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Mapping the evolution of hierarchical and regional tendencies in the world city network, 2000–2010

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ABSTRACT

This paper visualizes the evolution of the dominant hierarchical and regional patterns in the world city network, drawing upon an analytical framework integrating categorical correlation, hierarchical clustering, and alluvial diagrams. Our analysis confirms the continued interweaving of hierarchical and regional patterns in the world city network as measured by cities' similarities in the presence of globalized service firms, but equally highlights some of the key changes that have occurred between 2000 and 2010 such as the rise of the BRIC cities, Dubai's leading positions in the Arab Gulf, and the stratification of US cities.

1. Introduction

More than a decade ago, Hall (1999, p. 173) posited that the significance of face-to-face contact and the continuing significance of agglomeration imply that cities will continue to thrive. However, at the same time he suggested that we need a new urban theory of location of service industries in the context of increasing informationalization and globalization (see also Castells, 2001; Sassen, 2001). Hall's (1999) general ideas have been picked up in a wide variety of literatures, including the 'world city network' (WCN) research conducted in the context of Globalization and World Cities research network (GaWC, http://www.lboro.ac.uk/gawc). In WCN analysis, data on the office networks of producer services firms is used to estimate the shape and the geographies of emerging 'urban networks' at the global scale (Taylor, 2001, 2004; Taylor, Derudder, Hoyler, & Ni, 2013).

Diverse empirical researches into the geographies of the WCN have revealed that these can best be described as a variegated mix of hierarchical and regional tendencies. In the context of WCN, regions are defined based on network "clusters", which are groups of densely connected cities, so that connections within clusters are stronger than connections between clusters. Network-based regions are similar to *functional regions* in economic geography, where interactions are more intense within regional "borders" than across them (Anderson, 2012). These network-based regions often coincide with *formal* – geographical, institutional, or cultural – regions, i.e., cities from the same geographical or cultural region tend to reveal similar network connectivity patterns. For instance, based on a cluster analysis applied to a dataset specifying the location strategies of 100 globalized service firms in 234 cities across the world for the year 2000, Derudder, Taylor, Witlox, and Catalano (2003) find that the cluster results can best be described through both tendencies. More specifically, the hierarchical tendencies are revealed through the co-presence of cities with similar levels of overall involvement in the networks of globalized services firms. As a corollary, all clusters can be ranked based on the relative importance of their member cities, ranging from a two-city cluster made up of New York and London to a cluster with cities only housing a small number of globalized service firms such as Teheran, Labuan and Yangon.

However, the results do not simply reflect a straightforward hierarchical arrangement: there is also a series of regional dimensions, demonstrated by the presence of different clusters with cities of comparable importance but with different regional affiliations. This is for instance shown by the presence of two clusters just beyond the New York–London dyad: one cluster made up of leading non-US cities (Frankfurt, Tokyo, Hong Kong, Paris and Singapore), and the other of leading US cities (San Francisco, Chicago and Los Angeles). Similarly, there are different clusters of

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inter alia secondary Commonwealth cities, secondary United States cities, and secondary German cities, and this in spite of the comparable overall importance of their member cities in the office networks of globalized services firms. Derudder et al. (2003, p. 880, emphasis in original) thus conclude that the "results show more than clusters in an abstract 'service space', they represent *urban arenas* in geographical space." Rather than presenting a mere hierarchical ranking of clusters, they thus opt to organize their description of the global urban system around a combination of 'hierarchical bands' in which clusters with different regional orientations can be discerned.

The Derudder et al. (2003) study obviously represents a specific empirical take by focusing on the location strategies of leading service firms for the year 2000, and by applying a fuzzy clustering algorithm for discerning patterns. However, it can be noted that this mixture of hierarchy and regionality constantly re-emerges in this literature, irrespective of the data source, the data analysis technique, and the time period. Wall and van der Knaap (2011) and Ducruet, Ietri, and Rozenblat (2011), for instance, use a host of network analysis techniques to examine the WCN around 2005 as created by multinational corporations and air passenger/maritime freight networks, respectively, and thereby come to similar conclusions.

The ongoing presence of hierarchical tendencies and regional patterns in the WCN obviously does not preclude significant *change*. For instance, the quasi-general 'rise' of cities in China and the Arab Gulf has been widely documented, as well as the hierarchical unevenness of these changes as individual cities such as Shanghai, Beijing and Dubai surpass their wider regional trends, thus assuming an importance in line with that of the likes of Tokyo and Chicago (Alderson, Beckfield, & Sprague-Jones, 2010; Mahutga, Ma, Smith, & Timberlake, 2010; Derudder et al., 2010). The presence of such multilayered change in the WCN in the face of its ongoing hierarchical and regional complexity leads to the question how this change can be comprehensibly analyzed and represented (see Orozco Pereiro & Derudder, 2010).

To date, this challenge has not yet been taken up in this literature. As a consequence, longitudinal research into the WCN has generally been restricted to analyses of the shifting position of individual cities. However, this obviously falls analytically short of the detailed cross-sectional descriptions as detailed in the work of Derudder et al. (2003), Ducruet et al. (2011), and Wall and van der Knaap (2011). Against this backdrop, the purpose of this paper is to apply a visualization framework that allows for a *comprehensive* assessment of the multilayered evolutions in urban systems.

An exploratory visualization framework seems to usefully complement previous centrality-based studies (Rosvall & Bergstrom, 2010), as the visualization approach is able to, amongst other things, (1) synthesize information more compactly than tables; (2) reveal trends in data via visual aids, and most importantly, (3) explore unexpected trends and serve as hypothesis-generating tools. Indeed, visualization has long been identified as promising ways forward in the global urban network (Taylor, 2004), however – probably due to the fact that empirical global urban network studies usually involve hundreds of cities and firms – few empirical attempts have been made to realize the potential of visualization (however see Hennemann, 2013).

Our study employs a non-map based visualization framework to supplement conventional map-based methods (e.g., Liu, Neal, & Derudder, 2012) for the following reasons: Firstly, city networks in general and world city networks (WCNs) in particular represent a "meta-geography" (Beaverstock, Smith, & Taylor, 2000) in which relative positions of cities do not necessarily correspond to their absolute geographic locations, thus rendering maps – the conventional way of representing absolute geographic sites – less relevant for mapping WCN (Hennemann, 2013). Secondly, while maps remain the dominant way of visualizing spatial information, non-map based visualizations have been increasingly adopted to reveal dynamics of cities (see for example, Batty, 2006; Angel, 2012). These methods often focus on the hierarchical rather than the regional nature of urban systems. For example, Batty's (2006) *Nature* paper reveals the trajectories of individual cities within urban hierarchies (e.g., the rise and fall of Buffalo, NY) but focuses less on dynamics of groups of cities (e.g., the overall diverging trajectories of cities from the "Rust-Belt"). Thirdly, visualizing intercity networks by cities' absolute geographic positions (see for example, Liu et al., 2012) would usually produce cluttered networks due to strong geographical and network clustering (i.e., the regional tendencies discussed in this paper), make it difficult to represent long-term spatiotemporal changes (i.e., representing four-dimensional spatiotemporal information on a two-dimensional surface), and often need to be *supplemented* by other techniques (Rae, 2009).

The framework used here rests on two key premises. First, we argue that longitudinal research needs to use partitioning methods that provide 'consistent' grouping results across the entire timespan. That is, results for the different time points should be comparable in the sense that changes reflect structural change in the system rather than data heterogeneity. Second, assessments of change should not simply focus on the shifting position of individual cities, but allow tracking the broader changes in the hierarchical and regional geographies of the system as a whole. In this paper, we propose to tackle this by *adopting* a framework that combines categorical correlation, hierarchical clustering, and alluvial diagrams to assess the temporal evolution of the WCN.

Our framework is applied to GaWC data garnered for 2000, 2004 and 2010. For each year, the data provide ordinal measures of the importance of cities in the networks of the world's most important producer services firms. The data are transformed so that consistent datasets of 139 cities and 92 firms are used for describing the geographies of the WCN. The three 139×92 ordinal matrices are used as the input to our measurement and visualization framework, and the results are thereupon to explore the potential of this approach by identifying a number of key changes in the geographies of the WCN.

The remainder of this paper is organized as follows: In the next section, we discuss previous approaches to revealing geographical patterns in the WCN, and use this to sketch the general framework for examining change in the WCN. This is followed by a specification of our analytical framework, and a description of our data. In the results section, we explore the possibilities offered by our framework by discussing some key changes in the geographies of the WCN. The paper is concluded with an overview of our main findings, a discussion of our framework's limitations, and an overview of avenues for further research.

2. Identifying 'clusters' in WCNs

The empirical starting point for WCN analysis is a city-by-firm matrix, which is basically a two-mode or bipartite network (Liu & Derudder, 2012). Unlike more conventional one-mode networks where nodes are connected directly (e.g., cities linked by airline flows), a two-mode network features relationships between two disjoint groups of nodes (e.g., cities and firms) whereby there is no direct linkage between nodes of the same group (i.e., between cities or between firms). Two-mode network datasets can be either binary or valued (e.g., when values reflect cities' importance in firm's locational strategies).

Exploring the major tendencies in large two-mode networks such as WCN datasets often implies reducing the overall complexity to a coherent set of major patterns. In the empirical WCN literature, the identification of these tendencies is most