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African Urbanization in Context: Analysis of Trends and New Projections

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Abstract

The paper aims at projecting urban growth from 2010 to 2050 using United Nations, World Urbanization Prospects data, 2007 Revision. A third order polynomial was used to model urban-rural growth difference from 1950 to 2005 country by country, then projections were drawn to 2050. The model was tested over the year 2000 using the 1950-1995 data, giving very good results (mean percentage error of only 0.6%, mean absolute percentage error of 2.6%). The results of the model are compared to UN projection on urban growth for the period 2010-2050. Using the third order polynomial model, the African urban population is projected to stagnate around its current level of 40%, with little variations by regions up to 2050, while the UN predicts 62%. The findings suggest that UN projections are excessively high.

Introduction

Urban projections are increasingly used by policy makers not only for urban planning purposes but also by economists and demographers as one of the parameters of long-term economic and population projection models. The UN Population Division provides bi-annually urban projections and these are routinely used by various agencies. However, several authors have questioned their validity against the observed historical urban trends (Cohen 2003; Bocquier 2005). National data sources that form the basis of the UN database are criticized, mainly for the data inconsistencies observed in developing countries and for the difficulty associated with the lack of comparable urban definitions (Hugo and Champion 2003). However, the lack of reliable, timely, and regularly collected data is not the main concern for projections. The UN model has not fit past trends well, and has overestimated future trends (National Research Council 2003; Cohen 2004) because it is based on the assumption of convergent transition to high level urbanization and on the use of an incorrect assumption of linearity of the transition process (Bocquier 2005). Conforming to the mobility transition theory (Zelinsky 1971), an alternative method has proved more effective in projecting urban trends at country level (Bocquier 2005, 2010).

This paper explores urban projections obtained for Africa in comparison with other regions of the developing world, using a variant of the alternative method of projections (Mukandila 2010) on recent UN data (WUP 2009). We will systematically compare our projections for Africa with those of the UN at country level as well as sub-regional level. Results for Africa will be compared to those for other part of the developed and developing world, and Latin America and the Caribbean in particular. Our results serve to test the hypothesis of the unequal urban development, which is necessary to explain the hierarchical structure of the world urban system. In so doing, the results may help in perfecting development planning.

Literature review

The United Nations Population Division provides the most comprehensive and widely used projections of urban growth at national level. UN generates data on urbanization by interpolation (starting from 1st July 1950 to the end estimation period, 1st July 2005) and extrapolation (from 2005 to 2050) based on a linear regression model projection, using available census data. The inter-census Urban-Rural Growth Difference, denoted rur at time $t+1$ in UN documents is calculated by:

$$rur(t+1) = u(t+1) - r(t+1) \qquad (1)$$

Where $u(t+1)$ and $r(t+1)$ are respectively urban and rural growth rate in the interval of time $[t, t+1[$ and are derived respectively from urban and rural population at the time between time t and time $t+1$.

The proportion urban (PU) is the fraction of the total population living in urban areas at a given time, expressed as percentage of the total. It can be derived at any time T between two censuses from urban-rural ratio as follow:

$$PU(T) = \frac{URR(T)}{1+URR(T)}$$

Where $URR(T)$ is the urban-rural ratio resulting from dividing the urban by the rural population and can be expressed as function of $rur(t+n)$:

$$URR(T) = URR_t * e^{rur(t+n)*(T-t)} \tag{2}$$

The UN regression model used for projection is a weighted average of prior estimation of rur and hypothetical urban-rural growth difference noted $hrur$. This $hrur$ is computed from a regression model of rur against PU for country of 2 million inhabitants or more:

$$\begin{aligned} rur(i,t+5) &= W_{1,t} * rur(i,t) + W_{2,t} * hrur \\ &= W_{1,t} * rur(i,t) + W_{2,t} * (0.037623 - 0.02604 * PU(i,t) \end{aligned} \tag{3}$$

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

National Research Council (2000), Cohen (2004) and Bocquier (2005) are among those who have criticized UN projection model because of its implicit assumption that all countries will follow the historical path processes of urbanization experienced by developed countries.

Cohen (2004) investigates the quality of the available data, and the uncertainty of UN urban projection. Though he considered the data provided by the UN World Urbanization Prospects as invaluable and comprehensive resource on urban population change, the findings suggest that there was no accuracy in past urban projections. The paper criticizes the UN assumption that urbanization in developing countries will continue more or less unchecked and that large agglomeration will continue to grow to extraordinary height into the future as source of projection errors. The paper considers the geographic position of cities to project urban growth in developing countries. Cohen (2004) distinguished trends in large cities, intermediate and smaller cities. He suggested that large cities will play a significant role in absorbing anticipated future growth but the majority of residents still reside in much smaller urban settlement. Contrary to the popular view, he suggested that by 2015, the proportion of world's population living in large cities will approximate only 21%. Therefore 79% of the population will not be living in large cities (having a population of one million or more) and only 4.1% of the world's population is expected to be living in "mega-cities" (by convention, cities having 10 million or more inhabitants). The author disagrees with the interpretation suggestion that the majority of the world population will be living in huge mega-cities. He suggested that the most urban growth over the next 25 years will occur in far smaller cities and towns. The measurement of urban itself remains a major source of confusion in the study of urbanization and city growth.

The theory of mobility transition initiated by W. Zelinsky (1971) 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 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 urban-rural growth difference (URGD) against the proportion urban (PU) should form an inverted U-curve, starting at 0% or so and finishing at a maximum of 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.

The UN methodology assumes that all countries will follow in their urban transition the pattern of developed countries and reach the same level of urbanization over time. But empirical evidence shows that the urban transition follows different patterns according to the historical period each country went through and to its level of economic development. The curve formed by plotting URGD against PU shows different shapes, although most of them are indeed inverted U-curve.

Bocquier (2005) investigate the acceleration and deceleration stages of urban rural growth difference over urban transition period. He compared developed and developing countries' URGD (denoted *rur* in UN reports) plotted against PU to measure the stage of transition. 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 *rur*, it is better to model the excess increase in urban areas, denoted *xu*:

$$xu_t = U_t - U_{t-1} \cdot \left(\frac{U_t + R_t}{U_{t-1} + R_{t-1}} \right) = U_t - U_{t-1}.(1 + p_t) \tag{4}$$

where p_t is the total population growth rate and $U_{t-1}.(1+p_t)$ is the hypothetical absolute increase in urban areas if the urban areas were to grow at the same rate as the total population. Bocquier demonstrated that *xu* has a close relation to *rur*:

$$xu_t = rur_t \cdot \left(\frac{U_{t-1} \cdot R_{t-1}}{U_{t-1} + R_{t-1}} \right) \tag{5}$$

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. 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. Urban infrastructures capacities grow at a slower rate than the population. This limit to urban growth is not captured by the *rur*. The projection using *xu* will then be constrained by the overall population growth and therefore be dependent on, but also sensitive to, the projection of the total population.

Therefore, the following relation can be established...

$$xu_i(t+n) = rur_i(t+n) * \left(\frac{U(t) * R(t)}{U(t) + R(t)} \right) = f\left(PU_i(t)\right) \tag{6}$$

...and is adjusted by a polynomial of second degree:

$$xu_i(t+n) = f(PU_i(t)) = \beta_{i,0} + \beta_{i,1} * PU_i(t) + \beta_{i,2} * PU_i^2(t) \tag{7}$$

With:

i : Region or country

t : the year (time) of reference

$PU_i(t)$: Percentage of population that is urban (Percentage Urban)

n : n-year increment for step by step projection

$\beta_{i,0}, \beta_{i,1} and \beta_{i,2}$: Parameters computed for *i*, based on historical trends

The equation (7) models the excess in urban areas in the country i at the time t given the relation (6). It is understood that $rur_i(t+n)$ depends only on urban-rural growth differential while $xu_{i,t+n}$ depends not only on this differential but also on the total population growth of the country i expressing the ability to control for the population growth (Bocquier, 2005). Contrary to the UN assumption, Bocquier methodology suggests that each country will follow its own pattern of urban transition at its own pace and achieving its own level of urbanization.

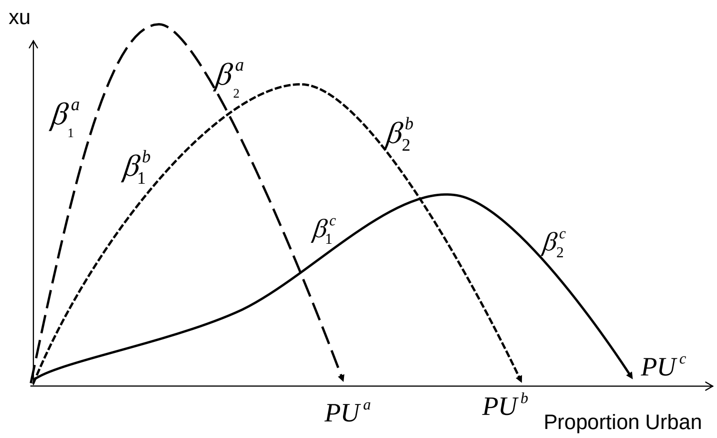

Figure 1: Ideal-type of xu-PU relationship for various level of development

The speed of urban growth differs from country to country and it is related to the economic position of the country in the world. If β_1 and β_2 are speed of urbanization respectively acceleration and deceleration and a , b and c respectively least developed, developing and developed countries. The model assume that countries have different speed of urbanization expressed by $\beta_1^a > \beta_1^b > \beta_1^c$ leading to different level of urbanization $PU^a > PU^b > PU^c$.

The proportion urban at which the URGD seems to converge to zero (called *urban saturation point* for convenience, when rural and urban areas are growing at the same pace) is different from one country to another and possibly corresponds to the urban capacity of the economy. The final stage of the transition depends on the country's position in the global system and defines when urban area is saturated. Bocquier (2005) suggested that the population becomes totally urban when xu approximates $\beta_0+\beta_1+\beta_2$ ($xu \Rightarrow \beta_0+\beta_1+\beta_2$).

In sum, the Bocquier model takes into account two factors: the speed of urban transition and possible urban saturation. The model relies belongs to the class of autoregressive, endogenous models, as the UN projection model. In other words, it does not use exogenous variables (such as GDP, HDI, etc) to explain the proportion urban and its trend. But unlike the UN model, the Bocquier model does not impose convergence toward an average behaviour. Instead each country follows its own urban transition, leading to different level of urban saturation.

Method

In the present paper, we explore a variation of the Bocquier model to analyze urban transition in Africa, in comparison to the rest of the world. Our model will also rely on UN urbanization series only. UN urban and rural population data used in this paper are those published in the World Urbanization Prospects (WUP 2010) using country results that are derived from census, country estimate, register of population, sample survey or UN estimate. Ideally, we would prefer to model the original data as provided by each country for the period 1950 to 2005, then project for the period 2010 to 2050. However, empirical data are not usually available to the public for most countries. We are therefore relying on UN estimate to compensate for the shortage of empirical data mostly in developing countries, and also to ease comparison with UN results. The UN is then interpolating data at fixed dates starting from 1950 with 5-year increment up to 2005.

Our analysis will focus on two variables; namely country population and urban population, for any individual country. The two variables are repeated measures across countries and time, forming a cross-sectional 5-year time-series that can be analyzed as panel data. A variable named excess urban will be created to model growth over time of the each country (see previous section). Bocquier (2005) projected urban growth using the polynomial of second order. In the present paper, we are using a polynomial equation of third order with constant term equalled to 0, which conforms better to the theoretical shape of the urban transition, as exemplified in Figure 1. The regression will be based on the following polynomial equation relative to the observed data:

$$y_i = \beta_{i,0} + \sum_{j=1}^{k} \beta_{i,j} x^j + \varepsilon_i \tag{8}$$

Where y is the observed value (*rur*) for the model, x the proportion urban, $\beta_1, \beta_2, \beta_3, \ldots, \beta_k$ coefficients for *j*th power of the predictor ($j = 1, 2 \ldots k$), β_0 is the intercept of Y, a constant which is preferably equalled to zero, and ε is the error term.

Contrary to linear regression, polynomial regression uses more parameters for a more flexible curve (Motulsky et al., 1987). The values of parameters will be determined by values that minimize the sum of the squares of distances between data points and fitted curve. The mathematical reasoning of the model is similar to a general linear regression model with k predictors to the power j and j varies from 1 to k based on the *k*th order of the polynomial equation for country i. For $k = 2$, the polynomial equation is said to be of second order and the quadratic expression forms a parabolic curve. For $k = 3$, the polynomial equation is said to be of third order forming a cubic expression. The intercept β_0, will be equalled to zero to reflect that urbanization start from 0% urban population for all countries. Replacing in equation 3.1 x by $PU(t)$, t being an index of time in the present research, we will model urban growth using a polynomial of third degree for country i:

$$f\left(PU_i\left(t\right)\right) = \beta_{i,1} * PU_i\left(t\right) + \beta_{i,2} * PU_i^2\left(t\right) + \beta_{i,3} * PU_i^3\left(t\right) + \varepsilon_i \quad (9)$$

The model will estimate the coefficient $\beta_{i,j}$ in fitting the data derived from the equality between the equation (9) and the equation (6) representing the excess urban population.

The research will exploit the maximum likelihood random effect model, constrained such that all countries intercepts β_0 are set to zero. Other regression parameters are specific to each country. The regression model is used to model the trend, but no attempt is made to use the goodness of fit or standard errors to project the trend or to give confidence interval of the trend. As the data are not real panel data but interpolated data at fixed time interval, the goodness of fit and standard errors would not be reliable. The model is implemented with the command 'xtreg' and options 'mle noconstant i(country)' in Stata.

According to the theory, Urban-Rural Growth Difference should follow an inverted-U shape when plotted against the proportion of the population who live in urban area (PU) over the urban transition period. However some countries do not follow this pattern. The historical inverted-U shape will be affected by country specific (idiosyncratic) historical trend. For example, South Africa's inconsistency in urban trend can find its explanation in the apartheid history where people had no free movement from rural and urban areas, at a time when the economy was declining due to international trade restrictions. China's urban trend is another example of a country where people were forced to live in rural areas (Cultural Revolution in China). When the policy restricting people to live in rural areas is lifted up a rebound is generally observed in the urban trend.

When the trend does not approximate the expected inverted-U curve, the country will be dealt with in one of the following two ways:

1. Discard the early part of the series that has abnormal trends and use the rest (truncated series): the model will only take into account the period where there is consistency (bell shape) in URGD trend.
2. If all the series cannot be used (often the case with poor quality of the original data), the country will be discarded.

A table of countries indicating the period affected by corrections is provided in the appendix (Appendix I).

The evaluation of the projection model will be done using historical data to see how accurate it would have been if it was used on 1950-1995 data to forecast urban growth from 1995 to 2005. The validity of the model will be anticipated using the method proposed by Keyfitz (1981). The Percentage Error will be determined by:

$$PE = \frac{\left(\hat{y} - y\right)}{y} \times 100 \quad (10)$$

Where $\hat{y}$ and y are respectively the modelled and observed data for 2005.

A positive $PE\,(PE > 0)$ will be an indication of an overestimation in the projections and a negative $(PE < 0)$ will reflect an underestimation. The model's objective will be to have Mean Percentage Error (MPE) such that $1 - MPE \geq 1 - \alpha$, with α being the acceptable error (5% for example).

The Mean Absolute Percentage Error (MAPE) will evaluate the accuracy of proportion urban forecasts and will be determined by:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{(\hat{y}_i - y_i)}{y_i}\right| \times 100 \qquad (11)$$

Where the number of countries i in the Development Group or Region is represented by n. To evaluate the distribution of countries' projections distance to the observed values, we will compute the number of countries' projected values falling into 1%, 5%, 10%, 15% and 20% percentage error interval below or above the observed values.

Results and Discussion

The period between 1950 and 2005 was adjusted and the goodness of fit was evaluated by observing the trend of excess urban population (*xu*) against percentage urban (*PU*) and four classifications were used to describe the reliability of the model on each country's data (see Annex). The classification of the fit (good, average, poor and unacceptable) is based on the reliability of the fit of the 3rd order polynomial model. The trend of *xu-PU* was observed to classify the country's stage in the urban transition. Three transition stages were observed, namely early, mid and late transitions.

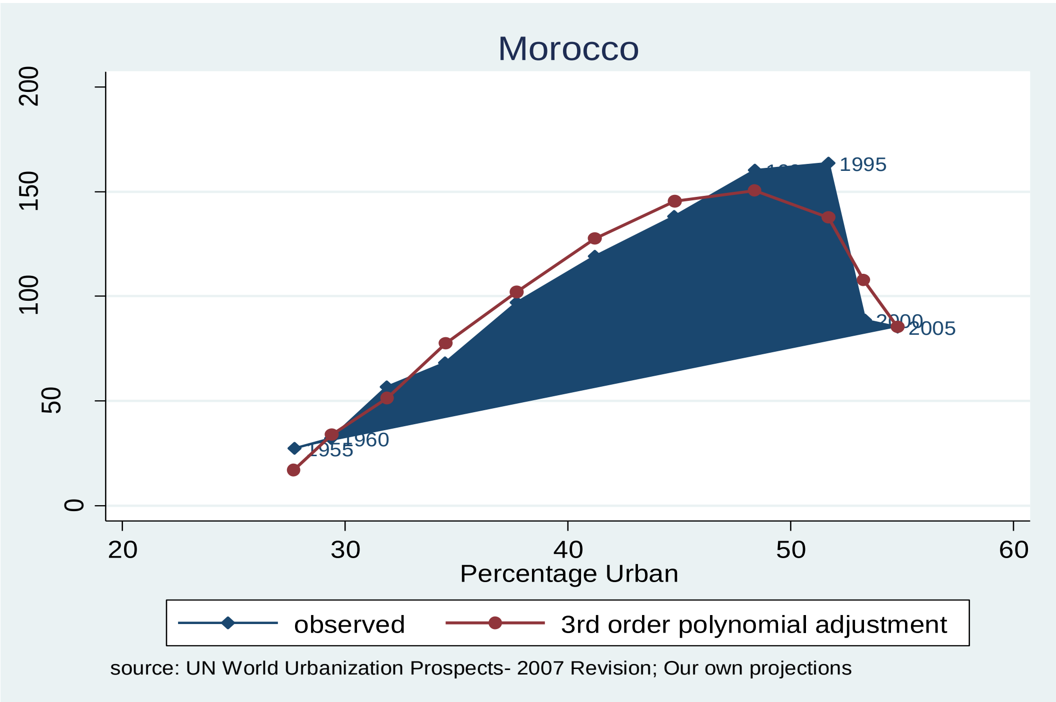

Figure 2: Excess urban population vs. Percentage urban: observed and adjusted trends for Morocco (good fit and mid-stage transition)

The graphs 2 to 4 present the adjusted and observed *xu-PU* trends for five typical countries. Morocco represents countries with a good fit, at mid-stage in the urban transition. The graph indicates that excess urban population in Morocco has already reached its maximum and has just started to decrease towards zero. Kenya's graph is an example of mid-stage transition. The excess urban population decreases rapidly since 1985 while the percentage urban growth slow down significantly. Zambia reached its late-stage of transition since 1985. The graph suggests that the urban growth become stationary since 1985 and also reverse move is depicted form the graph. The reversal in urban growth needs to be investigated to determine if it is due to bad data on urban population, change of urban definition or real high growth in rural areas exceeding urban growth.

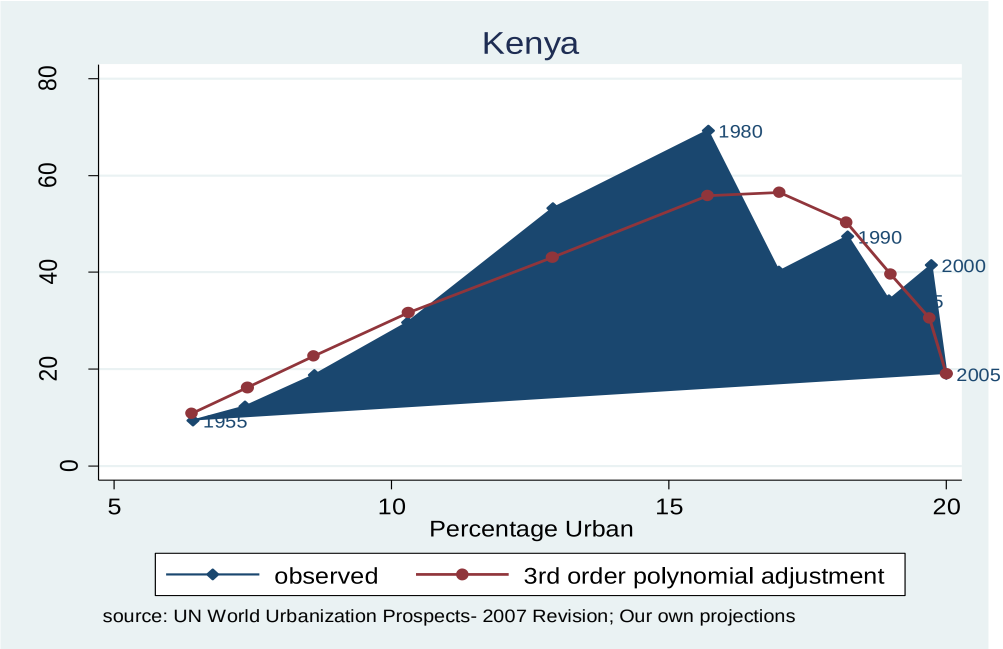

Figure 3: Excess urban population vs. Percentage urban:
observed and adjusted trends for Kenya (average fit and mid-stage transition)

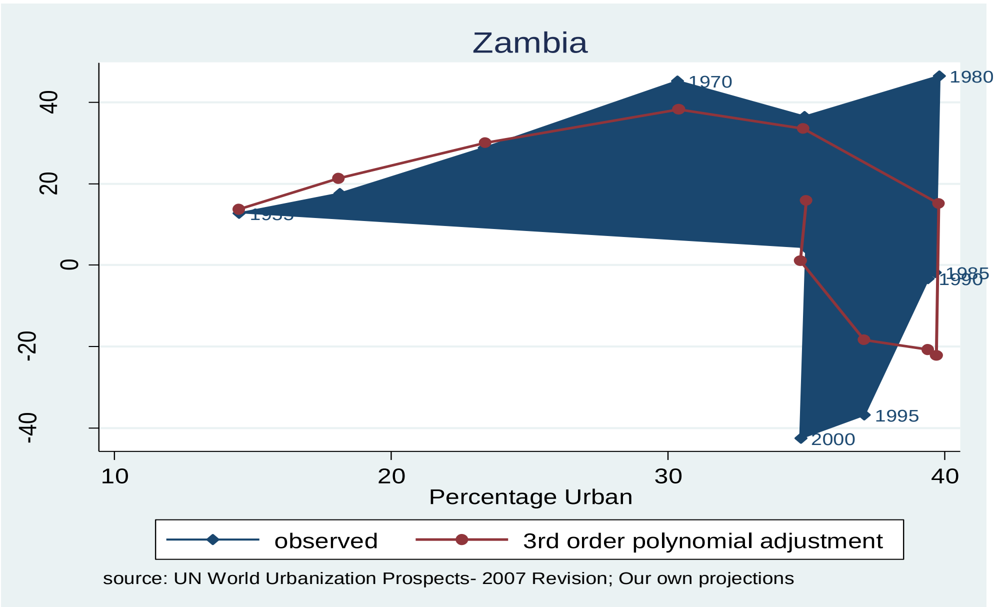

Figure 4: Excess urban population vs. Percentage urban:
observed and adjusted trends for Zambia (average fit and late-stage transition)

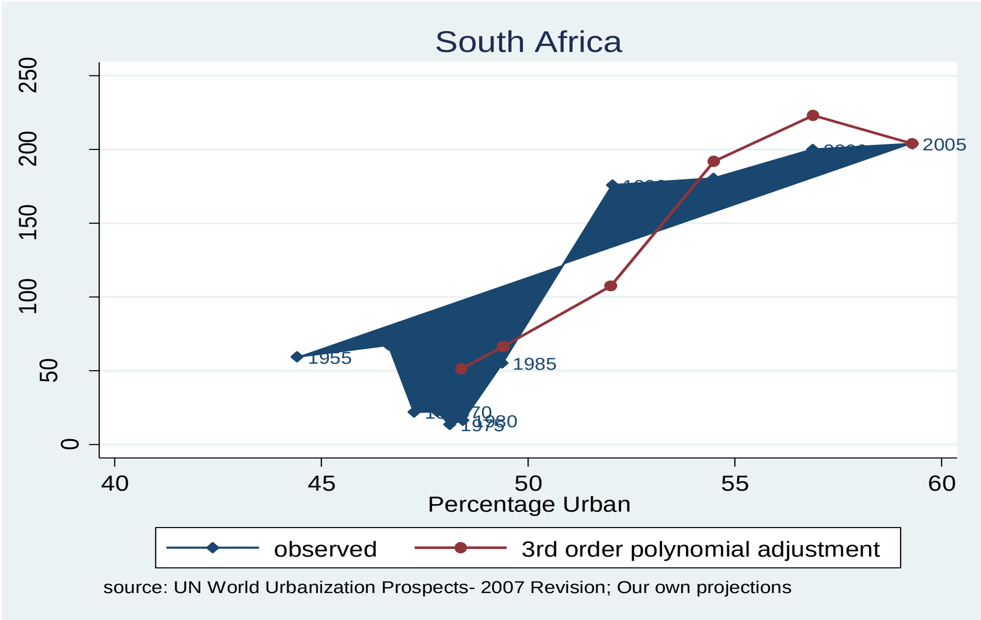

Figure 5: Excess urban population vs. Percentage urban:
observed and adjusted trends for South Africa (poor fit and mid-stage transition)

Urban population growth in South Africa did not follow a trend consistent with the theory of urbanization. The situation in 1980 (when urbanisation virtually stopped) can be linked to the apartheid era and its laws imposing population to remain in homeland. When these laws were abolished (gradually in the early 1980s), a rebound of excess urban population was observed, followed by a rapid urban population growth until the process reached its peak in the years 2000s. The projection on South Africa using the period between 1980 and 2005 suggests that urban growth will continue albeit slowly until reaching 61.6% of the total population living in urban areas.

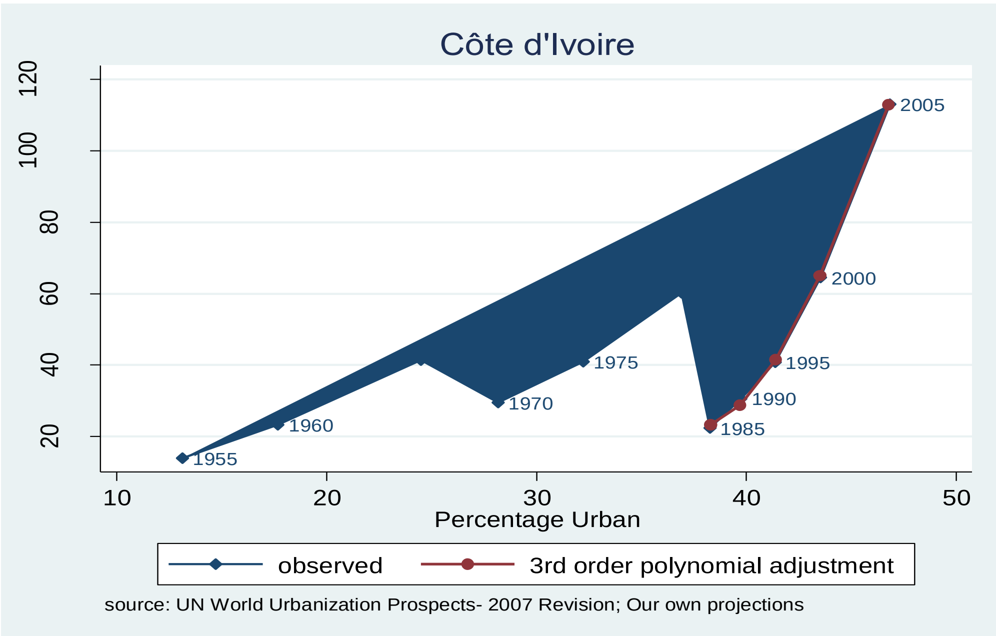

Figure 6: Excess urban population vs. Percentage urban:
observed and adjusted trends for Côte d'Ivoire (unacceptable fit)

The graph for Côte d'Ivoire is an indication that the historical data on urban population is not consistent with the urban transition model. The series shows that the proportion urban would keep growing and eventually reaching 100%. For lack of detailed information, it is difficult to say if this situation is due to faulty data, to change of definition or to the political and economic turmoil as the country experienced both a civil war and an economic recession.

The following graphs represent the urban-rural growth difference (*URGD*) against the percentage urban (*PU*) for some countries. They show clearly that the *URGD* projected by the UN departs greatly from the curvilinear historical trends. Even with relatively poor fit, our projected trends follow better the observed trends. To note, our model fits reasonably well trends that lead to saturation, when the proportion urban hovers around a convergence point as in Mauritania or Niger.

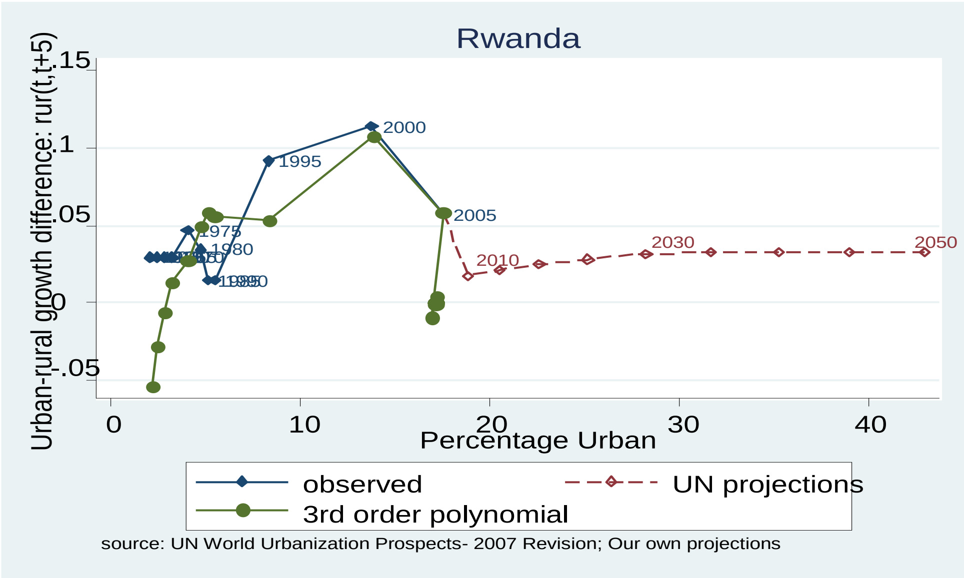

Figure 7: Urban-rural growth difference vs. Percentage urban: observed, adjusted, and projected trends for Rwanda (poor fit and mid-stage transition)

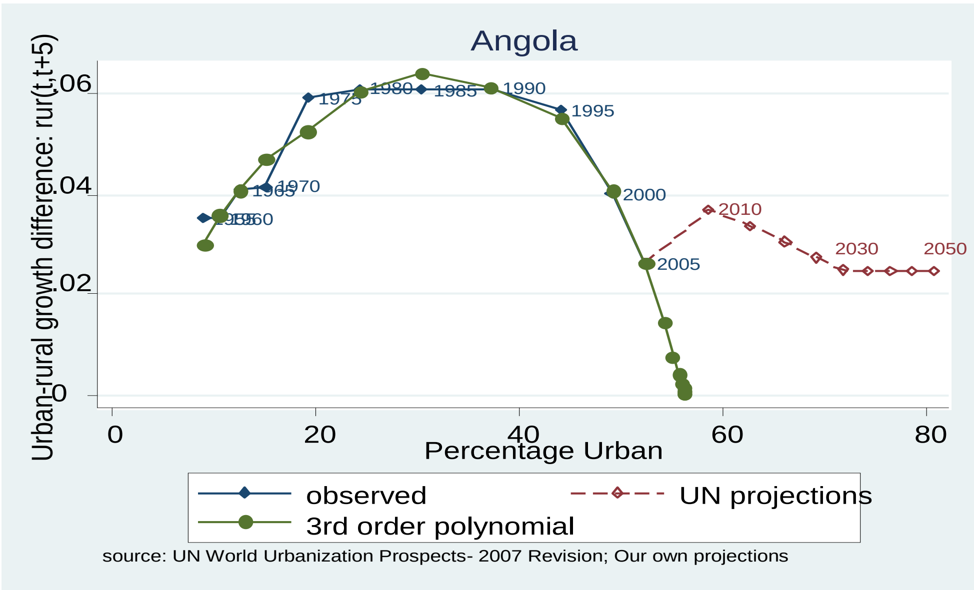

Figure 8: Urban-rural growth difference vs. Percentage urban: observed, adjusted, and projected trends for Angola (good fit and mid-stage transition)

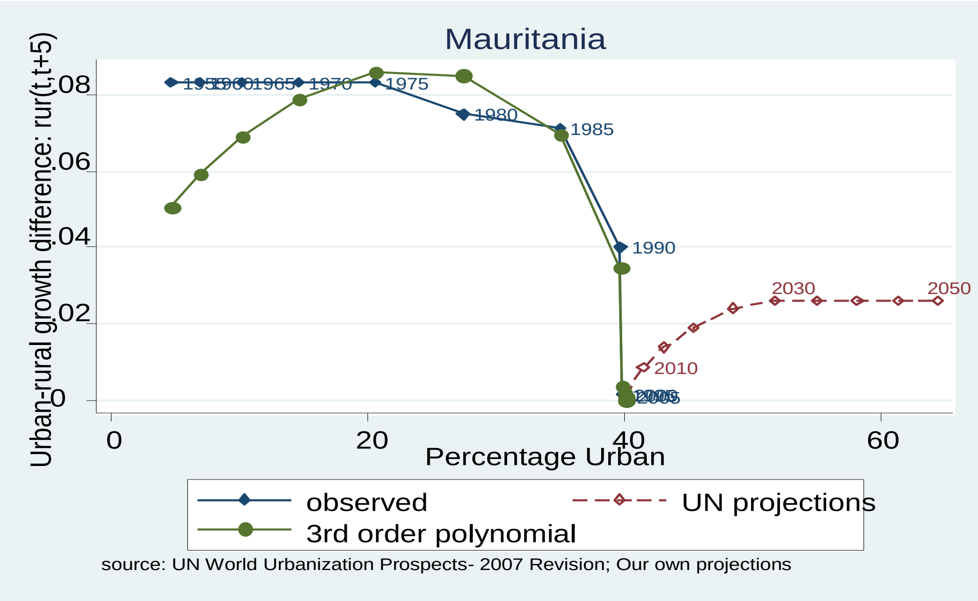

Figure 9: Urban-rural growth difference vs. Percentage urban: observed, adjusted, and projected trends for Mauritania (good fit and late-stage transition)

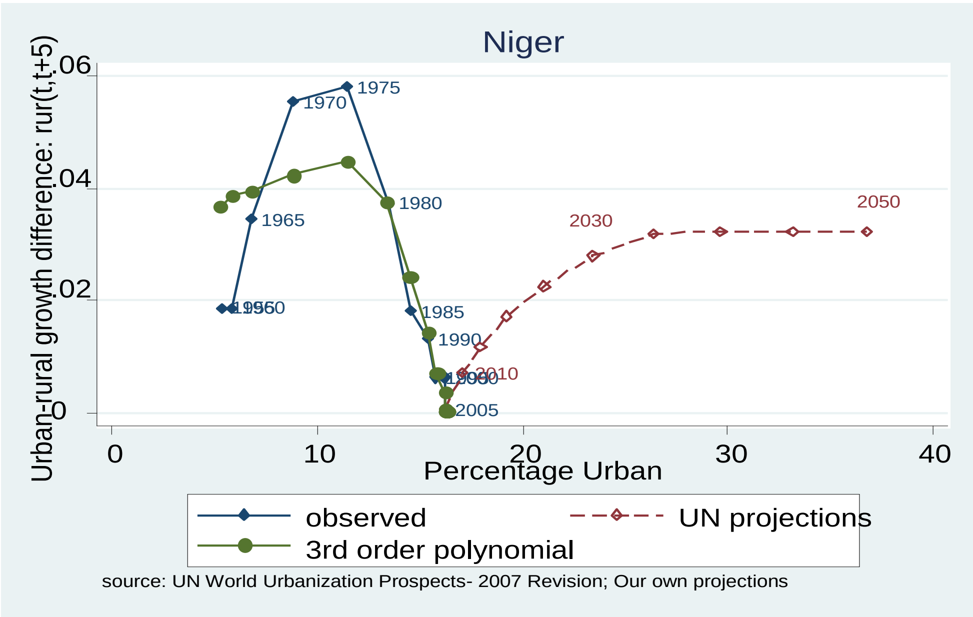

Figure 10: Urban-rural growth difference vs. Percentage urban: observed, adjusted, and projected trends for Niger (poor fit and mid-stage transition)

Conclusion

The detailed third order polynomial projections and UN projections from 2010 to 2050 can be found in Appendix 1. The evaluation of the model using Mean Absolute Percentage Error (MAPE) for the year 2000 indicates that the model is efficient with an average MAPE of 2.61% for all African countries. Except for countries with problematic data, most of African country projections in the evaluation were under 2% MAPE (75% of countries). 85% of African countries have a mean absolute percentage error under 5%. It is an indication that the model is reliable in its projection. MAPE per country can be found in the Appendix 3.

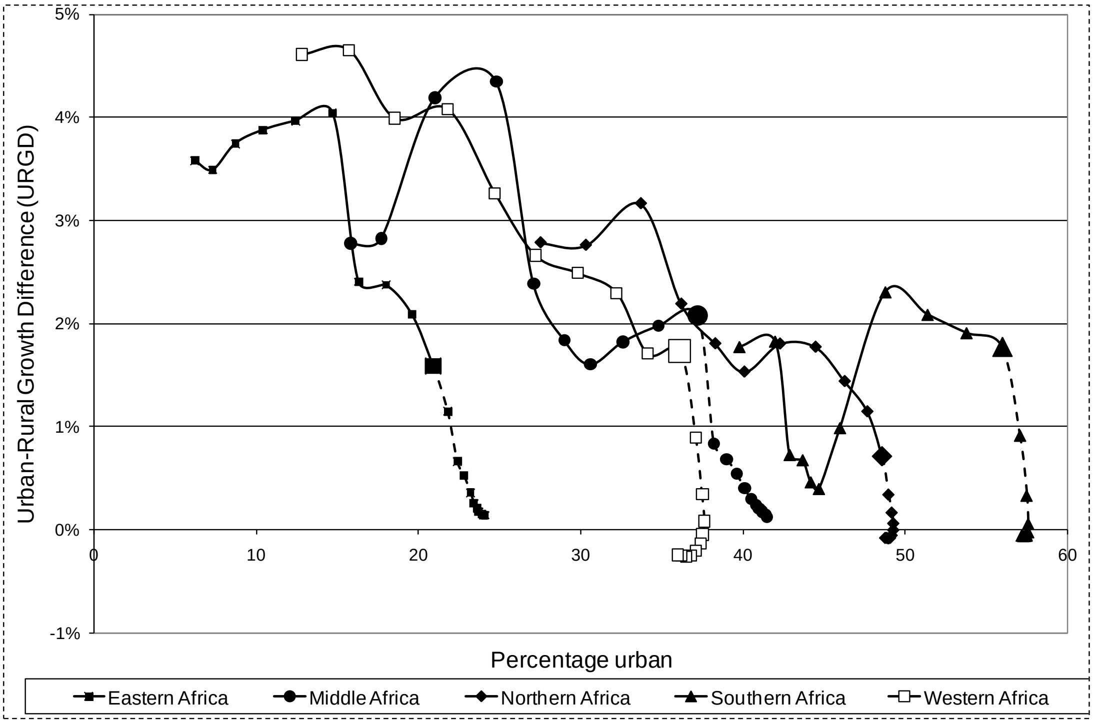

Figure 11: Urban-rural growth difference vs. Percentage urban: observed (plain line 1955-2000) and projected trends (dotted line 2000-2050) for the five African sub-regions (Western Africa without Burkina Faso, Côte d'Ivoire, Mali and Nigeria; Eastern Africa without Eritrea)

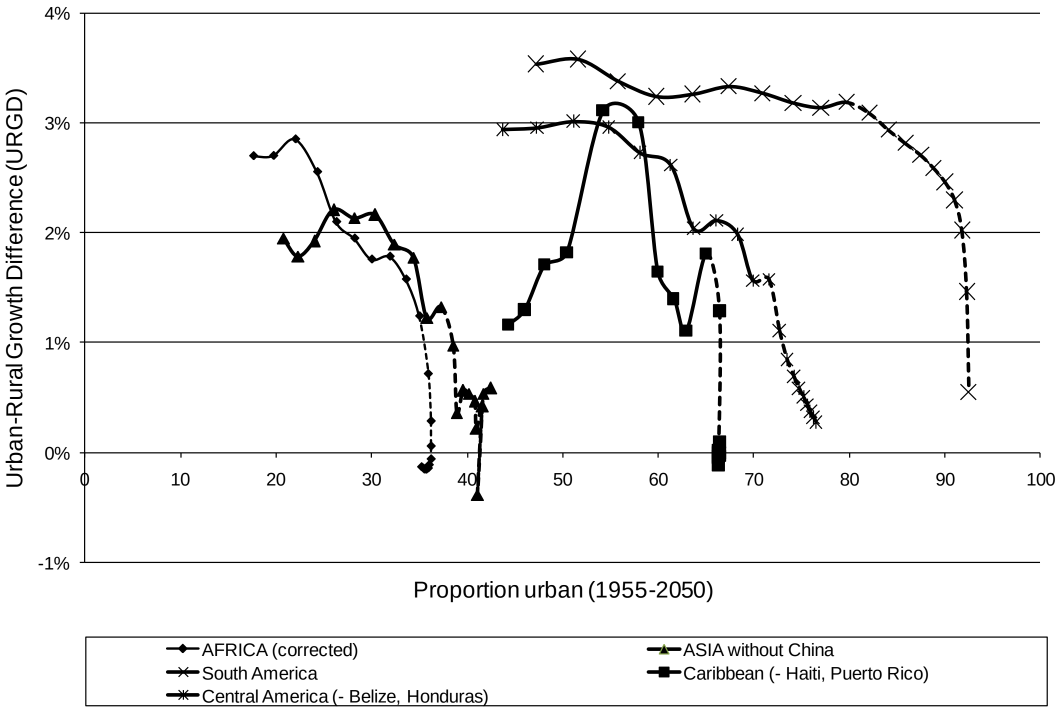

Figure 12: Urban-rural growth difference vs. Percentage urban: observed (plain line 1955-2000) and projected trends (dotted line 2000-2050) for Africa (without Burkina Faso, Côte d'Ivoire, Mali, Nigeria, Eritrea) and Latin America (without Haiti, Puerto Rico, Belize, and Honduras)

The aggregated trends (historical and projected) show that urbanisation converges to fairly low level for all regions of Africa (see Figure above). Because trends for some countries could not be fitted well with our model, these countries were removed from the aggregates. This is particularly crucial in Western Africa where data on Nigeria, the largest country on the continent, had to be removed, as well as Burkina Faso, Côte d'Ivoire, and Mali. The estimates for Western Africa are therefore very tentative.

With this limitation in mind, our projections show that the Eastern Africa region has the lowest proportion of population living in urban areas. The urban proportion will not vary significantly from 2010 to 2050 according the 3rd polynomial model. In the Eastern Africa region, only 24% of the population will be leaving in urban areas by 2050. The model foresees that Southern Africa will have the highest percentage of population living in urban areas by 2050, essentially because South Africa is weighing heavily in the region. The model predicts that 57% of Southern Africa region population (62% in South Africa) will be living in urban areas while the UN predicts 77%. Northern Africa is expected to reach 49% while the UN foresees 71% of population living in urban areas. The UN projection model predicts that 68% and 77% of the population respectively in Middle Africa and Western Africa will be living in urban areas while the third order polynomial foresees only 42% and 36%. However this latest figure is probably underestimated since it does not include Nigeria and Côte d'Ivoire, which were already 43% urban in 2000. Also, our projection for Western Africa shows a counter-urbanisation that may be spurious and again related to poor data quality. Therefore, with better quality data, it is probable that urbanisation would be projected above 45% in Western Africa, i.e. at higher level than in Middle Africa. For Africa as a whole, the percentage urban will probably hovers in the future around the same level as currently observed, i.e. around 39 to 40%, contrary to the UN-projected 62% in 2050.

In our model, the countries predicted to have the highest percentage of its population living in urban areas by 2050, will be the Reunion Island (92%, while the UN predicts 97%) and Gabon (95%, while the UN predicts 94%). Gabon is only country in Africa where the 3rd order polynomial model predicts a higher percentage of urban percentage of the population by 2050 than the UN. Among African countries predicted with lowest percentage urban are all in Eastern Africa and include Uganda (12%), Burundi (15%), Malawi (17%), Rwanda (17%), and Ethiopia (18%).

Current and projected urbanization trends are much lower in Africa and Asia (without China) than in Latin America (Figure 8). The high urbanisation in Latin America can be partly explained by physical constraints of the Caribbean and countries along the Andes as population of islands and mountainous countries tend to concentrate more in cities. However, these physical constraints do not operate in Central America, which with level of development comparable to the rest of Latin America is also highly urbanised. The level of urbanisation of Latin America actually reflects its higher rank in the world economy than Africa and Asia.

Acknowledgement

Our thanks go to the United Nations – Department of Economic and Social Affairs – Population Division for proving the most recent data to date (2007 Revision), and to the Latin American Population Association (*Asociacion Latinoamericana de Poblacion* – ALAP) for the invitation to its fourth Congress in La Habana Cuba to present the findings of the research.

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APPENDIX 1: Observed and Projected Percentage Urban in African Countries and Major Regions

Country/ Area Name	Observed		Projections						
			Period used for projection	3rd Order Polynomial	UN	3rd Order Polynomial	UN	3rd Order Polynomial	UN
	1950	2000		2010	2010	2030	2030	2050	2050
Africa	14.4	36	n.a.	38.8	40.0	n.a.	49.9	n.a.	61.6
Africa (without Eritrea, Burkina Faso, Côte d'Ivoire, Mali and Nigeria)	15.7	35	n.a.	36.2	50.5	35.9	60.1	35.2	72.6
Eastern Africa (without Eritrea)	**5.3**	**20.8**	n.a.	**22.4**	**23.6**	**23.6**	**33.3**	**24.1**	**47.4**
Burundi	1.7	8.3	1980 - 2000	10.4	11	13.5	19.8	15.2	33.3
Comoros	6.6	28.1	1950 - 2005	28.1	28.2	28.5	36.5	28.6	50.7
Djibouti	39.8	76	1950 - 2005	76.2	76.2	76.8	80.2	77.1	85
Eritrea	7.1	17.8	1975 - 2005	22.1	21.6	n.a.	34.4	n.a.	50.1
Ethiopia	4.6	14.9	1975 - 2000	16.3	16.7	17.4	23.9	17.7	37.5
Kenya	5.6	19.7	1950 - 2000	20.2	22.2	20.5	33	20.6	48.1
Madagascar	7.8	27.1	1950 - 2000	29	30.2	30.5	41.4	31	56.1
Malawi	3.5	15.2	1985 - 2000	16.9	19.8	17.1	32.4	17.1	48.5
Mauritius	29.3	42.7	1950 - 2005	42.8	41.8	42.9	48	42.9	60.5
Mozambique	2.4	30.7	1985 - 2000	36.4	38.4	39.8	53.7	40.4	67.4
Réunion	23.5	89.9	1950 - 2005	92	94	92	96.3	92	97.3
Rwanda	1.8	13.8	1950 - 2005	16.9	18.9	17.1	28.3	17.1	42.9
Seychelles	27.4	51	1950 - 2005	49.8	55.3	49.8	66.6	49.8	76.2
Somalia	12.7	33.2	1980 - 2000	35.4	37.4	36.2	49.9	36.4	63.7
Uganda	2.8	12.1	1975 - 2000	11.9	13.3	11.9	20.6	11.9	33.5
United Republic of Tanzania	3.5	22.3	1965 - 2000	25.1	26.4	29.1	38.7	32.1	54
Zambia	11.5	34.8	1950 - 2005	35.6	35.7	36.7	44.7	36.9	58.4
Zimbabwe	10.6	33.8	1950 - 2000	36.9	38.3	39.1	50.7	39.5	64.3
Middle Africa	**14**	**37.2**	n.a.	**39**	**43.1**	**40.8**	**55.9**	**41.5**	**68.1**
Angola	7.6	49	1950 - 2000	54.1	58.5	56	71.6	56.2	80.5
Cameroon	9.3	49.9	1980 - 2000	58.5	58.4	71.7	71	79.8	79.9
Central African Republic	14.4	37.6	1950 - 2000	37.9	38.9	38	48.4	38.1	61.6
Chad	4.5	23.4	1950 - 2000	24.1	27.6	24.7	41.2	24.9	56.7
Congo	24.9	58.3	1950 - 2000	60.5	62.1	62.5	70.9	63.3	79
Democratic Rep. of the Congo	19.1	29.8	1950 - 2000	29.4	35.2	29.2	49.2	29.2	63.2
Equatorial Guinea	15.5	38.8	1975 - 2005	38.8	39.7	38.8	49.4	38.8	62.4
Gabon	11.4	80.1	1950 - 2005	86.3	86	92.4	90.6	95	93.5
Sao Tome and Principe	13.5	53.4	1975 - 2000	56.6	62.2	56.9	74	56.9	82.1
Northern Africa	**24.8**	**47.7**	n.a.	**49**	**51.2**	**49.2**	**60.5**	**48.8**	**71**
Algeria	22.2	59.8	1970 - 2000	63.9	66.5	65.4	76.2	65.5	83.5
Egypt	31.9	42.8	1950 - 2000	43.1	43.4	43.2	50.9	43.3	63.3
Libyan Arab Jamahiriya	19.5	76.4	1950 - 2000	76.3	77.9	76.3	82.9	76.3	87.2
Morocco	26.2	53.3	1950 - 2000	55.8	58.2	57.3	69.2	57.5	78
Sudan	6.8	33.4	1980 - 2000	34.4	40.1	34.5	54.5	34.5	67.7
Tunisia	32.3	63.4	1950 - 2000	67.3	67.3	71.2	75.2	72.7	82
Western Sahara	31	83.9	1950 - 2005	81.9	81.8	83.4	85.9	83.8	89.4

Southern Africa	**37.7**	**53.8**	n.a.	**57.1**	**58.7**	**57.5**	**68.3**	**57.2**	**77**
Botswana	2.7	53.2	1980 - 2000	53.9	61.1	53.9	72.7	53.9	81.1
Lesotho	1.4	20	1985 - 2000	21.6	26.9	21.6	42.4	21.6	58.1
Namibia	13.4	32.4	1990 - 2000	33.1	38	33.1	51.5	33.1	65.3
South Africa	42.2	56.9	1975 - 2005	60.6	61.7	61.5	71.3	61.6	79.6
Swaziland	1.8	22.6	1950 - 2005	22.2	21.4	22.5	26.2	22.5	39.5
Western Africa (without Burkina Faso, Côte d'Ivoire, Mali and Nigeria)	**9.8**	**38.8**	n.a.	**44.7**	**44.9**	**52.7**	**57**	**57.7**	**68.4**
Benin	5	38.3	1950 - 2000	40	42	41.2	53.7	41.6	66.6
Burkina Faso	3.8	17.8	1975 - 2000	34.7	25.7	n.a.	42.8	n.a.	58.8
Cape Verde	14.2	53.4	1975 - 2000	51.7	61.1	51.7	72.5	51.7	80.8
Côte d'Ivoire	10.0	43.5	1980 - 2005	52.7	50.6	n.a.	64.1	n.a.	74.6
Gambia	10.3	49.1	1980 - 2005	58	58.1	68	71	71.8	81
Ghana	15.4	44	1975 - 2000	46.9	51.5	47.2	64.7	47.2	75.6
Guinea	6.7	31	1975 - 2000	32.2	35.4	33.1	48.6	33.4	62.9
Guinea-Bissau	10.0	29.7	1975 - 2005	29.6	30	29.6	38.6	29.6	52.7
Liberia	13	44.3	1950 - 2000	44.9	47.8	45.1	57.6	45.1	69.1
Mali	8.5	28.3	1975 - 2000	36.4	35.9	n.a.	51.3	n.a.	65.3
Mauritania	3.1	40	1950 - 2000	40.1	41.4	40.1	51.7	40.1	64.4
Niger	4.9	16.2	1950 - 2000	16.2	17.1	16.3	23.5	16.3	36.8
Nigeria	10.2	42.5	1970 - 2000	49.8	49.8	n.a.	63.6	n.a.	75.4
Saint Helena	51.6	39.7	1970 - 2005	39.4	39.7	39.3	46.4	39.3	59.3
Senegal	17.2	40.3	1950 - 2000	41	42.4	41.6	52.5	41.8	65.1
Sierra Leone	12.6	35.5	1950 - 2000	36.7	38.4	37.6	49	37.9	62.4
Togo	4.4	36.5	1980 - 2000	42	43.4	47.2	57.3	48.7	69.8

APPENDIX 2: Distribution of countries according to the quality of the goodness of fit and the stage in the urban transition

Stage of the transition	*Goodness of fit*				
	Excellent	Good	Average	Poor	Unacceptable
Early to mid stage	Angola	Burundi Gambia Madagascar Morocco Mozambique Zimbabwe	Benin Botswana Congo Gabon Kenya Malawi Sudan Tunisia	Algeria Cameroon Chad Ghana Guinea Lesotho Namibia Réunion Rwanda Somalia South Africa Togo Zambia	Burkina Faso Eritrea Mali Nigeria Sao Tome & Pr. Tanzania
Late stage		Djibouti Ethiopia Liberia Lybia Mauritius	Central Africa Comoros Egypt Eq. Guinea Mauritania Senegal Sierra Leone Zambia	Cape Verde Gambia Guinea Bissau Niger Seychelles Swaziland Uganda Western Sahara	Côte d'Ivoire DRC Saint Helena

APPENDIX 3: Third Order Polynomial Model Mean Absolute Percentage Error for the year 2000 based on data for the period 1950-1995

Region Name	Country	PE	APE
Eastern Africa	Burundi	0.5	0.5
	Comoros	-1.07	1.07
	Mayotte	-0.79	0.79
	Djibouti	-0.66	0.66
	Eritrea	0.19	0.19
	Ethiopia	-0.46	0.46
	Kenya	0.48	0.48
	Madagascar	-0.75	0.75
	Malawi	-0.33	0.33
	Mauritius	-0.39	0.39
	Mozambique	0.52	0.52
	Réunion	1.72	1.72
	Rwanda	-40.92	40.92
	Seychelles	1.66	1.66
	Somalia	0.14	0.14
	Uganda	0.68	0.68
	United Republic of Tanzania	0.66	0.66
	Zambia	-3.03	3.03
	Zimbabwe	-0.62	0.62
Middle Africa	Angola	-0.66	0.66
	Cameroon	-0.24	0.24
	Central African Republic	0.17	0.17
	Chad	1.47	1.47
	Congo	0.48	0.48
	Democratic Rep. of the Congo	1.2	1.2
	Equatorial Guinea	4.34	4.34
	Gabon	0.95	0.95
	Sao Tome and Principe	4.17	4.17
Northern Africa	Algeria	1.9	1.9
	Egypt	-0.23	0.23
	Libyan Arab Jamahiriya	0.3	0.3
	Morocco	-1.35	1.35
	Sudan	4.02	4.02
	Tunisia	-1.76	1.76
	Western Sahara	-3.23	3.23
Southern Africa	Botswana	8.41	8.41
	Lesotho	3.69	3.69
	Namibia	26.46	26.46
	South Africa	5.63	5.63
	Swaziland	-0.55	0.55
Western Africa	Benin	0.15	0.15
	Burkina Faso	2.38	2.38
	Cape Verde	10.25	10.25
	Côte d'Ivoire	0.37	0.37
	Gambia	-0.05	0.05
	Ghana	2.66	2.66
	Guinea	1.08	1.08
	Guinea-Bissau	0.95	0.95
	Liberia	0.78	0.78
	Mali	1.00	1.00
	Mauritania	-0.14	0.14
	Niger	0.37	0.37
	Nigeria	-0.08	0.08
	Saint Helena	0.6	0.6
	Senegal	0.23	0.23
	Sierra Leone	0.43	0.43
	Togo	0.33	0.33
	Mean Africa	**0.60**	**2.61**