Theoretical and Empirical Researches in Urban Management
Volume 13 Issue 3 / August 2018

INCOME AS A PRIMARY DRIVER OF SOUTH AFRICAN INNER CITY MIGRATION

Kevin J. DUFFY
Institute of Systems Science, Durban University of Technology, Durban 4000, South Africa
kevind@dut.ac.za

Thokozani S. SIMELANE
Institute of Systems Science, Durban University of Technology, Durban 4000, South Africa
tsimelane@hsrc.ac.za

Obiora C. COLLINS
Institute of Systems Science, Durban University of Technology, Durban 4000, South Africa
obiora.c.collins@gmail.com

Abstract
Drivers of migration to the inner areas of the five largest South African cities are investigated using computational modelling based on survey data. The primary migration driver for South African cities is established to be the need to find work but this is related to income in terms of salary distributions. These distributions vary for the different cities and fall into two groups, those with a normal distribution and those that peak in a very low income bracket. The link between these distributions and "attractiveness to move to a city" is considered using a simple model.
Keywords: Budgeting Migration, Models, South Africa, System Dynamics

1. INTRODUCTION

Rural-urban migration in African is producing one of the world's fastest rates of urbanisation (Kihato 2018). Along with these trends, South African cities are continually expanding. At least 56% of South African citizens reside in urban areas (Kok and Collinson 2006). All large South African cities are examples of complex developing urban centres with increasing numbers of foreign and domestic migrants. While rural-urban migration is common world-wide, the migrant labour system and forced migration has for decades created large migrant populations in South African cities (Crush, Williams and Peberdy 2005). Also, since the 1990's the removal of policies such as the group Areas Act, that

prohibited non-whites from settling permanently in South African city centres, has increased rural-urban migrations further (Crush, Williams and Peberdy 2005).

While many studies have found the effects of migration in the first world to be benign (Hatton and Tani 2005) this is not always the case in developing counties. Negative effects of rapid migration to cities can include a number of factors. High urban migration can have significant consequences on housing and services (Balbo and Marconi 2005). In fact, stress can be placed not only on the amount of housing required but also on the organization of the urban space itself (Balbo and Marconi 2005). Rapid migration can exacerbate the rate and severity of disease epidemics such as silicosis, tuberculosis and HIV (Rees et al. 2010). Also, as these diseases are often interrelated rapid migration can further complicate epidemics (Rees et al. 2010). It is problem enough that HIV rates are often high but the issues involved are complex because of their interrelation with other migration difficulties (Vearey et al. 2010). Other possible negative factors can include a drop in services in general (including education), increased unemployment (Kok and Collinson 2006), increased poverty and political instability (Arieff 2010), increased xenophobia (Crush 2008), threats to food security and the rural impact of migrant retrenchments (Crush and Frayne 2007).

On the other hand, there can be positive influences to urbanization. The places of origin often benefit from the migrants sending resources home (Kok and Collinson 2006). The urban areas can also benefit from the increased labour and intellectual capital that flow in. Individuals that move can also be better off in urban settings (even if poor) because of better services than in the original rural areas. This improvement can extend to immediate offspring as well. An infant nutrition study found that children born in rural areas were more likely to be undernourished than those born in a South African urban setting (Ramphele, Heap and Trollip 1991).

From the discussion above, rapid urban migration can have large and complex effects and thus, for individual communities, urban planners, and regional and national policy makers, knowledge of the processes and actual numbers can be important. In this study we consider the problem from the perspective of using computational modelling to assist in answering the social questions involved.

It is widely accepted that there are factors that together can lead to migration and these factors can be seen as the 'drivers' of migration (Van Hear, Bakewell, and Long 2018). These authors further categorize these drivers into those that push migration and those that pull migration. Based on empirical findings of Afghan migration to Iran and Pakistan, and Somali migration to southern Africa, these authors identify three sets of driver complexes that can be simplified to be 1. outward migration in a political economy of conflict, 2. inward migration due to a political economy of opportunity and 3. the

Theoretical and Empirical Researches in Urban Management
Volume 13 Issue 3 / August 2018

Theoretical and Empirical Researches in Urban Management
Volume 13 Issue 3 / August 2018

influences of established networks and a history of migration. Similarly, Black et al. (2011) propose five drivers of migration: economic, political, demographic, social and environmental. These effects are exacerbated by the growing inequality in incomes and human security between more- and less-developed peoples (Castles 2013). Seto (2011) considered the migration to cities in 11 Asian and African mega-deltas and found that in particular uneven spatial economic development is often the primary underlying driver of migration.

Carling and Collins (2018) contextualise the drivers of migration as notions of aspiration and desire recognising that even economic narratives of movement are socially constructed related to emotions within and across borders. Kährik et al. (2015) found that differing socio-economic groups are attracted to different city condition and hence regions. Anisimova et al. (2016) found that migration levels correlated with socio-economic attractiveness for 10 large Russian cities.

According to a survey of refugees who had migrated to South Africa, half left their countries to escape war and conflict (push drivers) and nearly 40% left their countries to find jobs and seek an improved standard of living (push and pull drivers). When asked the primary reason for moving to Johannesburg the relative importance of economic and political reasons evened out. Thus, the reason to move to a particular city appears to be due to its perceived value in terms of economic attractiveness.

In the present paper we compare South African cities to investigate what 'pull' drivers (attractive forces) contribute to levels of in-migration. In other words, what attracts people to a particular city? Migration pattern data collected from South African cities are considered to establish possible drivers of migration. In particular, the hypothesis tested is whether the need to find work (economic security) is a primary driver and to what extent this is affected by potential income differentials.

We also show how these drivers can be used in system dynamic simulation models to allow numerically based scenario predictions of population trends. Thus, mathematical formula relating migration drivers to population trends are sought rather than only statistical analyses of those drivers.

2. MODEL AND ANALYSES OF CITY ATTRACTIVENESS

What we are primarily interested in is what makes a particular city appear attractive? Questionnaires were given to individuals residing in each of the inner cities of Johannesburg, Tshwane, Durban, Port Elizabeth and Cape Town (Simelane 2017). The results showed that a large portion of most respondents moved to the inner cities for work (Figure 1). The only other significant reason given was to study. As can be seen in Figure 1 this trend was highest for Johannesburg where 0.88 of respondents

listed work as their reason for moving to the city. This result makes sense in that Johannesburg is a major economic and industrial hub in the context of southern Africa.

Given that work is an important factor how does work function as a motivation to move from one's home of origin to a city? A question in the survey asked respondents to list their present income levels. The results, for the five South African cities, are given in Figure 2. These results can be split into two categories, those cities whose distribution of income levels are skewed to lower income groups (Figure 2a) and those cities whose distribution of income levels were more normally distributed (Figure 2b).

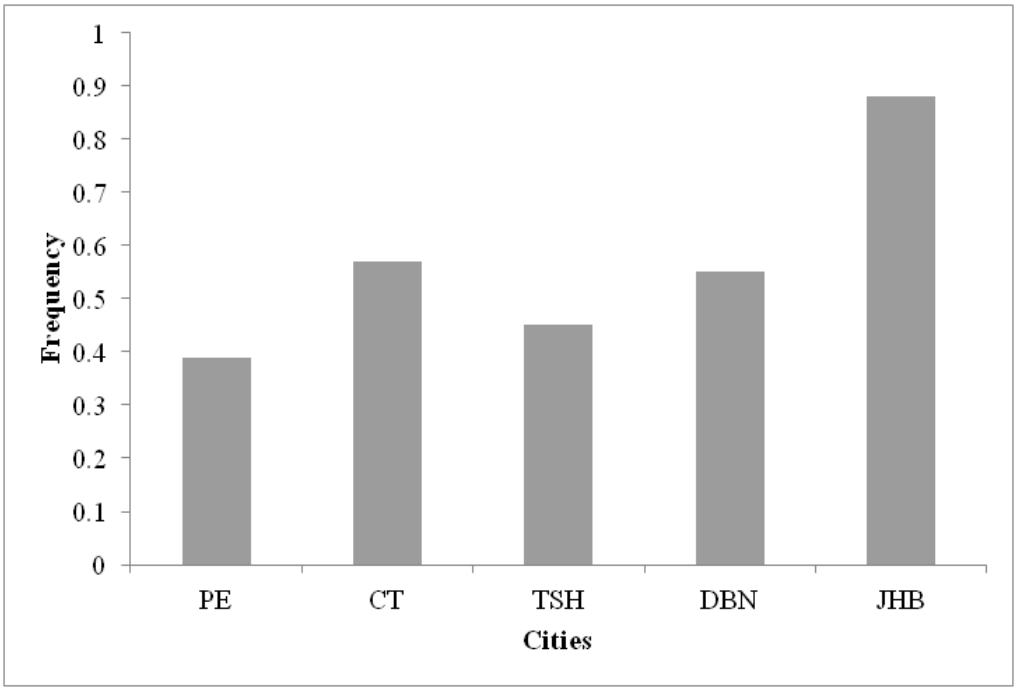

FIGURE 1 - THE PERCENTAGE FREQUENCIES FOR PEOPLE MOVING TO INNER CITIES OF SOUTH AFRICA FOR WORK. Cities are Port Elisabeth (PE), Cape Town (CT), Tshwane (TSH), Durban (DBN) and Johannesburg (JHB).

These results indicate that overall most inner city residents are in low income groups (Figure 2). However, Port Elisabeth, Cape Town and Tshwane have more jobs in the very low income categories. Durban and Johannesburg by comparison have a greater percentage of jobs in relatively higher income brackets. Thus, one would expect these cities to be more attractive than Port Elisabeth, Cape Town and Tshwane. For some reason Durban does not fit this trend (Figure 1) and it can only be surmised that Durban is not seen as a city with better jobs even though it does appear from other aspects of the study to match Johannesburg quite closely.

Theoretical and Empirical Researches in Urban Management
Volume 13 Issue 3 / August 2018

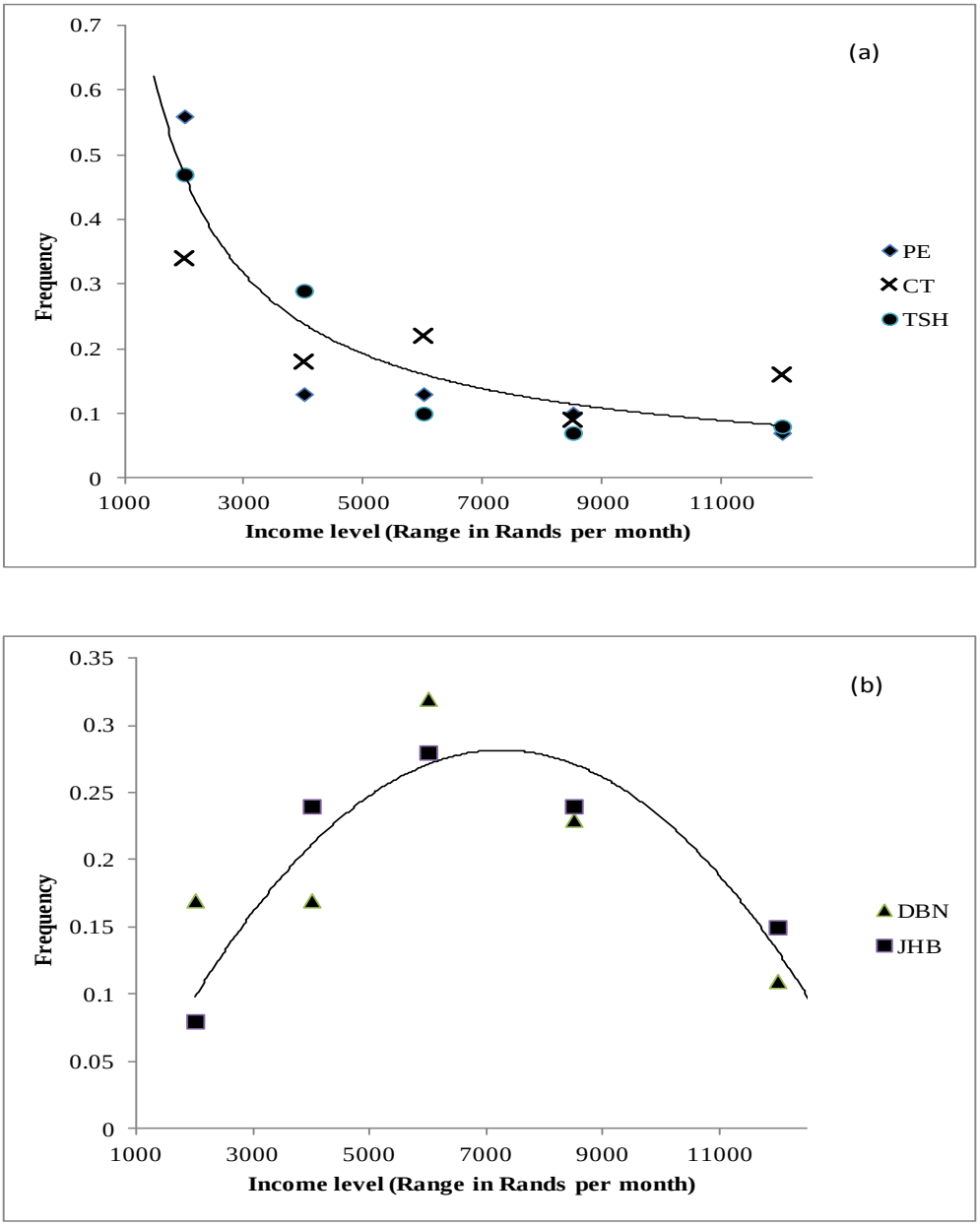

FIGURE 2. DISTRIBUTION OF INCOME LEVELS FROM SOUTH AFRICAN INNER CITIES FOR THE FIVE LARGE CITIES. Cities are Port Elisabeth (PE), Cape Town (CT), Tshwane (TSH), Durban (DBN) and Johannesburg (JHB). (A) Cities grouped because their distributions are skewed to lower income groups. (B) Cities grouped because their distributions are more normally distributed. The lines are approximate fits.

As can be seen from Figure 1 work is a primary driver for people to move to the larger South African cities and this appears to be dependent on the distribution of income levels (Figure 2). A first appraisal of these results shows that income level distributions are non-linear and can be fit by exponential or normal distributions. Thus, any connection between these distributions and city attractiveness through work are not immediately apparent. However, we required these factors as drivers for a system

dynamic model to predict population fluctuations over time. The initial assumption was that the relation between income level distributions and city attractiveness is linear even though the actual distributions are non-linear. The reason to make such a suggestion is that while the actual income distributions will be dependent on a host of factors particular to a city (hence the non-linear distribution) the effect of these distributions on an individual's desire for work might be much more direct (hence linear). With this assumption in mind the following linear model (for income level distributions and city attractiveness) for each of these cities was considered:

$$0.56a_1 + 0.13a_2 + 0.13a_3 + 0.10a_4 + 0.07a_5 = 0.39$$

$$0.34a_1 + 0.18a_2 + 0.22a_3 + 0.09a_4 + 0.16a_5 = 0.57$$

$$0.47a_1 + 0.29a_2 + 0.10a_3 + 0.07a_4 + 0.08a_5 = 0.45 \quad (1)$$

$$0.17a_1 + 0.17a_2 + 0.32a_3 + 0.23a_4 + 0.11a_5 = 0.55$$

$$0.08a_1 + 0.24a_2 + 0.28a_3 + 0.24a_4 + 0.15a_5 = 0.88$$

where a_1, a_2, a_3, a_4, a_5 are the parameters for relative rates of influence of the different income levels on city attractiveness. Note that line 1 of model (1) represent dynamic for the city of Port Elizabeth. Similarly, lines, 2, 3, 4 and 5 of the same model represent the dynamics for the cities of Cape Town, Tshwane, Durban and Johannesburg respectively. Mathematically, the solution (a_1, a_2, a_3, a_4, a_5) of model system (1) can be understood as the points where the dynamics of these cities coincide. This can help us determine if there are similarities in the socio-economic dynamics of the various cities based on income distribution.

The solution of this system of equations can be found using methods well understood and found in any textbook on linear equations (see for example Beezer (2006)). To simplify the procedure one can use a spread-sheet based algorithm that uses matrix algebra and provides a direct method for obtaining the parameters needed (Highland 2010).

Using Highland's (2010) algorithm to solve the system of equations (1) gives a unique solution (0.0232, 0.2636, -2.3764, 3.2620, 4.6492) with a negative value for the middle income bracket, R 5000 – R 7000. This result demonstrates similarities in the dynamics of these cities. Thus, it is possible to discuss the socio-economic dynamics of these cities in general as well as make predictions on future dynamics.

The analysis above gives initial insight into the socio-economic distribution of these cities (PE, CPT, DBN, JHB, TSH) based on their income levels. To improve our understanding on socio-economic dynamics using the income levels for the cities, we developed a dynamical system mathematical model.

Theoretical and Empirical Researches in Urban Management
Volume 13 Issue 3 / August 2018

A dynamical system mathematical model is a tool that can be used to analyse and understand complex phenomena. Given that the socio-economic dynamics of any city is associated with its population dynamics, we consider the population dynamics of each of the cities in formulating a better mathematical model. This can help to improve socio-economic development planning and policy making for the cities.

According to Statistics SA (2018), the population size for each of these cities (PE, CPT, DBN, JHB, TSH) have been increasing continuously since 1995 up and till this year (2018). The logistic population growth model is one of the simplest mathematical dynamical system models that can be used to analyse as well as make predictions of future population dynamics (Tsoularis and Wallace 2002). So, we consider the logistic growth population model given by

$$\frac{dN(t)}{dt} = r\,N(t)\left(1 - \frac{N(t)}{K}\right) \qquad (2)$$

where the variables t is time, N(t) is total population of the city at time t and the parameter r is the growth rate of the population and K is the carrying capacity of the city. Logistic population model (2) is a differential equation model and its solution can be obtained easily.

To use this model to analyse the socio-economic dynamics of the South African cities, first we extracted the population data of each of the cities for the period 1995 to 2018 (Statistic SA 2018, World population review 2018). Next we use our model to fit these population data for each city.

In fitting the model, parameter values for the growth rate r are taken from Statistics SA (2018) and the world population review of 2018. For the cities Port Elisabeth, Cape Town, Durban, Johannesburg, and Tswana are respectively given by 1.36%, 2.57%, 1.08%, 4.36%, and 4.33%. These model fittings were carried out using the built-in MATLAB least-squares fitting routine Fmincon in its optimization tool box. The carrying capacity K for each city is estimated by fitting the model to match the population data for each city. The estimated carrying capacity K for the cities Port Elisabeth, Cape Town, Durban, Johannesburg, and Tswana are respectively given by 11521000, 15597000, 7293000, 34965000, and 9024000. The results of the model fitting for these cities are given in Figure 3. These results demonstrate that our model can be used to study and predict population dynamics for each of these cities. More realistic models can also be developed (for example Figure 4) but for our purposes here the simple model (2) appears sufficient.

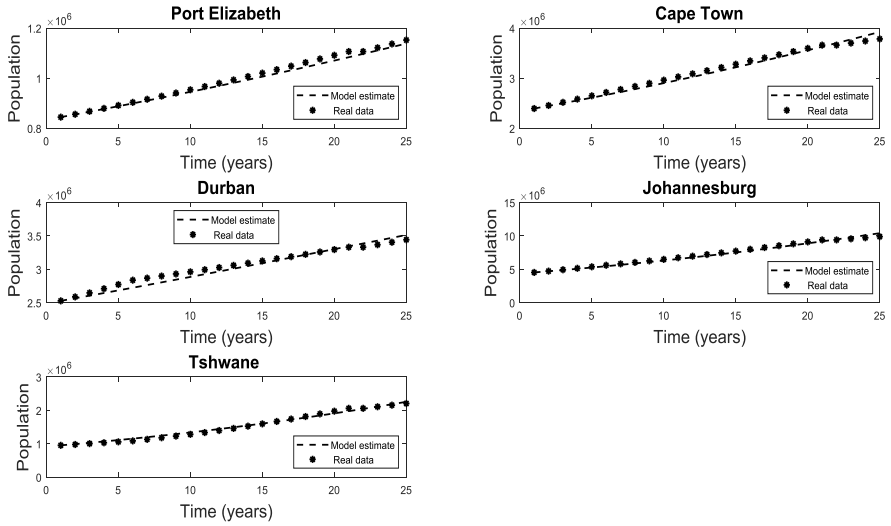

FIGURE 3 - MODEL FITTING OF THE POPULATION SIZE OF THE CITIES FROM 1995 TO 2018.
The bold lines represent the model fit and the stars represent the real data.

Having shown that our model (2) accurately fits the actual population data we use it to make population projections for these cities over the next 150 years and the results are given in Figure 5. These results illustrate the possible population dynamics of these cities in the next 150 years. Note that the population of Johannesburg becomes very large and only stabilises after a decade. Such information is necessary for socio-economic development planning and policy making.

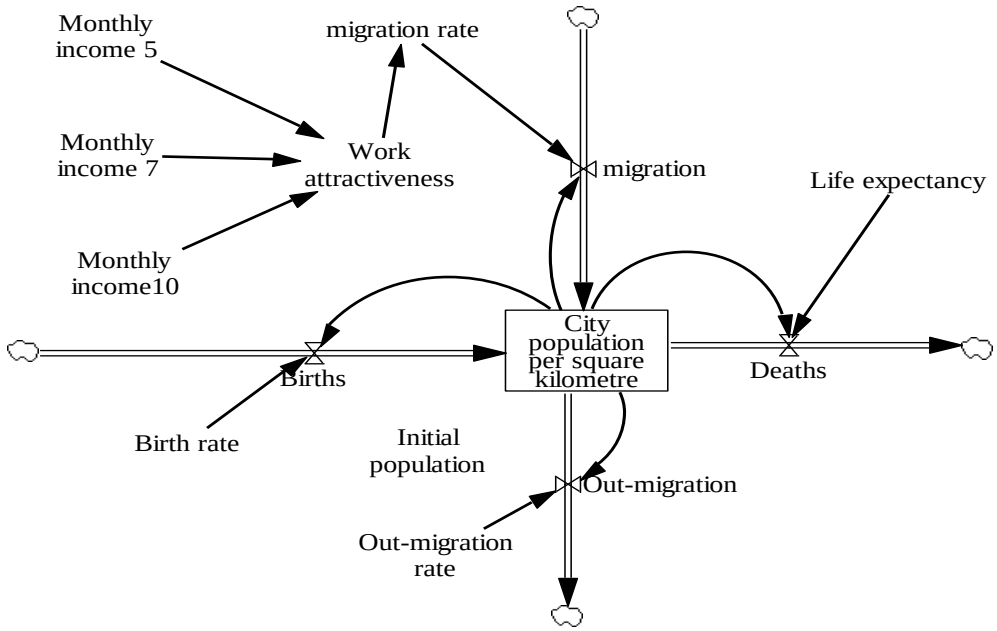

Figure 4 - An example of a system dynamic model for inner city migration.
Most factors are self-explanatory and the monthly incomes 5, 7 and 10 refer to the proportions of people in each of the income brackets R 3000 – R 5000, R 5000 – R 7000 and R 7000 – R 10000, respectively. Equations (2) and (3) are incorporated into the factors called Work attractiveness and In-migration.

Theoretical and Empirical Researches in Urban Management
Volume 13 Issue 3 / August 2018

Theoretical and Empirical Researches in Urban Management
Volume 13 Issue 3 / August 2018

Furthermore, we consider the model together with data for income levels for all the cities to analyse the socio-economic dynamics of these cities. The results of our analyses are given in Figure 6. This figure indicates that moving to an inner city because of its attractiveness as a place of work is based on that city having jobs in the income brackets R 3000 – R 5000, R 5000 – R 7000 and R 7000 – R 10000 with the greatest emphasis on the middle of these income brackets. Also, the very low income bracket (< R 3000) has less influence on this form of city attractiveness. Thus, very low and higher salaries are less important drivers for in-migration and so middle income salaries are the most important.

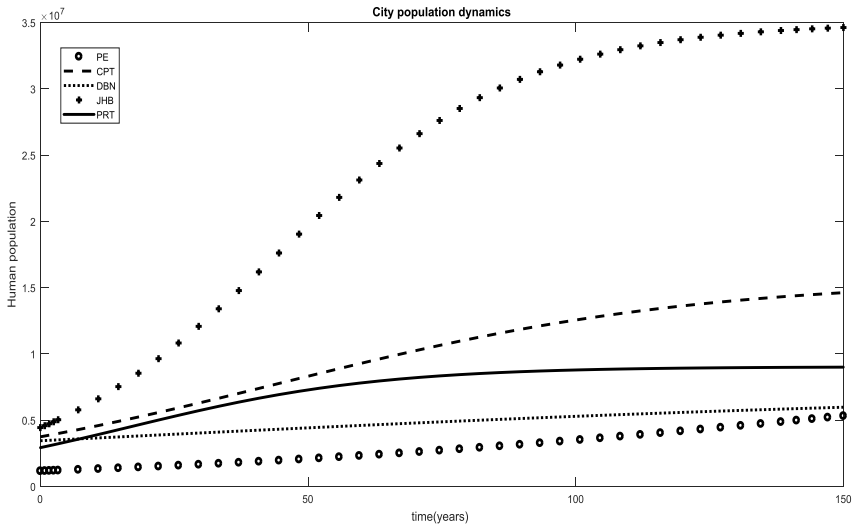

FIGURE 5 - ILLUSTRATION OF THE POSSIBLE EFFECT OF INCOME DISTRIBUTIONS ON POPULATION DYNAMICS. Population dynamics over 50 years is shown for the five cities using income distribution.

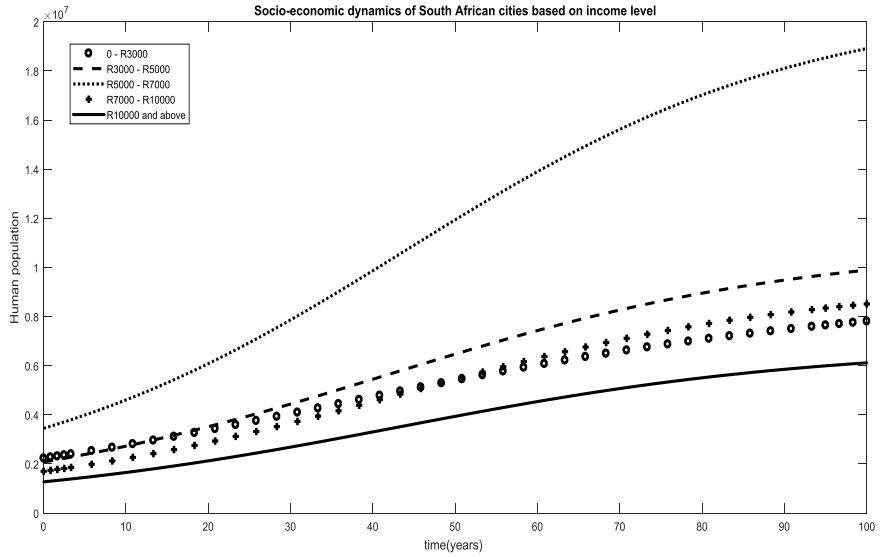

FIGURE 6 - ILLUSTRATION OF THE POSSIBLE SOCIO-ECONOMIC DYNAMICS OF THE CITIES. SOCIO-ECONOMIC DYNAMICS OF FOR ALL CITIES COMBINES OVER 100 YEARS SEPARATED BY INCOME DISTRIBUTION.

3. SUMMARY AND CONCLUSIONS

Using data from a survey of inner city residents in the five largest South African cities, work is shown to be a strong driver for migrating to those cities. The only other significant reason given was to study. Thus, as initially hypothesised, and found from a number of previous studies (Black et al. 2011, Castles 2013; Seto 2011; Van Hear, Bakewell, and Long 2018), migration was found here to be heavily influenced by an economic driver, primarily the need to find employment.

Of interest is the connection of this need to find employment and the potential income levels associated with getting that employment. Thus, the question asked was what perceived economic benefits might attract migrates to a particular city? Results of the survey indicated that overall most inner city residents are in low income groups but Port Elisabeth, Cape Town and Tshwane have more jobs in very low income categories and this result correlated with less migration. Thus, migrants are attracted to better paying cities. A lack of attractiveness for inner cities with mainly very low income jobs would make sense but is not necessarily obvious. Situations in places migrated from could be pushing people to move because of problems such as dire poverty or political instability (Van Hear, Bakewell, and Long 2018). Regardless, it appears that in South Africa when people are drawn to a city for work the lowest income jobs are less of a factor. Very high income jobs are also not as great a factor perhaps because these are perceived as, or are, less possible to attain. Cities with income distributions higher in the middle income brackets have the most impact on a person being attracted to a city for work. Johannesburg in particular matches this trend. Durban does not fit as strongly and it can only be surmised that other factors are influencing the results. For example, it might be that Durban is perceived to not have jobs in the attractive brackets when in fact it does.

What is especially interesting is that it is the shape of the distribution of income levels that influence a person to be attracted to a city for work. If one considers the data (Figures 1 and 2) the links are not immediately apparent as the income distributions are fit best by different non-linear regressions. A normal distribution with a peak at more middle income salaries results in a city being more attractive than a distribution that peaks at only low income salaries.

Using these results, equations relating work attractiveness to rates of in-migration have been produced. While never definitive equations like these can be used to probe scenarios of inner city migration patterns and can be incorporated into larger system dynamic models. Simulations of population trends using the model developed here matched actual population growth for each of the cities. Thus, the methodology is shown to be responsive to the realities of the situation.

Simple equations, as developed here, that relate city attractiveness to inner city migration can be used in larger predictive models to investigate and develop scenarios for planning and development. Using the example model here we show city income distributions affect population growth. For a prediction scenario over a 100-year period, inner city populations in South Africa are strongly influenced by the income bracket R 5000 – R 7000. Thus, the actual distributions of salaries are important. If the income distributions are approximately normal with a peak in the middle incomes, such as for Johannesburg, then the resulting populations grow faster than for distributions which are skewed to lower salaries.

Here we ignore other important ameliorating factors which will dampen populations as they grow. However, the high populations that are predicted (especially for Johannesburg) and the fact that they become stable only after approximately 100 years is both possible and important for understanding these dynamics and for planning purposes. Also, irrespective of the actual details in population trends in South Africa over the next decades, this research does illustrate the possible importance of income as a driver in South African city migrations. Finally, the methods presented here could be extended with the potential of further benefiting urban planners and policy makers.

REFERENCES

Anisimova, E.A., Glebova, I.S., Khamidulina, A.M., & Karimova, R.R. (2016). Correlation of migration level and city attractiveness. *International Business Management,* 10, 5577-5580.

Arieff, A. (2010). *Global Economic Crisis: Impact on Sub-Saharan Africa and Global Policy Responses*. DIANE Publishing.

Balbo, M., & Marconi, G. (2005). Governing International Migration in the City of the South. Global Migration Perspectives #38. Geneva: Global Commission for International Migration.

Beezer, R (2006). *A first course in linear algebra.* E-book. Retrieved May 6, 2018, from http://linear.ups.edu/

Black, R., Adger, W.N., Arnell, N. W., Dercon, S., Geddes, A., & Thomas, D. (2011). The effect of environmental change on human migration. *Global environmental change,* 21, S3-S11.

Carling, J., & Collins, F. (2018). Aspiration, desire and drivers of migration. *Journal of Ethnic and Migration Studies*, 44, 909–926.

Castles, S. (2013). The forces driving global migration. *Journal of Intercultural Studies*, 34, 122-140.

Crush, J. (2008). The perfect storm: The realities of xenophobia in contemporary South Africa. Southern African Migration Project, Migration Policy Series, 50. Cape Town: Idasa and Kingston, Ontario: Southern African Research Centre.

Crush, J., & Frayne 1, B. (2007). The migration and development nexus in Southern Africa Introduction. *Development Southern Africa*, 24, 1-23.

Crush, J., Williams, V., & Peberdy, S. (2005). Migration in Southern Africa. A paper prepared for the Policy Analysis and Research Programme of the Global Commission on International Migration. *Geneva: Global Commission on International Migration*.

Hatton, T. J., & Tani, M. (2005). Immigration and Inter-regional Mobility in the UK, 1982–2000. *The Economic Journal*, 115, F342-F35.

Highland, J. (2010). How to solve simultaneous equations in Excel. Retrieved May 6, 2018, from http://www.ehow.com/how_5896932_solve-simultaneous-equations-excel.html

Kährik, A., Novák, J., Temelová, J., Kadarik, K., & Tammaru, T. (2015). Patterns and drivers of inner city social differentiation in Prague and Tallinn. *Geografie,* 120, 275-295.

Kihato, C. (2018). NEPAD, the city and the migrant: implications for urban Governance. Migration Policy Brief (12), Southern African Migration Project.

Kok, P., & Collinson, M. (2006). *Migration and urbanisation in South Africa*. Statistics South Africa.

Ramphele, M. A., Heap, M., & Trollip, D. K. (1991). Health status of hostel dwellers: Part III. Nutritional status of children 0-5 years. *South African Medical Journal*, 79, 705-709.

Rees, D., Murray, J., Nelson, G., & Sonnenberg, P. (2010). Oscillating migration and the epidemics of silicosis, tuberculosis, and HIV infection in South African gold miners. *American journal of industrial medicine*, 53, 398-404.

Seto, K. C. (2011). Exploring the dynamics of migration to mega-delta cities in Asia and Africa: Contemporary drivers and future scenarios. *Global Environmental Change*, 21, S94-S107.

Statistics South Africa (2018). Retrieved April 7, 2018, from http://www.statssa.gov.za/

Simelane, T. S. (2017). Systems analysis of the transformation of South African cities (Doctoral dissertation).

Tsoularis, A., & Wallace, J. (2002). Analysis of logistic growth models. *Mathematical biosciences*, 179, 21-55.

Van Hear, N., Bakewell, O., & Long, K. (2018). Push-pull plus: Reconsidering the Drivers of Migration. *Journal of Ethnic and Migration Studies*, 44, 927–944.

Vearey, J., Palmary, I., Thomas, L., Nunez, L., & Drimie, S. (2010). Urban health in Johannesburg: the importance of place in understanding intra-urban inequalities in a context of migration and HIV. *Health & place*, 16, 694-702.

World Population Review (2018). Retrieved April 7, 2018, from http://worldpopulationreview.com