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Research note

How cities shrink: Complex pathways to population decline

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1. Introduction

The dominant narrative of urban shrinkage research asserts that population loss and economic restructuring stem from the interplay of macro-economic and demographic trends at the local scale (Rink, Haase, Großmann, Couch, & Cocks, 2012). However, few studies have attempted to disentangle and study the interdependent relationships amongst variables related to shrinkage using quantitative methods. Economic and demographic trends undoubtedly play a central role in the development of urban shrinkage, but are also part of a larger complex system complete with interdependencies and feedback loops. The relationships between economic, demographic and other processes must be taken into consideration in order to gain a more robust understanding of the evolution of urban shrinkage. Within a nonlinear system, how do economic and demographic processes related to urban shrinkage evolve at the local scale? And furthermore, how can the complex relationships between contributing factors be captured, represented and analyzed?

Empirical research examining the dynamic processes of shrinkage is necessary in order to grasp the nonlinear interdependencies between the causes and effects (Großmann, Bontje, Haase, & Mykhnenko, 2013). Hoekveld's (2012) work on the temporal and spatial aspects of shrinkage in the Netherlands is one of few studies to examine the complexities of shrinking trajectories. She concludes that the individual processes leading to shrinkage are strongly interrelated and display feedback mechanisms and circular causal trends.

This paper contributes to the effort to disentangle the causes and effects in the shrinking process. It does so by examining the relationships between fifteen demographic, migratory, economic and built environment factors in two case studies over a period of seventeen years from 1997 to 2013. It follows and builds upon Hoekveld's (2012) cross-correlation methodology by expanding the variables and integrating network analysis and visualization. The cross-correlation network analysis approach is applied to the Canadian case studies of Chatham-Kent, Ontario and Cape Breton Regional Municipality (CBRM), Nova Scotia to determine the order and influence of contributing processes to urban shrinkage. The analysis unpacks the processes leading to and stemming from urban shrinkage, providing insight into the complexity of shrinking city systems.

2. Circular causality of urban shrinkage

Broadly speaking, a shrinking Canadian city is a municipal district with a minimum population of 10,000 residents that has faced population losses for more than two years and is undergoing economic transformations with some symptoms of a structural crisis (adapted from Pallagst et al., 2009; Wiechmann, 2008). Although cities have been transforming, losing and gaining population since their inception, the recent phenomenon of urban shrinkage is considered distinct from historical population loss. Martinez-Fernandez, Audirac, Fol, and Cunningham-Sabot (2012) contend that modern urban shrinkage is a socio-spatial manifestation of globalization. The emergence of a global economy and the internationalization of the production process have altered manufacturing, distribution and consumption systems (ibid.). This has contributed to the shrinkage of industrial cities across the globe. The mobility and uneven development of human, financial and knowledge capital has assured the significance of large global cities (Sassen, 2001; Weaver & Holtkamp, 2015). And the global shift of populations to urban centers has been reinforced by new immigrants' tendencies to settle in larger, metropolitan regions (Skeldon, 2014).

Castells' (2004) network society presents cities as nodes in an information network. He postulates that the global economy has prompted capital and labor to concentrate in specific nodes of great importance while weakening nodes of lesser connectivity. This uneven flow of capital and information has allowed economic and demographic trends to self-perpetuate in both global and shrinking cities. This cyclical trend is outlined in Fig. 1, which depicts a conceptual model of urban shrinkage. Changing economic and demographic contexts and trends, at varying scales, have consequences for local urban development. This can lead to population decline, which in turn impacts urban development (Haase et al., 2013). This cyclical mechanism can be further reinforced by changes to migratory trends and the degradation of the built environment. The governance context also plays a crucial role in guiding and shaping urban development. The feedback loops, present at the local and external scale, can influence and be influenced by governance. This can potentially lead to further reinforcement of demographic and economic feedback mechanisms (Haase et al., 2013). These dynamic processes continue to have direct and indirect impacts on local urban development.

Due to the circular causality of the processes in shrinking cities, effects of the process can in turn become drivers (Haase, Rink, Großmann, Bernt, & Mykhnenko, 2014). The continued population

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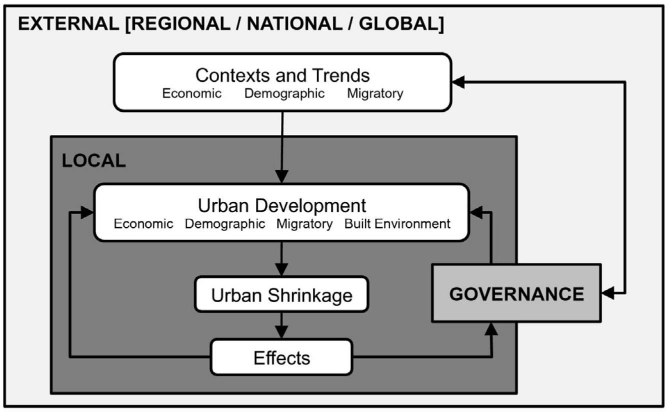

Fig. 1. Conceptual model of urban shrinkage.
Adapted from Haase, Bernt, Großmann, Mykhnenko, & Rink, 2013.

and economic decline in shrinking cities is often a result of self-reinforcing feedback mechanisms. Many researchers have recognized the multidimensionality of urban shrinkage (Martinez-Fernandez, Weyman, Fol, & Audirac, 2015; Pallagst et al., 2009). However little work has been done to disentangle the temporal dimension of these processes. Influenced by Jay Forrester (1971), the research presented in this paper integrates elements of system dynamics to shed light on the multidimensionality of urban shrinkage processes. Specifically this study explores the interrelationships between economic, demographic, migratory and built environment processes in two shrinking case study cities. The theorized direct relationships between the overarching variables are depicted in Fig. 2 (see Methods section for full description of variables).

It is hypothesized that there will be a two-way relationship between economic and migratory variables. Local economic prospects play an important role in the decision to move into, or out of, an urban area. The relationship between economic and built environment variables is also expected to be reciprocal. An increase in unemployment could have a negative effect on housing starts and completions. Such an effect could in turn reduce employment in construction-related industries. Migration and the built environment are also expected to influence one another as housing prospects may influence migratory decisions and changes in migratory patterns would impact the housing industry. Demographic change could also impact the built environment as housing purchasing trends and preference change with age. An aging population may be less likely to purchase newly developed homes. Lastly, a two-way relationship is expected between demographic and migratory variables. It is unlikely that in- and out-migrants will be equally distributed across the population, and therefore a change in migration will impact birth and death rates, as well as dependency ratios. Of course the

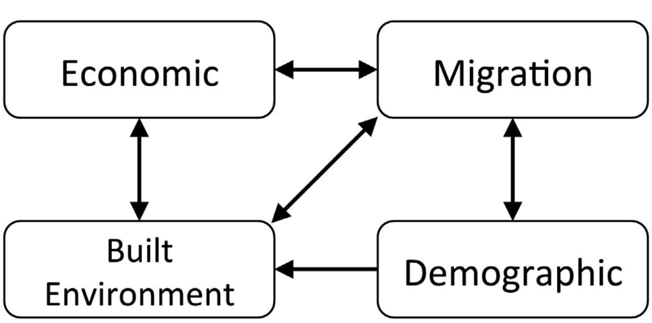

Fig. 2. Theorized relationships between economic, migration, demographic and built environment processes in shrinking cities.

specific relationships between variables are extremely context dependent. Historic local, regional, national and global processes all shape local urban development.

3. Methods

Time series analysis is often applied to investigate temporal relationships. However, capturing the intricacies of feedback loops and cycling mechanisms within and between the processes can be very challenging. This paper follows and builds upon Hoekveld's (2012) approach to representing and analyzing complex time series data. Cross-correlation network analysis is able to capture the strength, time and direction of processes in complex systems. This approach allows for deeper analysis and comparison of complex system trajectories. This section explains and defines the cross-correlation function, the variables in the study and the network visualization approach.

3.1. Cross-correlation

In many complex systems, like shrinking cities, a change in one variable precedes a change in another. In order to measure the time and direction, as well as the strength of the relationships between variables, cross-correlations coefficients are calculated. Essentially, cross-correlation coefficients are used to determine how one set of variables is related to past lags of another set of variables (Gottman, 1981). This time series analysis technique is often used in signal processing research to determine the time delay between signals (Knapp & Carter, 1976). Fig. 3 shows an example of two highly correlated time series, y_t and x_t. Because of their lack of synchronicity, a simple correlation calculation would not capture the full extent of their relationship. Using the cross-correlation function in SPSS, we are able to examine the relationship between these time series' while taking into account a potential lag between them. For example, if we considered x_t to be employment and y_t to be population, results would show that the two are highly correlated with a change in employment preceding a change in population by a lag of $t_2 - t_1$.

From the calculated coefficients it is possible to conclude the significance and direction (which variable precedes which) of the relationship at different lags. For this study, the lag range was from zero to five years. In other words, cross-correlation coefficients were calculated for each lag from zero to five years for every pairwise relationship. Essentially, this determines if a change in one variable preceded a change in another by zero, one, two, three, four or five years. Only relationships significant at the 0.01 level were included in the analysis.

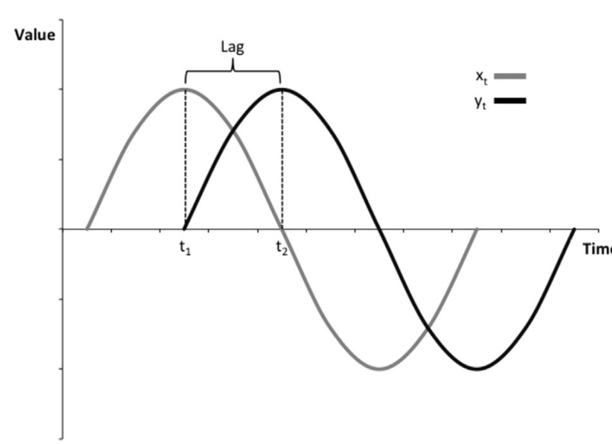

Fig. 3. Example of two highly correlated, but lagged time series (author's illustration).

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