Demographic Research a free, expedited, online journal
of peer-reviewed research and commentary
in the population sciences published by the
Max Planck Institute for Demographic Research
Konrad-Zuse Str. 1, D-18057 Rostock · GERMANY
www.demographic-research.org

DEMOGRAPHIC RESEARCH
VOLUME 12, ARTICLE 9, PAGES 197-236
PUBLISHED 04 MAY 2005
www.demographic-research.org/Volumes/Vol12/9
DOI: 10.4054/DemRes.2005.12.9

Research Article

World Urbanization Prospects: an alternative to the UN model of projection compatible with the mobility transition theory

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Demographic Research–Volume 12, Article 9
a research article

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Abstract

This paper proposes to critically examine the United Nations projections on urbanisation. Both the estimates of current trends based on national data and the method of projection are evaluated. The theory of mobility transition is used as an alternative hypothesis. Projections are proposed using a polynomial model and compared to the UN projections, which are based on a linear model. The conclusion is that UN projections may overestimate the urban population for the year 2030 by almost one billion, or 19% in relative term. The overestimation would be particularly more pronounced for developing countries and may exceed 30% in Africa, India and Oceania.

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1. Introduction

The United Nations Population Division has been publishing and revising its World Urbanisation Prospects since 1991 (the latest being the 2002 revision: United Nations 2002) and this has become a popular source of data and analysis of the past, current and future proportion urban in each country, region or continent of the world. As urban issues get more attention, notably in the Millennium Development Goals (MDG), it is increasingly used as an instrument for projections of some other global trends, such as poverty (UN-Habitat 2003; World Bank 2003), energy consumption (EIA 2004; IEA 2004), environment and resources (UNDP et al. 2003), etc. Projections and even estimations, for recent years, of other global trends cannot afford to do without urbanisation projections, as they are often a key indicator of global integration. No other organisation than the UN has been successful in compiling a database on urbanisation that equals the UN database in scope and quality. An early attempt to offer alternative to the UN database is the GEOPOLIS database, which is using a common agglomeration (building-blocks density) and population (10,000 inhabitants threshold) criteria for all countries (Moriconi-Ebrard 1993, 1994). Unfortunately, this database is at present only available up to 1990 and its procedures have not been recognized by an international body. A more recent alternative using polygons created from satellite images of night-time lights is offered by the Gridded Population of the World (GPW) database under construction at the Columbia University's Earth Institute's Center for International Earth Science Information Network (CIESIN) and available online (Balk et al. 2004). This last approach is promising but the data on urban agglomerations are not yet available world-wide and may reflect more the availability of electricity than the actual population size and density.

Since the UN data is largely used and referred to, analysing the historical trends and projections from this set of data will be more useful to the interested reader and also to the planner than to refer to not yet internationally agreed alternatives. Nevertheless, and without questioning the merits of the UN database on urbanisation, it is necessary to assess its limits. This has already been done through a number of publications since the inception of the UN method of projection for urban population. Among the most recent works that build on this literature, B. Cohen (2004) offers the most up-to-date and concise evaluation of the UN forecasts focusing on less developed countries (LDC) and is actually summarizing the work published in more details by the National Academy of Sciences (USA) in a major and recent book addressing various urban issues in LDC (National Research Council 2003). Another book published at around the same time focuses on the definition and measurement problems as regard to urbanisation (Hugo and Champion 2003). From these recent publications, it appears that while acknowledging the importance of the work done by the UN, demographers and geographers are very critical about the quality of the national urbanisation estimates and the method of projection used by the UN.

What about using national estimates rather than internationally-agreed estimates? The UN argues (1997, p160) that though "*the quality of the estimates and projections made is highly dependent on the quality of the basic information permitting the calculation of the proportion urban*" and that "*the criteria used to identify urban areas vary from country to country and may not be consistent even between different data sources within the same country*", it still relies "*on the data produced by national sources that reflect the definitions and criteria established by national authorities*". This justification is based on UN reports published in the 1960s that concluded that "*it is not possible or desirable to adopt uniform criteria to distinguish urban areas from rural areas*". This opinion will appear outdated to the 21st century reader: first, many attempts have been made since the 1960s to harmonise databases on urbanisation, at least at a regional level (European Union, CELADE), precisely to allow comparison across time and space. Maintaining the same definitions of urban areas might also enable time comparison for each particular country. Considering that most urban definitions are inadequate for analysis, the effort is now directed towards more flexible definitions using the building-block areas as the smallest units of analysis, thus permitting presentation along different criteria depending on the focus of the analysis (Hugo and Champion 2003). Therefore, the only remaining justification for using national definitions is that the data based on those definitions are readily available, whereas more sophisticated definitions are still to be tested and approved by national and international entities. That is the main reason why, despite its inadequacy and all scientific efforts to remedy it, the UN database will still be used for many years, unless considerable international effort is directed towards collecting data in a format that would be suitable for applying more flexible definition of urban areas. This reason only would suffice to develop a methodology to obtain proper projections using the currently available UN data based on national definitions.

What about the projection method? Let alone the difficult problem of the availability of reliable data, and temporarily working with the hypothesis that national definitions capture reasonably well the proportion urban, the method of projections used by the UN since its first projections of urban population needs examination. B. Cohen (2004) showed – by comparing the 2001 UN report with the previous ones – that the UN projections for urban population for the year 2000 were systematically biased upward for countries with low and lower middle level of development (theses results also appear in the NAS publication: National Research Council 2003). The mean percentage errors (MPE) for the 20-years length of forecast could be as high as 27.2% (South Asian countries), but even the MPE for the 5-years length of forecast exceeds 3% in countries with low and lower middle level of development. Actually, even in the latest UN report (2002 revision), the projection method has implication not only for the projection period 1995-2030, but also for the estimation period 1950-1995. Though this is not clearly stated in the report, a number of LDC did not actually offer data on urbanisation for the 1990s and even for the 1980s and projections had to be made for these two decades. As our analysis will show, the projection method has an effect on the estimates of the urban population as early as in 1990.

Why should the projections be systematically biased? Why are LDC more affected by this bias than more developed countries (MDC)? The first part of this paper will demonstrate that these problems originate mainly in the regression model used in the method of projection. Are there alternative theories that could help to better hypothesize on urbanisation trends? The second part of this paper will present a refinement to the theory of mobility transition and will test its implications on urbanisation projections. An original method of projection will be considered and its results will be compared to the UN projections. In this paper, to facilitate comparative reading, we adopt the same vocabulary and notations as found in the UN reports.

2. An evaluation of the UN projections

The principle of the UN interpolation (starting from 1st July 1950 to the end of the estimation period, 1st July 1995) and extrapolation (same principle applies from 1995 to 2030) is based on the linear projection of the relevant inter-census urban-rural growth difference, denoted rur in the UN reports. At any time $t+1$ the rur can be noted, with rates expressed in terms of the population at time t and $t+1$:

$$rur_{t+1} = u_{t+1} - r_{t+1} = \frac{U_{t+1} - U_t}{U_t} - \frac{R_{t+1} - R_t}{R_t}$$

where u_{t+1} and r_{t+1} stands respectively for the urban and the rural growth rate in the interval $(t, t+1)$, U_t for the urban population and R_t for the rural population at time t. In the general case, for any interval $(t, t+n)$, the rur is computed using the formula:

$$rur_{t+n} = \frac{ln(U_{t+n}/U_t)}{n} - \frac{ln(R_{t+n}/R_t)}{n}$$

The proportion urban (PU) at time T within an intercensal period for interpolation, $t < T < t+n$, is determined by the equation:

$$PU_T = URR_T \ / \ [1 + URR_T]$$

where

$$URR_T = URR_t \ * \ exp[rur_{t+n} \ * \ (T - t)]$$

and

$$URR_t = U_t / R_t \ .$$

The same formula applies for extrapolation outside an intercensal period, $t + n < T$, and the rur is determined from the urban and rural populations of the closest intercensal period $(t, t + n)$ available (United Nations 2002).

To implement the UN projection model, one needs to know only the total population and the urban population (or the proportion urban) at different dates. All other quantities are derived from these. The UN projection model belongs therefore to the class of endogenous autoregressive projection models. It is not explanatory as no independent, exogenous variables are introduced in the estimation.

It can be shown that the projection method described above mathematically overestimates urban growth. As correctly stated in the UN report, the urban-rural growth difference "*declines as the proportion urban increases because the pool of potential rural-urban migrants decreases as a fraction of the urban population, while it increases as a fraction of the rural population*" (United Nations 2002, p106). Therefore, the UN has developed a model for the evolution of the hypothetical urban-rural growth difference (denoted $hrur$ in the UN report). This model is "*obtained by regressing the initial observed percentage urban on the urban-rural differential for the 113 countries with more than 2 million inhabitants in 1995. [. . .] The projection of the proportion urban is carried out, based on a weighted average of the observed urban-rural growth difference for the most recent period available in a given country and the hypothetical urban-rural growth difference*" (United Nations 2002, p111).

In practical terms, interpolations at specific dates from 1955 to 1995 (estimation period) are derived from the rur computed using the intercensal data, as explained above, whereas the UN model for urban projections is a weighted average of the preceding estimation of rur and of the hypothetical urban-rural growth difference for the projection period ($hrur$) computed from a regression model of rur against PU as per 1995 in countries i of 2 millions inhabitants and more:

$$\begin{aligned} rur^*_{i,t+5} &= W_{1,t} * rur_{i,t} + W_{2,t} * hrur \\ &= W_{1,t} * rur_{i,t} + W_{2,t} * (0.037623 - 0.02604 * PU_{i,t}) \end{aligned}$$

where

$$\begin{array}{lll} W_{1,t} = 0.8 & W_{2,t} = 0.2 & \text{when } t = 1995 \\ W_{1,t} = 0.6 & W_{2,t} = 0.4 & \text{when } t = 2000 \\ W_{1,t} = 0.4 & W_{2,t} = 0.6 & \text{when } t = 2005 \\ W_{1,t} = 0.2 & W_{2,t} = 0.8 & \text{when } t = 2010 \\ W_{1,t} = 0 & W_{2,t} = 1 & \text{when } t \geq 2015 \end{array}$$

The projection is conducted step by step, by five-year increment, the estimate for one projection period being used for the projection of the next.

The implications of such a method are the following:

- Because the linear regression model is based on data compiled when the world urban transition was well on its way (the proportion urban was 45.1% in 1995, with regions' estimates ranging from a minimum of 21.9% in Eastern Africa to a maximum of 87.4% in Australia/New-Zealand), it does not take into account the true relation between urban-rural growth difference and the percentage urban at the beginning and at the end of the urban transition from low to high proportion urban. As noted by an earlier critique (National Research Council 2003, p496), the declining function has not only the effect of slowing down the urban growth of highly urbanised countries but it has also the effect of speeding the urbanisation process of little urbanised countries. According to the empirical equation mentioned above, one could theoretically have in some countries a 3.76% rur at the beginning of the process when initial percentage urban is zero, though we expect from historical observation of countries with low percentage urban that the rur be growing progressively from zero value. This is not however the main problem: historically, the rur reached higher level than 4% or even 5% in some countries or regions (e.g. in Melanesia when the rur was around 6% for an initial 11.5% percentage urban in the late 1960s). The flaw is more at the other end of the process. We certainly cannot expect the rur to reach 1.16% when the initial population is already 100% urban, because when all the population is urban the rur can only be zero or negative, leading to a decrease in the percentage urban. Very few countries of more than 2 million inhabitants (the threshold chosen to compute the regression model) can reach 100% urbanisation so the contradiction is not very likely to arise, but it is still important to incorporate in the model the trends at the limit. Therefore, without even considering the empirical data, a non-linear model would be more consistent with the mathematical relation between the rur and the percentage urban. In addition, considering the empirical data, the model should make provision for the quasi-stabilisation of urbanisation below 100%, as already observed in some, mostly developed countries.

- Because the model is uniquely applied on all countries, it cannot take account of the historical differences in the urban transition from one country to another. Applied to projections, the model makes the implicit assumption that all countries should go through the same process of urbanisation as the currently developed countries. Not only does this assumption appear Western-centred, but as we will see (it is best illustrated graphically) it does not even fit the current trends of the rur for developed countries. Therefore, an appropriate model should at least fit differently the countries according to their historical path in the urbanisation process. The rur has never been much higher than 3% in developed countries whereas it could reach 5% or more in developing countries. In other words, significant urban growth started in the 18th Century in developed countries in order to reach a 55% proportion urban in 1950 and have more rapidly progressed in the second half of the 20th century to reach 75% in 1995. The urbanisation in developing countries, on the contrary, starting from less than 10% in 1900, rapidly reached 18% in 1950 and 38% in 1995.

2.1 Evidence of non-linearity in the relation between urban-rural growth difference and the percentage urban

Ideally, we would want to draw historical trends of urbanisation for all countries of the world since the beginning of ages. No currently available database can offer such long trends, even for the more developed countries or for the last two centuries only. Actually, the earliest date at which one can have a reasonable picture of the urbanisation worldwide is 1950. Estimates for earlier periods exist but only for Europe (Bairoch 1985; Chandler 1987; de Vries 1984) and China (Chandler 1987; Liang 2001) (for a synthesis on both, see Woods 2003). It is therefore not easy to demonstrate what should be the form of the relation between urban-rural growth difference and the percentage urban during the early stage of the urbanisation process, especially outside Europe.

In figures 1 to 5, we plotted the trends formed by the urban-rural growth difference, rur, in the $(t-5, t)$ time interval against the proportion urban, PU, at time t for different regions of the world. The curves read from left to right and the first point represents the year 1955. Subsequent points are defined over five-year intervals until the year 2030, the last point on the curve. The projection period is represented for each region by dotted lines from 1990.

The reason why a linear model was used when the UN started its projection exercise in the 1980s was that at the time, very few countries had more than three observed points on the rur-PU curve from the 1950s to the 1970s. In absence of deeper historical trends, a sensible solution was to model the trend across countries at a given time. The different level of urbanisation at which these countries were captured was supposed to reflect the most likely path the less urbanised countries would follow to reach, one day, the level of the most urbanised countries.

Now that data are available from the 1950s to the 1980s, and sometimes to the 1990s, there is less reason to believe that a linear model relating rur and PU should still be fitted. In hardly any region of the world the relation follows a linear downward pattern, except maybe in Western Africa (Figure 1), South America and Central America (Figure 2). Most patterns from 1955 to 1990 follow an inverted U-curve whether in develop-

Figure 1: Urban-Rural Growth Difference versus Proportion Urban in Africa (1950-2030, projection period represented by a dotted line; source: UN, 2004)

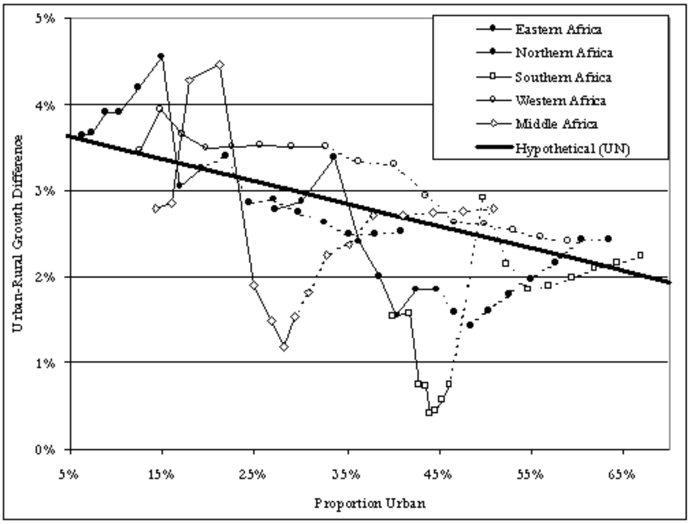


Figure 2: Urban-Rural Growth Difference versus Proportion Urban in Caribbean, South and Central America (1950-2030, projection period represented by a dotted line; source: UN, 2004)

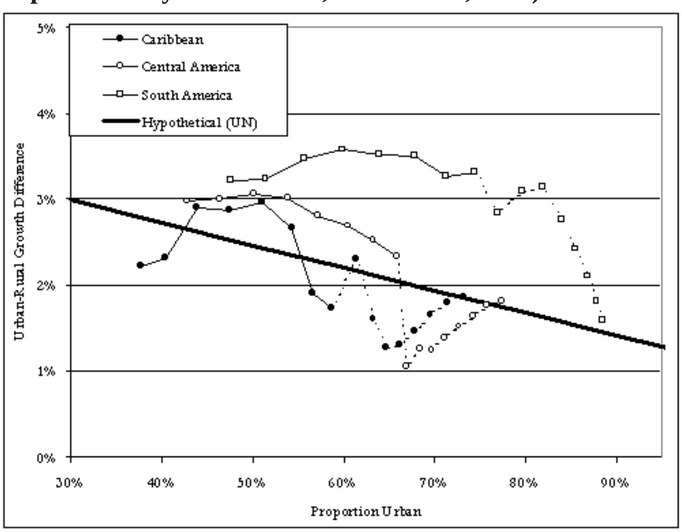


Figure 3: Urban-Rural Growth Difference versus Proportion Urban in Asia (1950-2030, projection period represented by a dotted line; source: UN, 2004)

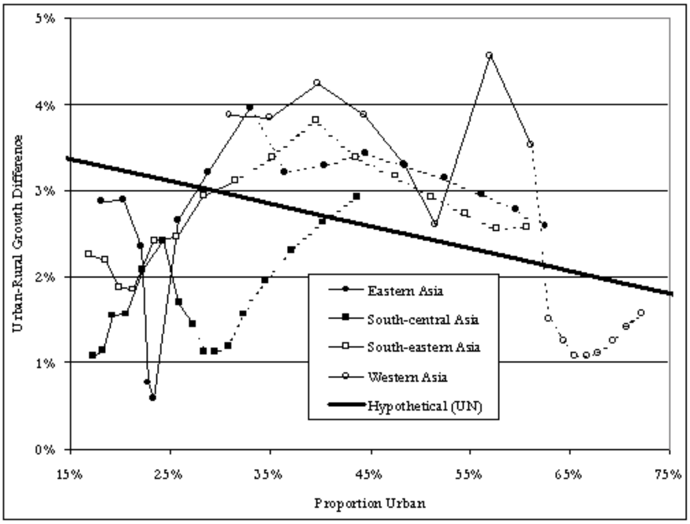


Figure 4: Urban-Rural Growth Difference versus Proportion Urban in Less Developed Oceania (1950-2030, projection period represented by a dotted line; source: UN, 2004)

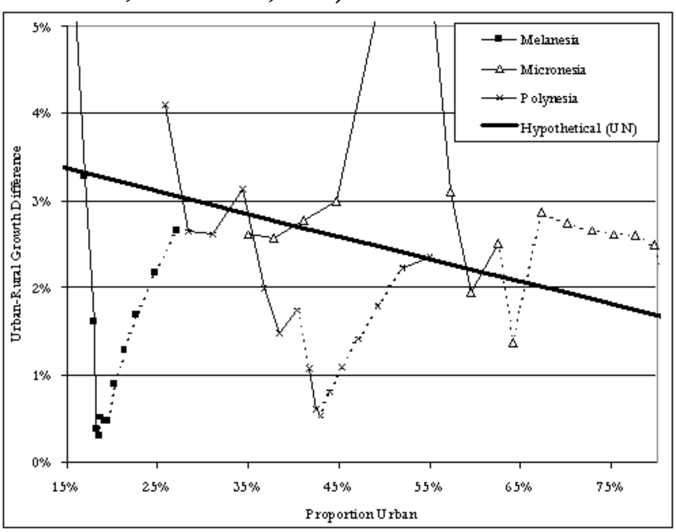
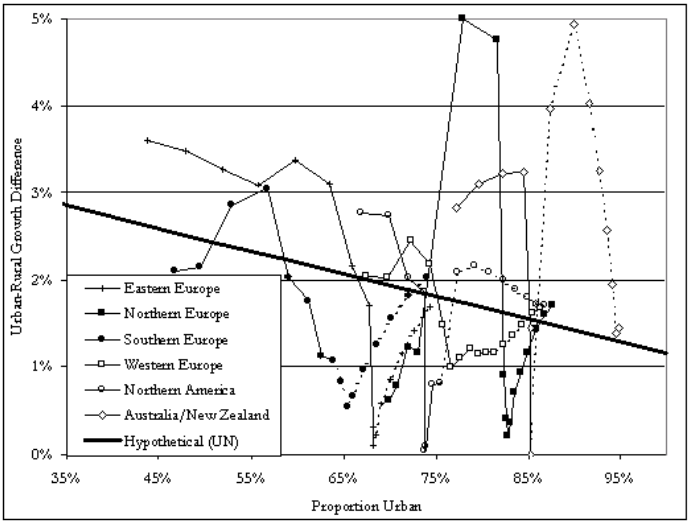


Figure 5: Urban-Rural Growth Difference versus Proportion Urban in Developed Regions (1950-2030, projection period represented by a dotted line; source: UN, 2004)



ing countries (Eastern Africa, Middle Africa, Northern Africa, Caribbean, South-Central Asia, Melanesia and Micronesia) or in developed countries (Southern Europe and Northern Europe). Other regions follow a more ambiguous pattern but almost all have seen the rur falling sharply from peak values usually attained in the 1950s and 1960s for the LDC regions, or in the 1970s and 1980s for the MDC regions. Exception to that phenomenon are found in Asia: Western Asia, which after a sharp fall in the 1970s, experienced the opposite trend in the 1980s; South-Eastern Asia experienced a rise in the 1970s and 1980s, and Eastern Asia in the 1980s, though this can be attributed to China[1] only.

Rather intriguingly, some regions, particularly in Africa but also in Oceania, show a slight increase in the rur in the 1980s that could be interpreted as a reversal of the overall downward trend. However, this upward trend is limited and rather reflects the use of the UN model of projection for some countries where data were incomplete prior to 1995. This shows that the method not only has an effect on the 1995-2030 projection period but also on the later part of the estimation period, i.e. in the 1980s up to 1995, as data on urbanisation were not readily available for all developing countries.

[1]The peculiar case of China can be explained by the Cultural Revolution, which forced from the mid-1960s to the mid-1970s many urbanites to live in rural areas (Liang 2001), but also by changes in the official urban definition (United Nations 2002, p18 & 21).

2.2 Evidence of overestimation in the projection of the proportion urban

We have seen the urbanisation trends in the second half of the 20th century. Do the UN projections observe the same trends or do they depart significantly from the empirical, historical observations? The easiest way to confirm the latter is to observe the trends formed by the dotted lines on Figures 1 to 5 for the period 1990-2030. For ease of interpretation and in order to better show the effect of the UN model of projection, we added the regression result that was used to fit and to project the value of rur.

Although the graphs show data grouped by world regions, whereas the UN estimation and projections were done country by country, it is clear that this method of projection has the effect of:

- Reversing the downward trend for those regions which fell below the regression line in 1995. This is particularly visible for developing Oceania and European regions (Figure 4 and 5), but also for other regions like Middle Africa (Figure 1) or South-Central Asia (Figure 3). In these regions, the rur sort of 'bounced' to reach the level of the regression line.
- For those regions which fell above the regression line in 1995, maintaining the rur at high level for some time before it joins the regression line.

Some other regions (South-Eastern Asia, Southern Africa, Central America and Australia-New Zealand) follow patterns that do not fit the above description, but generally, none of the trends for the projection period 1995-2030 follow the patterns of the estimation period 1950-1995, with the possible exceptions of Western Africa and Central America. The Figures make it clear that the UN projections are not prolonging historical trends. As expected – since the UN projection model applies uniformly to all countries –, all regions line up against the regression line in the vicinity of 2030.

What are the effects on the projected urbanisation level? The reversal of the downward trend and inflation of the rur have the effect of increasing urban growth mostly in developing countries, and maintaining urban growth at high level in developed countries. We then expect the projected proportion urban at the 2030 horizon to be largely overestimated. In other words, the UN method of projection is implicitly imposing a unique, historically dated, MDC-oriented model of urban transition on all countries of the world, leading to a systematic overestimation of the world urbanisation.

3. In search for an alternative model for projecting urbanisation

Our contention is that projections should be based on the history of urban transition and take account of the different levels of development across the world. It has been shown that there is a high correlation between the proportion urban and the level of development, measured either by gross domestic product (GDP) or by the human development index (HDI) (Davis and Henderson 2003; Njoh 2003; Woods 2003). Though the causal relationship between urbanisation and development is far from clear, an endogenous projection model should apply differently depending on the specific urban history of the country at stake and should not necessarily lead to a high proportion urban for all countries or regions of the world.

The theory of mobility transition initiated by W. Zelinsky (1971; 1983) offers an ideal type of a country which, starting from a low proportion urban and low urban growth, should go through a development process that leads to high urban growth. At the beginning of the mobility transition, urban growth is generally migration-driven whereas at its end the contribution of natural growth to the urban to rural growth differential is higher. At the end of the mobility transition, the country should reach a high proportion urban and low urban growth, as observed in the developed countries. Graphically, it means that the plot of the rur against the PU should form an inverted U-curve, starting at 0% or so and finishing maybe at 100%. The mobility transition theory recognised that each country might follow the urban transition at its own pace. This seems to be indeed the case, as some western countries took more than two centuries to reach their current level of urbanisation whereas some other countries experienced the same transition in less than 50 years.

However this theory, is not clear about the effect of the development process on the actual level of urbanisation that each country should reach at the end of the mobility transition. It is hypothesized that development as it is known in the Western world should expand to the rest of the world so that, at the end of the day, all countries should reach the same level of urbanisation, close to the level reached in the present MDC. On the contrary, the empirical evidence of the preceding section shows that the urban transition might follow different patterns according to the historical period it went through and to the level of economic development reached. In statistical terms, the curve formed by plotting rur against PU has different shapes. Not only the modal point of the curve varies a lot (reaching a maximum of 6% in Melanesia, for example), but also the proportion urban at which the rur seems to converge to zero is different.

We will call this point of convergence the urban saturation point for convenience. It represents the point where rural and urban areas are growing at the same pace. The term saturation as employed here does not mean it is an absorbing state where the country or region is trapped after rur eventually reaches zero. In the real world of urbanisation, cases of counterurbanisation (when rur is less than 0) and erratic variations around a focal point (when rur is alternatively greater and smaller than 0) are not uncommon. Our concept of urban saturation is meant here to identify a theoretical point of convergence of the urban transition process that can be different from one country to another and that could possibly correspond to the urban capacity of the economy, which can itself evolve over time.

In this section, we will start by giving the principal characteristics of a model for urban projection before proposing a new model of projection based on two key principles: historical perspective and country-based approach. We will then implement the model and show that it actually fits well the observed urbanisation process of most countries in the world and offers a quite reasonable alternative to the UN projections, even with imperfect data. Note that our empirical *model of urban transition* does not pretend to exhaust the complexity of Zelinsky's theoretical *model of mobility transition*, which is more comprehensive in its attempt to integrate the demographic transition theory. However, the model of urban transition can help testing the validity of some of the hypotheses of the model of mobility transition regarding the evolution of urbanisation.

3.1 Principle characteristics expected from a projection model for urbanisation

To follow a historical perspective on urban transition, an alternative model of projection based on macro-data should integrate two new factors: speed of urban transition and possible urban saturation, or even counterurbanisation as seen in some developed countries as early as in the 1970s (Champion 1989; 2000). The new models for projection should rely more on the past, empirically observed trends, and should keep the arbitrary choice to a minimum. The new projection model should be endogenous, i.e. based on the available data only, as the UN projection model is. Our objective here is not to offer a projection model with explanatory power, using a number of exogenous variables (such as GDP, HDI, etc.) that could explain the proportion urban and its trend, but to offer better projections using the known quantities only.

The model should take into account that projections do not necessarily converge toward an average behaviour. The model should allow each country or region to follow its own urban transition, leading to different level of urban saturation. A polynomial of second degree should ideally conform to the inverted-U shape historically observed up to 1995 in most countries and the projected rur^* will take the form:

$$rur^*_{i,t+5} = F(PU_{i,t}) = \beta_{i,0} + \beta_{i,1} * PU_{i,t} + \beta_{i,2} * PU^2_{i,t}.$$

As for the UN model, the projection will be conducted step by step, by five-year increment, the estimate for one projection period being used for the projection of the next. Before going into the details of the implementation of the polynomial model, we will explain why the excess total absolute increase in urban areas should be preferred to the rur for modelling.

3.2 The underlying mathematics of the urban transition process

The reader would have already noticed that the relation between the urban-rural growth difference (rur) and the proportion urban (PU) plays an important role in the UN projections. As noted in the UN report, the rur is a difference of rates. As such, it does not take account of the constraints imposed by the risk pool (the absolute number) in both urban and rural areas. Using intercensal rates seems perfectly sensible for interpolation because the census data represent observed boundaries and therefore the interpolation necessarily lies within the possible. For extrapolation, however, the rur, which depends largely if not mostly on migration flows, should ideally be constrained by the actual pool of the population in the origin and destination areas. As mentioned earlier, the solution found by the UN is to find by way of a regression a hypothetical urban-rural growth difference for the projection period ($hrur$). From our diagnosis this method appears inappropriate and our contention is that finding a better function for $hrur$ will not improve the projection, as long as the rur for all countries will be used as a basis for projection. Fitting the data country by country should give much better projections. But we also found that the projections improve when the difference of growth between urban and rural areas is measured in absolute terms rather than in relative terms. Instead of modelling the rur we will model the excess increase in urban areas, denoted xu:

$$xu_t = U_t - U_{t-1} * \left(\frac{U_t + R_t}{U_{t-1} + R_{t-1}} \right) = U_t - U_{t-1} * p_t \qquad (1)$$

where p_t is the total population growth rate and $U_{t-1} * p_t$ is the hypothetical absolute increase in urban areas if the urban areas were to grow at the same rate as the total population. We chose xu because of its close relation to rur, as demonstrated in the Appendix 1:

$$xu_t = rur_t * \left(\frac{U_{t-1} * R_{t-1}}{U_{t-1} + R_{t-1}} \right). \qquad (2)$$

This relation makes computation for projection easy. But the main reason for preferring xu over rur is its ability to control for population growth. Contrary to rur, which expresses a difference between growth rates, xu depends not only on this differential but also on the total population growth. When the total population grows less, the number of migrants from the sending area is also diminishing, thus reducing the potential growth of the receiving area (Keyfitz 1980; Rogers 1995). The use of xu can also be interpreted as a control of the capacity of the urban areas to absorb an excess increase in absolute terms. Our hypothesis is that urban infrastructures at large (housing, health, education, energy, services) cannot sustain high population growth, whatever the relative difference of growth between urban and rural area. The capacity of absorption of urban infrastructures grows at a slower rate than the population and constitutes a limit to urban growth that is not captured by the rur. The projection using xu will then be constrained by the overall population growth and therefore be dependent on (and sensitive to) the projection of the total population.

Instead of projecting the rur^* from a polynomial regression on PU:

$$rur^*_{i,t+5} = \beta_{i,0} + \beta_{i,1} * PU_{i,t} + \beta_{i,2} * PU^2_{i,t}$$

we will project xu^* from a polynomial regression on PU:

$$xu^*_{i,t+5} = rur^*_{i,t+5} * \left(\frac{U_t * R_t}{U_t + R_t}\right) = \beta_{i,0} + \beta_{i,1} * PU_{i,t} + \beta_{i,2} * PU^2_{i,t} \qquad (3)$$

for each country i in the interval $(t-1, t)$. The model is country-specific (the three parameters β_0, β_1 and β_2 are computed for each country i), historically-based and makes a minimum assumption about the form of the relation (a polynomial function of second degree) between known quantities (rur and PU). Note that when the theoretical urban transition model applies and gives an inverted-U shape to rur against PU, then simple properties of the polynomial function are that the parameter β_2 should be negative and that a maximum excess increase exists at $PU_t = -\beta_1/(2 * \beta_2)$. Also, when PU increases (to the limit of 100%), the excess increase xu should converge to zero at the saturation point $PU_{max} = (-\beta_1 + \sqrt{\beta_1^2 - 4\beta_2\beta_0})/2\beta_2$. If PU_{max} is actually greater than 100% (a rare case), then the population becomes totally urban when $xu \Rightarrow \beta_0 + \beta_1 + \beta_2$.

3.3 Model implementation

As the UN data are based on National Definitions of urban areas, their quality is subjected to variations within countries (historical variations) and between countries (geographical variations). In particular definitions for early years (1950s or 1960s) are often not consistent with the latest definitions used. In that case national trends are better fitted using the most recent estimations. In other instances, UN estimations for the most recent periods show inconsistencies as some countries did not provide for any valuable estimation of their urban population for the last observation dates (1990, 1985 or even 1980) thus leading the UN to supplement with their own estimates. However, these estimates are based on the method of projection criticised above and can lead to biased results. To avoid any bias introduced by the UN method of projection, we will only take into consideration the UN estimations up to the time of the most recent data available at the country level, as mentioned in the UN report annex. Therefore, the estimation period will vary depending on the data availability of each country or territory[2]. However, we made no attempt to

[2]In this paper, and for ease of presentation, the term 'country' includes territories (very often islands) that are not necessarily politically independent but for which the UN gathered specific data on urbanisation. The word country in this paper implies no judgment about the legal or other status of a territory.

harmonise the definition of urban areas, neither historically nor geographically.

Despite the definitional problem and contrary to our initial belief, the polynomial model works much better than expected at the country level. Our fear was that by using a country-specific model we would end up with a lot more inconsistencies due to the varying quality of the data. If it were so, we would have to resort to a region-based model, e.g. by grouping countries in homogenous area of development. Instead, most countries follow a typical inverted U-curve as hypothesized at the beginning of this study from the mobility transition theory. By fitting the excess total increase in urban areas, xu, instead of the rur, the polynomial form imposed in the model produces much better fit of historical trends than expected[3].

The procedure to come out with the best possible fit and projection is as follows:

1. Fit the polynomial model on all countries for the estimation period, i.e. from 1950 to the latest date when an estimate is available on the basis of available national data – the estimation period varies from one country to the other.
2. Compute the projected urban population and other necessary indicators for the next five-year interval.
3. Compute the same for the next five-year interval using previous projections up to 2030, excluding countries that reach 100% urban by projection.
4. Identify the outliers, i.e. the countries for which the parameter β_2 in the model is positive (U-curve instead of the expected inverted U-curve).
5. Examine the pattern of urban growth for the identified outliers and identify the possible country-specific (historical) outliers in the estimation of urban population. This is easily done by identifying the early periods' estimations (generally in the 1950s and 1960s) that influence most the unexpected fit, although some bad fit can also be caused by recent estimation (e.g. for the 1990s or even the 1980s). The earlier estimates, e.g. for the 1950s or the 1960s, are retained for computation even if they are not based on national data, so long as the country is not an outlier.
6. Fit the polynomial model on all countries for the estimation period, after excluding some observation points for the countries identified as outliers.
7. Do again step 1 to 6 until all possibilities of exclusion of country-specific observations are explored.

Countries where all the population is urban at the end of the observation period are excluded from the projection exercise: Hong Kong, Macao, Singapore, Gibraltar, Holy

[3]Computations were made using the Stata 8.0 program $xtreg$ with random effect (re option) and the country as the group variable ($i(country)$ option). Specific models were run on Nigeria and Aruba. For all other countries, the final model R^2 (measuring the percentage of the variance explained) is 83.45% and the Wald Chi^2 with 632 degree of freedom is 28349.48 ($p < 0.0001$). These statistics show that the model fits very well the data. The model on rur gave results close to the model on xu, but with slightly more outliers and a less satisfactory fit ($R^2 = 67.41\%, p < 0.0001$).

See (Vatican), Monaco, Anguilla, Cayman Islands, Bermuda, Nauru. These countries are all set on small territories or islands, with no possibility of extension, so that their urbanisation has reached an absorbing state, i.e. these countries are not supposed to gain rural population at a later stage. Only three small countries or territories, all situated in Polynesia, were 0% urban in 1950-2000: Pitcairn (population< 100 inhabitants), Tokelau (< 1500), Wallis and Futuna Islands ($< 14,500$). Whether these few countries which did not so far gain any urban population should one day have an urban population is debatable but no model can be fit for those tiny countries.

The Figure 6 illustrates for some countries – Sweden, Mexico, India, and China – how the polynomial model fits the historical trend (from left to right). The polynomial model adjusts the xu against PU but the results are presented here as rur versus PU to facilitate comparison between countries. The Figure also illustrates that the trend projected by the UN model (dotted curve) greatly departs from the trend projected by our model.

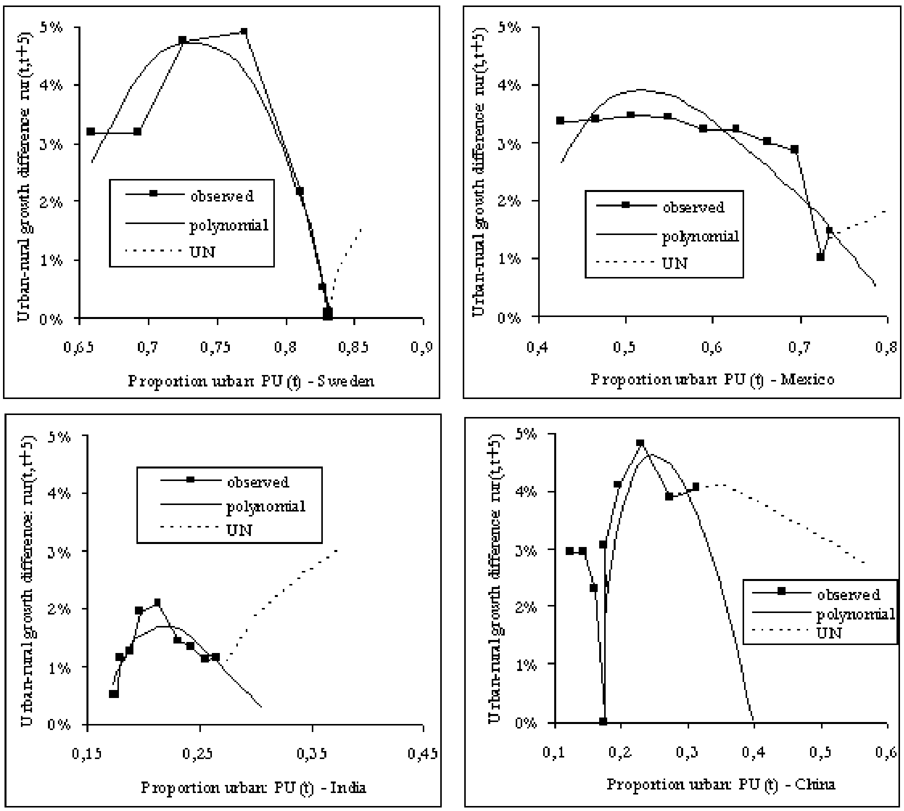
3.4 Corrections imposed on outliers

The Appendix 2 shows the importance of outliers identified after running the polynomial model. In this Appendix, the great outlying countries, for which we had to find specific solutions, are indicated. Other outliers were more easily dealt with and are also listed in the Appendix 2 along with the solution found to integrate them in the general model. We were not able to find any adjusting solution for only one small Caribbean island, Barbados (less than 270,000 inhabitants in 2000). For this country, we simply replicated the level of urbanisation attained in 1990, the year of the latest estimate, as the proportion urban did not vary much before.

Two cases are worth mentioning here. We had to run a specific model for Nigeria. In this country, hardly any data is available, except two unreliable censuses (1963 and 1991), to support any valuable projection on urbanisation. The projection using the standard polynomial model on xu proved unrealistic (leading to exponential urban growth from 2010: the proportion urban would reach about 80% in 2030 and would still increase after), because the population growth is probably overestimated for the whole country. Using rur proved more realistic, but the projections thus obtained should not be taken as very reliable either and are reported in the tables for the sake of offering a reasonable estimate for West Africa and for Africa as a whole. Another exception is Aruba Island in the Caribbean for which we run a simple regression model of xu on PU, without the PU^2 component. Again, the projection should not be considered as very reliable for this country.

Other special corrections include correcting the population urban in Kenya and in Senegal. In Kenya, the proportion urban was grossly overestimated to 34.8% in the 1999 Census report and does not reflect the existing core urban population but the local au-

Figure 6: Urban-Rural Growth Difference (Observed, Polynomial Model and UN Model) versus Proportion Urban for Sweden, Mexico, India and China



thorities instead, i.e. with no consideration of the size of the towns and of their limits. This undocumented change of definition led the UN to increase the estimates of the level of urbanisation at earlier dates (1995, 1990 and even 1985). Our correction for Kenya consisted in estimating the level of urbanisation in 1990 as per the published 1989 Census results and in discarding the UN estimates for 1995 and 2000. For Senegal, we used the latest 2002 Census results (not considered in the UN report) to estimate the level of urbanisation in 1990, 1995 and 2000, as the previous census was done long ago in 1987.

A last special case is with Colombia. In this country, the estimates for 1980 and 1985 looked inconsistent with the historical trend before 1980 and after 1985. We simply deleted those two observation points and found projections more compatible with the estimates for the years 1990 to 2000.

We had to adjust the model for 64 (i.e. 28%) out of 228 countries or territories of the UN database. The adjusted countries represent 43.2% of the world population en 2000 and China alone 21.0%. The adjustments were important in Southern Africa (affecting the estimates for 94% of the population of this region), Eastern Asia (86%, representing China only), South Eastern Asia (77%), Western Africa (73%), Western Asia (62%), Western Europe (54%), Eastern Africa (36%) and Micronesia (32%). Two third of the adjustments (representing 30.8% of the world population) involved the removal of some early estimation of urbanisation, mostly the 1950s and 1960s estimates, i.e. applying the polynomial model on the most recent data. These corrections originate in absence of national data (i.e. estimation by the UN), poor quality of national data or in changes of definition of urban areas. The adjustments consisted for the remaining one third of correction cases (representing 12.4% of the world population) in removing the latest estimations that appeared inconsistent with historical trends. This is where the adjustments are the most debatable. We would of course prefer to use recent estimates as they are supposed to reflect better the current level of urbanisation. However the latest estimates are subjected to definitional changes as much as the earliest estimates. Kenya is a good example where a change of definition led to an unexpectedly high growth in urban areas. Because the author happened to live in Kenya at the time of writing, he was able to identify the definitional problem and make the necessary corrections. But certainly similar problems may arise for other countries identified as outliers, though it is not in the capacity of the author to document them all. For ease of interpretation of the results, the Appendix 2 is offering a correction score attached to the estimates depending on the extent of the corrections made on each outlier (score 1 for mild correction to score 5 for severe correction). A detailed examination of the countries identified as outliers is needed to produce better projection estimates in the future.

Despite a number of outliers, and after some adjustment, the polynomial model fits quite well 89.5% of all countries, representing 87.6% of the world population, if we include in those figures the countries with minor corrections (for which only the early estimates, from 1950 but no later than 1975, were removed), i.e. excluding the serious outliers with a correction score greater than 2 (see Appendix 2). Despite the variety of the definition of urban areas across countries and its occasional change over time in some countries, the results are certainly confirming the overall validity of the urban transition model for the estimation period. The complete urban projections up to 2030, by country and by regions, are available on the website http://www.demographic-research.org/, under the entry for publication 12-9 as an additional file in Excel format.

4. A comparison of the results obtained through the UN and the polynomial models of projection

To confirm the validity of the model for the projection period, one needs to wait until estimates are produced for the year 2000 and more on the basis of country data. However it is possible to anticipate on the validity of the model in two ways, following the method proposed by N. Keyfitz (1981):

- On past periods, by comparing the discrepancy measured by the Mean Percentage Error (MPE) between the projections of the urban population obtained from the polynomial model from truncated data (e.g. 1950-1980) and the urban population as estimated by the UN (in 2000, for a 20-years projection period). We can then compare the results with the performance of the UN model over the same period. To assess this performance, we rely on the estimate of the MPE computed by B. Cohen (2004) by comparison of the projection made in the 1980 UN report with the estimates for 2000 made in the 2001 UN report, for 169 countries. For the sake of comparison with Cohen's analyses, we also computed the Mean Absolute Percentage Error (MAPE) measuring the imprecision of the forecasts.
- On future period, by comparing the MPE of UN past projections with the Mean Percentage Difference (MPD) between UN future projections and the projections obtained from the polynomial model. If the UN model is overestimating the urban population in the same proportion for past and future forecasts and if the polynomial model better fits the historical trend, then the MPE and the MPD should give comparable results.

In both ways, we chose a long projection period (20 years) for comparison because the MPE and MPD might not show large discrepancies for shorter projection period. The Table 1 shows that the average performance of the polynomial model, with an MPE of only 1.1%, are quite good considering that no correction for outliers were conducted here and that the model is run on only seven observation points by country. However, the

MAPE is high (27.0%) showing more imprecision than the UN projections (20.6%)[4]. Removing 27 outliers (countries for which the projection of urban population was more than 1.5 times less or more than the estimation for the year 2000) improves considerably the precision, the estimate for the whole world becoming almost exact (MPE = 0.0%) with an imprecision divided by three (MAPE = 9.1%).

Table 1: Mean Percentage Error (MPE) and Mean Absolute Percentage Error (MAPE) in urban population polynomial projections by comparison with UN estimate for 2000 by level of development, size of the country and continent

Major Area or region	MPE 1980-2000 (20-year projection)	MAPE 1980-2000 (20-year projection)	Number of countries*
WORLD	-1.1 %	27.0 %	209
World after eliminating 27 outliers	0.0 %	9.1 %	182
More developed countries	0.4 %	6.0 %	54
Less developed countries	-1.4 %	32.1 %	155
LDC after eliminating 24 outliers	-0.2 %	10.4 %	131
Size of the country:			
0-2 million	2.1 %	26.8 %	76
2-10 million	5.8 %	19.1 %	59
10-50 million	14.9 %	27.9 %	54
50+ million	-6.2 %	27.3 %	20
Continent:			
Africa	-3.7 %	23.3 %	51
Africa after eliminating 8 outliers	-8.3 %	16.0 %	43
Asia	-1.8 %	36.4 %	45
Asia after eliminating 6 outliers	2.3 %	9.1 %	39
Europe	4.2 %	6.6 %	46
South America	4.3 %	8.6 %	41
North America	-6.3 %	6.3 %	5
Oceania	-4.0 %	4.6 %	21

Source: our own computation by comparison of the projections obtained by the polynomial model with the UN estimation for 2000. MPE and MAPE are weighted by population size in 2000. Outliers are defined here as countries for which the projection of urban population was more than 1.5 times less or more than the estimation for the year 2000.

* Countries 0% or 100% over the projection period are excluded from the computation.

[4] Part of this difference might be attributed to the choice of countries: Cohen used 169 countries "*whose boundaries have not change substantially*" over the period while we used the whole UN data set on 209 countries (there are 228 countries in the UN database but 19 were or became totally urban or totally rural over the period).

The fit is actually better for MDC (MPE = 0.4%, MAPE = 6.0%) than for LDC (MPE = -1.5%, MAPE = 32.1%). The error in the projection is attributed mainly to some LDC. Removing 24 outliers (including China and Indonesia, two big outliers) from the computation improves considerably the fit for LDC (MPE = -0.2%, MAPE = 10.4%). Africa and Asia show much higher variations (MAPE = 23.3% and 36.4% respectively) than other parts of the world (MAPE varying from 4.6% to 8.6%). Here again removing outliers improves the projections a lot (reducing the MAPE to 16.0% and 9.1% respectively for Africa and Asia). This is an indication that the quality of the data on urbanisation greatly affects the precision of the projections, a conclusion that converges with Cohen's analysis of the bias in UN projections (Cohen 2004, p47).

The performance of the UN model over the past period 1980-2000, as measured by Cohen, is compared in Table 3 to the MPD measuring the difference between the UN projections and the polynomial projections for the 1995-2015 period. The Table 2 contains the detailed MPD by region of the world while the Table 3 compares the MPE and the MPD by country size for the 20-year projection period. Note that Cohen computed the MPE using the 2000 estimates from the 2001 UN report, nicknamed " 'actual' data" in his paper, which are not totally based on country data since not all countries had data available for this date. Even the 2003 UN report considers the 1995 data to be mostly based on country data whereas the 2000 estimates are said to be a mix of estimates and projections. Therefore for our computation of MPD, we considered the UN projections to be based on data up to 1995: the 20-year projection is for 2015 and the 35 year projection is for 2030. The 20-year projection period seems more reasonable to compare Cohen's MPE and our own measure of MPD as the bias in measuring MPE will be minored by the difference due to the UN projection method.

The MPE is closer to zero in the polynomial projections (-1.1%, see Table 1) than it is in the UN projections (14.1%, see Table 3). The polynomial model would have performed much better on average than the UN model over the same period and using almost [5] the same data. Also, the polynomial projections do not appear so biased for the LDC (MPE = -1.4%), contrary to the UN projections, which are higher in low income countries (MPE = 23.1%), and in lower middle income countries (MPE = 6.9%, but 25.6% when excluding China) and in upper middle income countries (MPE = 12.8%), compared to 'only' 6% in high income countries (Cohen 2004, Table 4)[6].

If the polynomial model better fits the historical trend than the UN model, then the MPE for the past and MPD for the future should have comparable values, though the projections started from lower level of urbanisation in the case of MPE. The distribution of MPE and MPD are indeed strikingly similar for the 20-year projection period (Table 3).

[5] See note 4

[6] Cohen's results are not computed for each continent or region as defined in the UN report.

Table 2: Bias of UN model as measured by the Mean Percentage Difference (MPD) between the UN projections and the polynomial projections of urban population

Major area, region, country or area	2000	2015	2030
WORLD	2.2 %	14.9 %	34.5 %
WORLD excluding China	2.7 %	18.4 %	42.0 %
More developed regions	1.3 %	5.0 %	10.5 %
Less developed regions	2.6 %	23.2 %	51.0 %
Less developed regions excluding China	3.3 %	22.6 %	50.7 %
AFRICA	9.1 %	28.5 %	52.6 %
Eastern Africa	17.3 %	49.4 %	81.6 %
Middle Africa	6.9 %	33.2 %	66.0 %
Northern Africa	7.3 %	19.2 %	36.8 %
Southern Africa	-0.2 %	14.0 %	29.0 %
Western Africa	4.4 %	12.8 %	28.0 %
ASIA	1.6 %	23.0 %	55.6 %
ASIA excluding China	1.3 %	11.1 %	33.7 %
Eastern Asia	0.4 %	22.1 %	46.4 %
Eastern Asia excluding China	-0.7 %	1.2 %	7.7 %
South-central Asia	1.0 %	11.7 %	38.7 %
South-eastern Asia	3.2 %	14.9 %	33.4 %
Western Africa	0.1 %	5.5 %	16.9 %
EUROPE	0.0 %	2.5 %	8.0 %
Eastern Europe	-0.6 %	0.9 %	7.0 %
Northern Europe	0.0 %	2.2 %	5.6 %
Southern Europe	0.5 %	5.5 %	14.6 %
Western Europe	0.7 %	2.9 %	5.7 %
LATIN AMERICA AND THE CARIBBEAN	0.9 %	2.8 %	4.9 %
Caribbean	7.1 %	15.2 %	26.4 %
Central America	1.1 %	4.8 %	11.3 %
South America	0.2 %	0.7 %	0.2 %
NORTHERN AMERICA	4.8 %	10.8 %	15.2 %
OCEANIA	1.3 %	7.1 %	20.4 %
Australia/New Zealand	1.4 %	4.6 %	5.4 %
Melanesia	1.0 %	13.7 %	56.5 %
Micronesia	3.5 %	16.4 %	27.8 %
Polynesia	-0.8 %	3.2 %	22.0 %
Less Developed Oceania	1.0 %	13.2 %	52.7 %

Source: our own computation by comparison of the UN projections and the polynomial regression model. MPD is weighted by projected population size.

Table 3: Bias of UN projections as measured by the Mean Percentage Error (MPE) and the Mean Percentage Difference (MPD) in urban population projections

Major Area or region	MPE 1980-2000 (20-year projection)	MPD 1995-2015 (20-year projection)	MPD 1995-2030 (35-year projection)
WORLD	14.1 %	14.9 %	34.5 %
WORLD exluding China	19.0 %	18.4 %	42.0 %
Size of the country:			
0-2 million	7.4 %	10.4 %	33.8 %
2-10 million	12.0 %	11.8 %	22.0 %
10-50 million	21.6 %	22.3 %	42.2 %
50+ million	12.4 %	13.1 %	33.4 %
50+ million exluding China	18.9 %	17.7 %	43.5 %

Source MPE: Table 4, Cohen (2004). 20 years: comparison of projection in 1991 UN report with estimates for 2000 as per 2001 UN report (169 countries).
Source MPD: our own computation by comparison of the projections obtained by the UN model and by the polynomial regression model (228 countries).

MPE is weighted by population size in 2000 whereas MPD is weighted by projected population size.

The overestimation of the urban population by the UN over the 1980-2000 period seems to replicate almost identically for the 1995-2015 period, for all country size, and looks worse when we exclude China. The difference between the UN model and the polynomial model is very high for the whole of Africa and for Eastern Africa and Middle Africa in particular. The difference is also substantial in Eastern Asia (mainly because of China), in South-Central Asia and South-Eastern Asia, as well as in the Caribbean, Melanesia and Micronesia. All these regions are notoriously less developed, but the difference is also observed for more developed regions such as Northern America. The fact that the analysis of the bias of UN projection tallies very closely with the analysis of the difference between the UN projection and our own projection seems to indicate that the polynomial model is well suited for projecting the historical urban trends. But of course, only the future will tell if our projections were right.

Table 4 gives summary measures of urbanisation at the 2030 horizon using the UN and the polynomial model. The proportion urban would be 49.2% in the latter against 60.8% in the former, a difference of 11.6 percentage points. In absolute term, the difference in the projected urban population is 947 million. Developing countries account for 90.3% of this difference, Asia alone for 69.9% and Africa for 19.2%. Some Asian countries particularly contribute to the difference between the two estimations (detailed results not shown here): China (31.7%), India (22.4%), as well as other countries of the Indian sub-continent like Bangladesh (3.8%) and Pakistan (3.0%), and also Indonesia (3.1%). Among developed countries, United States of America are the main contributor to the difference in the world estimation (4.5%).

Obviously any projection will be sensitive to the estimation in these countries, which are also among the most populous in the world. Because they concentrate a large share of the world population, China (1.28 billion inhabitants in 2000, 1.45 projected in 2030) and India (1.02 billion in 2000, 1.42 in 2030) are of particular concern regarding urbanization. In the case of China, the Cultural Revolution led to a sharp slow-down in the late 1960s followed by a sharp rise in the urban growth in the late 1970s (Liang 2001). However our projections, which discarded the data prior to 1970, predict that the urban growth should start to decline at the end of the 20th century and that the proportion urban in China should stabilize at less than 40% from 2030. This departs largely from the UN projections predicting figures of 35.8% in 2000 and 60.5% in 2030, as illustrated in Figure 6. In our projection, the stabilization of the proportion urban at what would seem a low level is partly due to the definition of urban areas. China is using a very high threshold (100,000 inhabitants) combined with population density criteria together with a complex functionalist definition of smaller urban agglomeration using various criteria (majority of non-agriculture activities, percentage use of water, industrial output, GDP, etc.). To add on the difficulty, these criteria evolved significantly since the 1980s (Zhu 2003). The UN series up to 1995 seems to be consistent with the 1990 definition. The last, more internationally accepted change of definition was implemented in 2000 with the effect of increasing by about 6 points the level of urbanization, estimated at 36.1% in 2000, as compared to 30.9% in 1999. Using an even more standard definition of urban areas (e.g. agglomerations of 10,000 inhabitants or more) would obviously lead to a much higher level of urbanization, maybe adding up 10 percentage points to the figures published with the 1990 definition, which would make China 50% urban by the year 2030 according to our projection trends (instead of 40% using the 1990 definition).

One has to bear in mind that both UN and polynomial projections are made according to the definition used in each country. The projections are then not strictly comparable for all countries. Part of the overestimation by the UN projections originates in applying a regression model on urbanization data that are not based on a standard definition of urban areas. By so doing, the UN regression model is imposing an average definition of urban areas on all countries. Applying this model on China can only lead to overestimation in the projection period, whatever the historical trend of this country, simply because its urban definition makes the estimation in China for the 1950-1995 period lower than the world average. Our polynomial model, because it is country-specific, controls for the between-countries definitional problem. In the case of China, our projections follow the 1990 definition. At an aggregated level (for Eastern Asia and for the whole world), the estimation of urban population will be pulled downward by China with this old definition. One would need computing the series with the new 2000 definition to get better historical

Table 4: Comparison of the UN model and the polynomial model (P) for urbanisation projections at the 2030 horizon

Major area	Proportion Urban			Relative Difference in Urban Population	Absolute Difference in Urban Population	Percentage Difference in Urban Population	Urban-Rural Growth Difference (2025-2030)	
	UN	P	P-UN				UN	P
World	60.8 %	49.2 %	-11.6 %	-19.1 %	-946,841	100.0 %	2.08 %	0.13 %
More developed regions	81.7 %	74.3 %	-7.4 %	-9.1 %	-92,123	9.7 %	1.93 %	0.16 %
Less developed regions	57.1 %	44.6 %	-12.4 %	-21.7 %	-854,718	90.3 %	2.32 %	0.29 %
AFRICA	53.5 %	40.5 %	-13.0 %	-24.3 %	-181,432	19.2 %	2.31 %	0.45 %
Eastern Africa	41.0 %	27.2 %	-13.7 %	-33.5 %	-63,456	6.7 %	2.52 %	0.85 %
Middle Africa	54.4 %	34.1 %	-20.3 %	-37.4 %	-38,860	4.1 %	2.80 %	-0.02 %
Northern Africa	63.4 %	50.5 %	-12.8 %	-20.2 %	-34,272	3.6 %	2.43 %	0.33%
Southern Africa	67.0 %	52.3 %	-14.7 %	-21.9 %	-7,149	0.8 %	2.23 %	0.09 %
West Africa	58.9 %	50.1 %	-8.8 %	-14.9 %	-37,695	4.0 %	2.41 %	0.83 %
ASIA	54.5 %	41.0 %	-13.5 %	-24.9 %	-662,080	69.9 %	2.49 %	0.20 %
Eastern Asia	62.6 %	44.0 %	-18.7 %	-29.8 %	-309,725	32.7 %	2.58 %	0.00 %
South-central Asia	43.7 %	32.8 %	-11.0 %	-25.1 %	-240,483	25.4 %	2.93 %	0.35 %
South-eastern Asia	60.7 %	48.5 %	-12.2 %	-20.2 %	-87,108	9.2 %	2.56 %	0.54 %
Western Asia	72.3 %	64.7 %	-7.7 %	-10.6 %	-24,764	2.6 %	1.58 %	-0.17 %
EUROPE	79.6 %	74.3 %	-5.3 %	-6.6 %	-36,182	3.8 %	1.84 %	0.21 %
Eastern Europe	74.3 %	69.6 %	-4.7 %	-6.3 %	-12,145	1.3 %	1.69 %	0.01 %
Northern Europe	87.7 %	83.5%	-4.3 %	-4.9 %	-4,260	0.4 %	1.71 %	0.11 %
Southern Europe	74.1 %	65.4 %	-8.7 %	-11.7 %	-12,026	1.3 %	2.03 %	0.01 %
Western Europe	86.4 %	82.3 %	-4.1 %	-4.7 %	-7,752	0.8 %	1.68 %	0.43 %
LATIN AMERICA and CARIBBEAN	84.6 %	82.1 %	-2.0 %	-3.0 %	-17,976	1.9 %	1.67 %	1.08 %
Caribbean	73.3 %	60.4 %	-12.9 %	-17.6 %	-5,857	0.6 %	1.87 %	-0.06 %
Central America	77.5 %	70.9 %	-6.6 %	-8.5 %	-12,730	1.3 %	1.82 %	0.21 %
South America	88.6 %	88.8 %	0.1 %	0.1 %	611	-0.1 %	1.60 %	2.13 %
NORTHERN AMERICA	86.9 %	75.4 %	-11.4 %	-13.2 %	-46,611	4.9 %	1.70 %	-0.01 %
OCEANIA	74.9 %	68.7 %	-6.2 %	-8.2 %	-2,560	0.3 %	0.48 %	-0.50 %
Australia/New Zealand	94.9 %	90.0 %	-4.9 %	-5.1 %	-1,375	0.1 %	1.45 %	0.35 %
Melanesia	27.2 %	18.2 %	-9.0 %	-33.2 %	-1,046	0.1 %	2.65 %	-0.24 %
Micronesia	81.2 %	70.0 %	-11.2 %	-13.8 %	-84	0.0 %	1.85 %	0.09 %
Polynesia	55.0 %	48.4 %	-6.5 %	-11.9 %	-55	0.0 %	2.36 %	0.34 %
Less Developed Oceania	32.0 %	23.0 %	-9.0 %	-28.1 %	-1,184	0.1 %	2.27 %	-0.18 %

Source: our own computation by comparison of the UN projections and the polynomial regression model. MPD is weighted by projected population size.

estimates and projections for China and Asia as a whole.

We don't expect the same definitional problem with India because this country uses a much lower threshold (5,000 inhabitants), together with a functionalist approach (administrative centers, non-agricultural activities). According to our projections (illustrated in Figure 6), the level of urbanization in India would hardly reach 31% in 2030. This compares with 41.4% in the UN projection for 2030 but with persistent growth after this date. Here the difference in estimation is mainly attributed to the difference in modeling.

If the polynomial model proved right, the majority of the developing world would not live in urban areas by 2030. The population would stay predominantly rural in Africa and in Asia (Table 4). Even more importantly, the potential for future urban growth is very much reduced in the projections based on the polynomial model. As an indication of this potential, the urban-rural growth difference (rur) for the period 2025-2030 is reported in Table 4. In the UN projections the rur ranges in each region between 1.5% and 3% whereas in the polynomial projections the rur hovers around 0% and exceeds 2% only in South America, while it is sometimes negative (as in Western Asia and Melanesia), indicating reverse urbanisation.

The UN methodology used for projection inevitably forecasts that the proportion urban would one day reach 100%. On the contrary, the polynomial model indicates that urban saturation could be attained not long after 2030. Therefore, there is a huge discrepancy between the UN projections and our projections based on the historical patterns of urban transition. According to the polynomial model, very few countries would still have in 2030 a high potential for urban growth. The Table 5 indicates the most populous countries (with 50 million inhabitants or more in 2030) which would still have a high rur (more than 0.5% a year in the 2025-2030 period). Quality of the projections notwithstanding (six of them were subjected to special corrections before projections, see Appendix 2), those large, mostly developing countries[7] representing 18.8% of the world population in 2030 would account for 38.1% of the urban population increase between 2025 and 2030. India with a rur of only 0.26% a year would account for 12.3% of the world urban population increase. To summarize, ten developing countries would contribute to more than half of the world urban population increase in the 2025-2030 period. Many of the remaining countries would have reached their urban saturation level, contributing marginally to the world urban growth after 2030.

5. Conclusions: improving projection models

It is clear from our analysis that the UN projections are biased and lead to a gross overestimation of urbanization trends. Contrary to the common belief, the UN projections are

[7] Germany is an exception, but its contribution to the world urban population increase is marginal.

Table 5: Ten largest countries (>50 million) still having a high urban growth potential (>0.5%) in the 2025-2030 period according to the polynomial model projections

Country	Projected population in 2030 ('000)	Projected Proportion Urban in 2030	Urban-Rural Growth Difference 2025-2030	Additional urban population 2025-2030
Indonesia[4]	227,567	57.2 %	1.02 %	7,630
Pakistan[1]	271,600	39.3 %	0.78 %	10,906
Brazil	222,078	92.3 %	3.44 %	8,126
Nigeria[1]	206,696	63.7 %	1.71 %	13,117
Mexico	133,591	79.2 %	0.53 %	3,519
Ethiopia	127,220	24.8 %	2.10 %	4,995
Islamic Republic of Iran[3]	94,441	76.6 %	2.40 %	4,710
Germany[3]	81,511	92.2 %	1.71 %	110
Colombia[1]	60,843	91.7 %	5.96 %	3,952
Republic of Korea	50,042	90.2 %	0.85 %	79
Total 10 countries	1,525,588	-	-	57,144
China	1,450,521	39.8 %	0.02 %	2,554
India	1,416,576	30.9 %	0.26 %	18,432
World	8,130,149	49.2 %	0.13 %	149,974

Note: Countries subjected to corrections in the polynomial model are indicated by their correction score: 1 (mild correction), 3 (high correction), 4 (very high correction). The projections for those countries are therefore to be cautiously interpreted.

not based on the extrapolation of historical trends. We proved that this can be attributed mainly to an inappropriate projection model that systematically biases the urban estimates upward, and also to the quality of the available data. The fairly simple polynomial model that we propose here as an alternative captures most of the historical trends (as reported by the UN) and projects them well in the future, country by country. We hope that the results presented here will extend the debate and that other models will be proposed to the users of world urban population projections. In particular, we should compare the results of the projections using the UN data with the multiregional projections obtained using more complex models (Rogers 1995) capable of offering better results albeit with more detailed data. Meanwhile, the polynomial model of urban transition has limitations that should be taken into account to refine the projections:

- Our projections are based on the World Urbanization Prospects published by the UN, with estimates of the urban and total population by 5-year intervals from 1950. In reality, censuses are not always available from that date and are rarely conducted every five years and our model is therefore partly based on interpolations. It would be better to use – and not more difficult to implement – the original estimation points from census data or other sources.

- Results show that the information on urbanisation is better used at a country level than at a sub-regional level or continental level. An improvement would be to work at a sub-country level for such countries as China, India, etc., where there are huge discrepancies between provinces or States.
- Particular effort should be devoted at finding better estimations for the countries for which we had to make specific corrections. In these countries the problem is more with the data that form the base for projection than with the model itself.
- International comparisons become difficult when countries are using very different urban definitions. Coordination is needed to evaluate the population in urban areas according to an internationally recognised definition. An alternative to the projection of the overall urban population would be the projection of the urban population above high thresholds (e.g. agglomerations of more than 20,000, 50,000, 100,000 or 500,000 inhabitants) that could easily be computed using a list of towns and cities ranked by size in each country. A model relating the estimates obtained at each threshold could then be used to evaluate a standard urbanisation rate at a lower threshold (e.g. 10,000 inhabitants).

To improve the projections, it is however clear that the available data set is not satisfactory. As earlier recommended by an international panel of scientists (National Research Council 2003), considering the importance of urban projections for demographers and geographers, and also for other scientists and policy makers, the UN's Population Division would give everyone a great service in making the original data set available to the public so that projections and data from each country are put under the scrutiny they deserve by the scientific community.

Whatever the alternative model based on historical trends, the expected results will change the perception that we have of urbanisation and of its relation to development. The urban population could be as much as one billion less than expected and the world might not, after all, become predominantly urban. From our projections, it would appear that in a foreseeable future the level of urbanisation will probably be much more heterogeneous than previously thought. Whether this is good or bad news depends on the perspective than one has on development. If the correlation between on one hand urbanisation and on the other hand GDP, HDI, poverty index or other social and economic development indicators is confirmed, then the tentative urban projections presented here reflect the persistence of poverty and of great economic inequalities over the world. Our projections also call for the revision of the projection of the global population as the reduction of mortality and fertility – the speed of the demographic transition is often attributed to the influence of the urban way of life – might not be so important. The projections of urban population have great consequences on environmental policies too. In a less urbanised world, the developed countries would still be responsible for most of the greenhouse gas emission while most of the natural resources would remain in the developing world.

6. Acknowledgements

This work was initiated while the author was a visiting scholar at the African Population and Health Research Center (APHRC) in Nairobi, Kenya. A preliminary version of the paper was presented at the occasion of seminars at APHRC, at UNCHS-Habitat headquarters as well as at Développement, Inégalités et Analyse de Long terme (DIAL), the author's research unit in Paris. The author would like to thank all members of these institutions as well as the anonymous referees for their useful comments and suggestions. The usual disclaim applies.

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Appendix I

The relation between the Urban-Rural Growth Difference (rur) and the Excess Increase in Urban Areas (xu)

Andrei Rogers (1995) noted that the urban-rural growth difference can be expressed using the migration and natural increases in urban and rural areas: [8]

$$rur_t = u_t - r_t = (n_u - m_{u,r} + \frac{R_{t-1}}{U_{t-1}} * m_{r,u}) - (n_r - m_{r,u} + -\frac{U_{t-1}}{R_{t-1}} * m_{u,r}) \quad (1)$$

where all rates are computed in term of the population at time $t-1$:
natural rate in the urban population:

$$n_u = \frac{N_u}{U_{t-1}}$$

natural rate in the rural population:

$$n_r = \frac{N_r}{R_{t-1}}$$

migration rate from urban to rural areas, expressed per urban resident:

$$m_{u,r} = \frac{M_{u,r}}{U_{t-1}}$$

migration rate from rural to urban areas, expressed per rural resident:

$$m_{r,u} = \frac{M_{r,u}}{R_{t-1}}$$

where N and M stand respectively for the natural and the migration increase.

Separating in equation (1) the natural rates from the migration rates and expanding gives:

$$\begin{aligned} rur_t &= \left[\frac{N_u}{U_{t-1}} - \frac{N_r}{R_{t-1}}\right] + \left[\frac{M_{r,u}}{R_{t-1}}\left(\frac{R_{t-1}}{U_{t-1}} + 1\right) - \frac{M_{u,r}}{U_{t-1}}\left(\frac{U_{t-1}}{R_{t-1}} + 1\right)\right] \\ &= \left[\frac{N_u}{U_{t-1}} - \frac{N_r}{R_{t-1}}\right] + \left[M_{r,u} * \frac{U_{t-1} + R_{t-1}}{U_{t-1} * R_{t-1}} - M_{u,r} * \frac{U_{t-1} + R_{t-1}}{U_{t-1} * R_{t-1}}\right] \end{aligned}$$

[8] For convenience of demonstration, we will consider a one-year interval. The demonstration can easily be extended to five-year intervals.

In this last expression of rur, one notices that apart from the natural and migration increases, the right-hand side of the equation makes a repeated use of the population urban and rural known from the preceding period $t-1$. It is actually possible to simplify the equation by extracting from the righ-hand side the term $\frac{U_{t-1}+R_{t-1}}{U_{t-1}*R_{t-1}}$:

$$\begin{aligned} rur_t &= \left(\frac{U_{t-1}+R_{t-1}}{U_{t-1}*R_{t-1}}\right) + \left[\left(\frac{R_{t-1}}{U_{t-1}+R_{t-1}}\right) * N_u - \right. \\ &\quad \left. - \left(\frac{U_{t-1}}{U_{t-1}+R_{t-1}}\right) * N_r + M_{r,u} - M_{u,r}\right] \\ rur_t &= \left(\frac{U_{t-1}+R_{t-1}}{U_{t-1}*R_{t-1}}\right) + \\ &\quad + \left[N_u - \left(\frac{U_{t-1}}{U_{t-1}+R_{t-1}}\right) * (N_r + N_u) + M_{r,u} - M_{u,r}\right] \end{aligned} \tag{2}$$

By noticing that $\left(\frac{U_{t-1}}{U_{t-1}+R_{t-1}}\right) * (N_r + N_u)$ is simply the theoretical natural increase in urban areas if urban areas were to grow at the same natural rate than the total population, we can rearrange equation (2) so that:

$$rur_t * \left(\frac{U_{t-1}*R_{t-1}}{U_{t-1}+R_{t-1}}\right) = N_u - \left(\frac{U_{t-1}}{U_{t-1}+R_{t-1}}\right) * (N_r + N_u) + M_{r,u} - M_{u,r} \tag{3}$$

which is to be interpreted as, in the interval $(t-1, t)$:

excess increase in $U =$ excess natural increase in $U +$ excess migration increase in U

The left-hand side of equation (3) now contains only known quantities based on the population estimates in urban and rural areas, whereas the right – hand side now contains unknown (to the urbanisation database) quantities – natural and migration balances.

We can verify that the left-hand side of equation (3) represents well the excess increase in urban areas by remembering that:

$$rur_t = u_t - r_t = \frac{U_t - U_{t-1}}{U_{t-1}} - \frac{R_t - R_{t-1}}{R_{t-1}}$$

and rearranging from equation (3):

$$\begin{aligned}
rur_t * \left(\frac{U_{t-1} * R_{t-1}}{U_{t-1} + R_{t-1}}\right) &= \left(\frac{U_t - U_{t-1}}{U_{t-1}} - \frac{R_t - R_{t-1}}{R_{t-1}}\right) * \left(\frac{U_{t-1} * R_{t-1}}{U_{t-1} + R_{t-1}}\right) \\
&= (U_t * R_{t-1} - R_t * U_{t-1}) * \left(\frac{1}{U_{t-1} + R_{t-1}}\right) \\
&= \frac{U_t * (U_{t-1} + R_{t-1}) - U_{t-1} * (U_t + R_t)}{U_{t-1} + R_{t-1}}
\end{aligned}$$

we finally obtain the excess total increase in urban areas xu:

$$xu_t = rur_t * \left(\frac{U_{t-1} * R_{t-1}}{U_{t-1} + R_{t-1}}\right) = U_t - U_{t-1} * \frac{U_t + R_t}{U_{t-1} + R_{t-1}} = U_t - U_{t-1} * p_t \quad (4)$$

where p_t is the total growth rate of the population and $U_{t-1} * p_t$ the hypothetical absolute increase in urban areas if the urban areas where to grow at the same rate as the total population.

Appendix II: Outliers by Region, Percentage in the World Population and Corrections score

UN country code	Country or region name	Nb of countries	Population 2000	Nb 0%/100% urban	percent 0% 100% urban	Pop 100% urban	% 100% urban (pop.)	Nb of outliers	Percent outliers	Population outliers	% outliers in the population	% serious outliers (correction score>2)	year begin (median)	year end (median)	Specific correction	Correction score
900	WORLD	228	6 070 581	19	8,3%	13 463	0,2%	64	28.1%	2 625 147	43,2%	12,4%	1950	1995	6	
901	More developed regions	55	1 193 872	5	9,1%	168	0,0%	7	12.7%	123 945	10,4%	8,5%	1950	2000	0	
902	Less developed regions	173	4 876 709	14	8,1%	13 295	0,3%	57	32.9%	2 501 202	51,3%	13,4%	1950	1995	6	
903	AFRICA	56	795 671	2	3,6%	1 389	0,2%	20	35.7%	347 915	43,7%	29,1%	1950	1995	3	
910	Eastern Africa	18	252 515	2	11,1%	1 389	0,5%	5	27.8%	90 111	35,7%	25,9%	1950	1993	1	
174	Comoros		705					1		705			1970	1995	0	1
404	Kenya		30 549					1		30 549			1950	1990	1	4
454	Malawi		11 370					1		11 370			1980	2000	0	2
834	Tanzania (United Rep. of)		34 837					1		34 837			1950	1990	0	3
716	Zimbabwe		12 650					1		12 650			1970	1995	0	1
911	Middle Africa	9	92 960	0	0,0%	0	0,0%	3	33.3%	14 100	15,2%	0,5%	1950	1990	0	
24	Angola		12 386					1		12 386			1950	1980	0	2
226	Equatorial Guinea		456					1		456			1950	1985	0	3
266	Gabon		1 258					1		1 258			1965	1995	0	1
912	Northern Africa	7	173 615	0	0,0%	0	0,0%	2	28.6%	30 530	17,6%	0,0%	1950	1995	0	
12	Algeria		30 245					1		30 245			1970	2000	0	1
732	Western Sahara		285					1		285			1970	1995	0	1
913	Southern Africa	5	50 448	0	0,0%	0	0,0%	3	60.0%	47 619	94,4%	3,8%	1960	2000	0	
72	Botswana		1 725					1		1 725			1975	2000	0	2
516	Namibia		1 894					1		1 894			1960	1990	0	4
710	South Africa		44 000					1		44 000			1965	2000	0	1
914	Western Africa	17	226 133	0	0,0%	0	0,0%	7	41.2%	165 556	73,2%	72,4%	1950	1995	2	
132	Cape Verde		436					1		436			1970	1990	0	1
288	Ghana		19 593					1		19 593			1950	1985	0	3
324	Guinea		8 117					1		8 117			1960	1995	0	4
624	Guinea-Bissau		1 367					1		1 367			1965	1995	0	1
466	Mali		11 904					1		11 904			1970	1985	0	4
566	Nigeria		114 746					1		114 746			1965	1990	1	1
686	Senegal		9 393					1		9 393			1970	2000	1	5

Appendix II (cont'd)

UN country code	Country or region name	Nb of countries	Population 2000	Nb 0%/100% urban	percent 0% 100% urban	Pop 100% urban	% 100% urban (pop.)	Nb of outliers	Percent outliers	Population outliers	% outliers in the population	% serious outliers (correction score>2)	year begin (median)	year end (median)	Specific correction	Correction score
900	WORLD	228	6 070 581	19	8,3%	13 463	0,2%	64	28.1%	2 625 147	43,2%	12,4%	1950	1995	6	
901	More developed regions	55	1 193 872	5	9,1%	168	0,0%	7	12.7%	123 945	10,4%	8,5%	1950	2000	0	
902	Less developed regions	173	4 876 709	14	8,1%	13 295	0,3%	57	32.9%	2 501 202	51,3%	13,4%	1950	1995	6	
935	ASIA	50	3 679 737	3	6,0%	11 273	0,3%	20	40.0%	2 042 001	55,5%	9,6%	1950	1995	0	
0	Asia without China	49	2 404 522	3	6,1%	11 273	0,5%	19	38.8%	766 786	31,9%	14,8%	1950	1995	0	
906	Eastern Asia	7	1 481 110	2	28,6%	7 257	0,5%	1	14.3%	1 275 215	86,1%	0,0%	1950	2000	0	
0	Eastern Asia w/o China	6	205 895	2	33,3%	7 257	3,5%	0	0.0%	0	0,0%	0,0%	1950	2000	0	
156	China		1 275 215					1		1 275 215			1970	2000	0	1
921	South-central Asia	14	1 486 049	0	0,0%	0	0,0%	6	42.9%	245 410	16,5%	6,6%	1950	1995	0	
64	Bhutan		2 063					1		2 063			1950	1970	0	4
364	Iran (Islamic Rep. of)		66 443					1		66 443			1950	1990	0	3
524	Nepal		23 518					1		23 518			1950	1990	0	3
586	Pakistan		142 654					1		142 654			1960	2000	0	1
762	Tajikistan		6 089					1		6 089			1970	1985	0	5
795	Turkmenistan		4 643					1		4 643			1970	1995	0	1
920	South-eastern Asia	11	520 355	1	9,1%	4 016	0,8%	6	54.5%	402 257	77,3%	45,1%	1960	1995	0	
116	Cambodia		13 147					1		13 147			1985	2000	0	1
626	Timor-Este (Dem. Rep.)		702					1		702			1960	1990	0	1
360	Indonesia		211 559					1		211 559			1965	1995	0	4
458	Malaysia		23 001					1		23 001			1965	1990	0	4
608	Philippines		75 711					1		75 711			1965	2000	0	1
704	Viet Nam		78 137					1		78 137			1975	2000	0	2
922	Western Asia	18	192 222	0	0,0%	0	0,0%	7	38.9%	119 119	62,0%	11,5%	1950	1995	0	
196	Cyprus		783					1		783			1960	1995	0	1
400	Jordan		5 035					1		5 035			1965	2000	0	1
414	Kuwait		2 247					1		2 247			1965	1995	0	1
512	Oman		2 609					1		2 609			1965	1995	0	1
682	Saudi Arabia		22 147					1		22 147			1950	1980	0	4
792	Turkey		68 281					1		68 281			1970	2000	0	1
887	Yemen		18 017					1		18 017			1975	1995	0	2

Appendix II (cont'd)

UN country code	Country or region name	Nb of countries	Population 2000	Nb 0%/100% urban	percent 0% 100% urban	Pop 100% urban	% 100% urban (pop.)	Nb of outliers	Percent outliers	Population outliers	% outliers in the population	% serious outliers (correction score>2)	year begin (median)	year end (median)	Specific correction	Correction score
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901	More developed regions	55	1 193 872	5	9,1%	168	0,0%	7	12.7%	123 945	10,4%	8,5%	1950	2000	0	
902	Less developed regions	173	4 876 709	14	8,1%	13 295	0,3%	57	32.9%	2 501 202	51,3%	13,4%	1950	1995	6	
908	EUROPE	47	727 986	4	8,5%	88	0,0%	7	14.9%	123 945	17,0%	13,9%	1950	2000	0	
923	Eastern Europe	10	304 538	0	0,0%	0	0,0%	1	10.0%	22 480	7,4%	0,0%	1950	2000	0	
642	Romania		22 480					1		22 480			1970	2000	0	1
924	Northern Europe	13	94 123	0	0,0%	0	0,0%	1	7,7%	74	0,1%	0,0%	1950	2000	0	
833	Isle of Man		74					1		74			1965	1990	0	1
925	Southern Europe	15	145 822	3	20,0%	55	0,0%	2	13,3%	3 179	2,2%	2,1%	1950	2000	0	
8	Albania		3 113					1		3 113			1960	1985	0	4
20	Andorra		66					1		66			1970	2000	0	1
926	Western Europe	9	183 502	1	11,1%	33	0,0%	3	33,3%	98 212	53,5%	53,5%	1950	2000	0	
276	Germany		82 282					1		82 282			1950	1985	0	3
438	Liechtenstein		33					1		33			1980	2000	0	4
528	Netherlands		15 898					1		15 898			1960	1995	0	4
904	LATIN AMERICA / CARIBBEAN	46	520 229	5	10,9%	605	0,1%	12	26.1%	110 246	21,2%	13,1%	1950	1995	3	
915	Caribbean	24	37 673	5	20,8%	605	1,6%	6	25.0%	10 076	26,7%	22,2%	1950	1995	2	
533	Aruba		93					1		93			1950	1985	1	3
44	Bahamas		303					1		303			1970	1990	0	1
52	Barbados		267					1		267			1950	1990	1	0
332	Haiti		8 005					1		8 005			1950	1980	0	4
670	Saint Vincent & Grenadines		118					1		118			1975	1995	0	2
780	Trinidad & Tobago		1 289					1		1 289			1970	1990	0	1
916	Central America	8	135 213	0	0,0%	0	0,0%	2	25.0%	17 631	13,0%	13,0%	1950	1998	0	
222	El Salvador		6 209					1		6 209			1950	1990	0	3
320	Guatemala		11 423					1		11 423			1950	1985	0	3
931	South America	14	347 343	0	0,0%	0	0,0%	4	28.6%	82 539	23,8%	12,1%	1950	2000	1	
32	Argentina		37 074					1		37 074			1965	2000	0	1
170	Colombia		42 120					1		42 120			1950	2000	1	1
238	Falkland Islands (Malvinas)		3					1		3			1970	1995	0	1
858	Uruguay		3 342					1		3 342			1980	2000	0	2

Appendix II (cont'd)

UN country code	Country or region name	Nb of countries	Population 2000	Nb 0%/100% urban	percent 0% 100% urban	Pop 100% urban	% 100% urban (pop.)	Nb of outliers	Percent outliers	Population outliers	% outliers in the population	% serious outliers (correction score>2)	year begin (median)	year end (median)	Specific correction	Correction score
900	WORLD	228	6 070 581	19	8,3%	13 463	0,2%	64	28.1%	2 625 147	43,2%	12,4%	1950	1995	6	
901	More developed regions	55	1 193 872	5	9,1%	168	0,0%	7	12.7%	123 945	10,4%	8,5%	1950	2000	0	
902	Less developed regions	173	4 876 709	14	8,1%	13 295	0,3%	57	32.9%	2 501 202	51,3%	13,4%	1950	1995	6	
905	NORTHERN AMERICA	5	315 915	1	20,0%	80	0,0%	0	0.0%	0	0,0%	0,0%	1950	2000	0	
909	OCEANIA	24	31 043	4	16,7%	28	0,1%	5	20.8%	1 040	3,3%	0,0%	1950	2000	0	
927	Australia/New Zealand	2	22 937	0	0,0%	0	0,0%	0	0.0%	0	0,0%	0,0%	1950	2003	0	
928	Melanesia	5	6 996	0	0,0%	0	0,0%	1	20.0%	814	11,6%	0,0%	1950	2000	0	
242	Fiji		814					1		814			1975	2000	0	2
954	Micronesia	7	499	1	14,3%	12	2,4%	2	28.6%	158	31,7%	0,0%	1950	1995	0	
584	Marshall Islands		51					1		51			1980	2000	0	2
583	Micronesia (Fed. States of)		107					1		107			1970	1995	0	1
957	Polynesia	10	611	3	30,0%	16	2,6%	2	20.0%	68	11,1%	0,0%	1950	2000	0	
16	American Samoa		58					1		58			1970	1990	0	1
798	Tuvalu		10					1		10			1980	1995	0	2

Notes: Countries 0% urban from 1950 are: Pitcairn (population $<$100 inhabitants), Tokelau ($<$1500), Wallis and Futuna Islands ($<$14500). Countries 100% urban in 1995 or before are: Hong Kong, Macao, Singapore, Gibraltar, Holy See (Vatican), Monaco, Anguilla, Cayman Islands, Bermuda, Nauru. Countries reaching 100% after 1995 are: Djibouti (2005), La Runion (2030), Gabon (2025), Guadeloupe (2005), Cook Islands (2025). Only the 64 countries for which a correction was made are listed above. Correction scores are: 1 for mild (removal of estimates $<$1970 for 30 countries), 2 for average (removal of estimates $<$1980 for 10 countries), 3 for high (removal of estimates $>$1985 for 9 countries), 4 very high (removal of estimates $>$1980 for Bhutan and Liechtenstein, or combination of 1 and 3, for 10 other countries), 5 for severe (removal of estimates $<$1970 and removal of estimates $>$1985 for Senegal and Tajikistan). In addition, specific corrections were conducted for some countries. For Colombia, the estimates for 1980 and 1985 were not used for the regression. For Kenya, the UN estimates for 1985 and 1990 were replaced by our own estimates based on the published 1979 and 1989 Census results. For Senegal, the UN estimates for 1990 to 2000 were replaced by our own estimates based on the published 1987 and 2002 Census results. For Aruba, a simple regression model (without PU^2) was used. For Nigeria, a regression on rur was used instead of the regression on xu. The author failed to find any specific corrections for the Barbados, where the 1990 proportion urban was simply replicated to subsequent dates.