
India	2001	35	0.65	0.3689	0.2403	0.17	1.41	0.24
Mali	1998	47	1.52	0.1604	0.2436	0.39	0.62	0.24
Argentina	2001	24	2.34	0.1062	0.2488	0.61	0.41	0.25
Switzerland	2000	184	5.51	0.0620	0.3417	1.43	0.24	0.34
Nicaragua	2005	153	1.91	0.1983	0.3784	0.50	0.76	0.38
Iran	2011	367	1.84	0.2085	0.3829	0.48	0.80	0.38
Portugal	2001	22	2.43	0.1605	0.3894	0.63	0.62	0.39
Venezuela	2011	25	1.31	0.3198	0.4178	0.34	1.23	0.42
Egypt	2006	27	0.91	0.4841	0.4393	0.24	1.86	0.44
Colombia	2005	33	2.92	0.1609	0.4697	0.76	0.62	0.47
Mexico	2010	2456	1.94	0.2425	0.4698	0.50	0.93	0.47
Indonesia	2010	494	1.66	0.2967	0.4923	0.43	1.14	0.49
Cuba	2002	169	2.09	0.2585	0.5405	0.54	0.99	0.54
Ghana	2000	110	3.04	0.1826	0.5548	0.79	0.70	0.55
Brazil	2000	558	2.64	0.2174	0.5749	0.69	0.83	0.57
Nepal	2001	63	1.53	0.3928	0.6017	0.40	1.51	0.60
Canada	2006	288	4.8	0.1381	0.6636	1.25	0.53	0.66
Honduras	2001	298	2.58	0.2592	0.6679	0.67	0.99	0.67
Australia	2011	333	8.39	0.0812	0.6815	2.18	0.31	0.68
USA	2000	3107	6.18	0.1109	0.6861	1.61	0.43	0.68
France	2006	22	4.86	0.1551	0.7538	1.26	0.59	0.75
New Zealand	2006	70	11.01	0.0686	0.7555	2.86	0.26	0.75
Thailand	2000	76	2.34	0.3300	0.7710	0.61	1.27	0.77
Malaysia	2000	136	3.53	0.2196	0.7756	0.92	0.84	0.77
El Salvador	2007	262	2.45	0.3198	0.7835	0.64	1.23	0.78
Ecuador	2001	995	3.13	0.2586	0.8101	0.81	0.99	0.81
Peru	2007	1832	3.79	0.2267	0.8595	0.98	0.87	0.86
Costa Rica	2000	81	5.96	0.1563	0.9323	1.55	0.60	0.93
Dominican Republic	2010	155	2.87	0.3477	0.9971	0.75	1.33	0.99
Paraguay	2002	236	5.07	0.1968	0.9972	1.32	0.75	0.99
Haiti	2003	41	1.88	0.5527	1.0377	0.49	2.12	1.04
Senegal	2002	34	5.17	0.2096	1.0838	1.34	0.80	1.08
Chile	2002	342	6.56	0.1710	1.1222	1.70	0.66	1.12
Bolivia	2001	112	5.19	0.2186	1.1335	1.35	0.84	1.13
China	2000	31	1.87	0.6101	1.1439	0.49	2.34	1.14
Tunisia	2004	24	3.57	0.3265	1.1662	0.93	1.25	1.16

Uganda	2002	56	3.3	0.3754	1.2398	0.86	1.44	1.23
Cambodia	1998	149	3.48	0.4045	1.4069	0.90	1.55	1.40
Cameroon	2005	58	7.02	0.2068	1.4524	1.82	0.79	1.45
Guinea	1996	34	4.77	0.3061	1.4593	1.24	1.17	1.45
Viet Nam	2009	63	2.54	0.5759	1.4622	0.66	2.21	1.46
Fiji	2007	78	10.87	0.1438	1.5626	2.82	0.55	1.56
Panama	2000	75	6.66	0.3186	2.1227	1.73	1.22	2.11
Kyrgyzstan	1999	52	4.57	0.4949	2.2596	1.19	1.90	2.25
Mongolia	2000	21	6.28	0.4554	2.8587	1.63	1.75	2.85
Mean			*3.85*	0.2607	0.8695	1.00	1.00	1.00

Notes:

1. For the five-year derived from country censuses, this is the year when the census was taken. The migration intervals refer to the five year prior to the census date in this year.